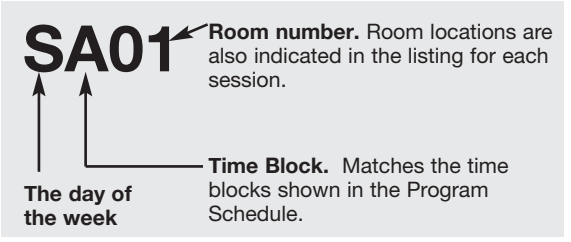
How to Navigate the Technical Sessions

There are four primary resources to help you understand and navigate the Technical Sessions:

- This Technical Session listing, which provides the most detailed information. The listing is presented chronologically by day/time, showing each session and the papers/abstracts/authors within each session.

The Session Codes



Time Blocks

Sunday

A	**Virtual Only- 6:00- 7:30am**
B	7:45-9:15am
Plenary –	9:35-10:45am
C	11:15-12:30pm
Keynotes –	1:30-2:30pm

Monday

A	**Virtual Only- 6:00- 7:30am**
B	7:45-9:15am
Plenary –	9:35-10:45am
C	11:15-12:30pm
Keynotes –	1:30-2:30pm
D	2:45- 4:15pm
E	4:30-6pm

Tuesday

A	**Virtual Only- 6:00- 7:30am**
B	7:45-9:15am
Plenary –	9:35-10:45am
C	11:15-12:30pm
Keynotes –	1:30-2:30pm
D	2:45- 4:15pm
E	4:30-6pm

Wednesday

A	**Virtual Only- 6:00- 7:30am**
B	7:45-9:15am
Plenary –	9:35-10:45am
C	11:15-12:30pm
Keynotes –	1:30-2:30pm
D	2:45- 4:15pm
E	4:30-6pm

Sunday, 7:45AM-9:15AM

■ SB01

CC Ballroom A / Virtual Theater 1

Hybrid Meet the Editors

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

Chair: Gizem Korpeoglu, Eindhoven University of Technology, , London, WC1E 6BT, United Kingdom

1 - Moderator
Gizem Korpeoglu, Eindhoven University of Technology, London, WC1E 6BT, United Kingdom

2 - Panelist
Anant Mishra, Carlson School of Management, University of Minnesota, Minneapolis, MN, 55455, United States

3 - Panelist
Cheryl Gaimon, Georgia Institute of Technology, Scheller College of Bus., Atlanta, GA, 30308-1149, United States

4 - Panelist
Kamalini Ramdas, London Business School, A215 Sussex Place, Regent's Park, London, NW1 4SA, United Kingdom

5 - Panelist
Jurgen Mihm, Insead, Boulevard De Constance, Fontainebleau, 77300, France

■ SB02

CC Ballroom B / Virtual Theater 2

Hybrid Peter C. Fishburn Memorial Panel

Sponsored: Decision Analysis Society

Sponsored Session

Chair: L Robin Keller, University of California, Irvine, Irvine, CA, 92697-3125, United States

1 - Peter C. Fishburn Memorial Panel
L Robin Keller, University of California, Irvine, Irvine, CA, 92697-3125, United States

Peter C. Fishburn made foundational contributions to many aspects of decision theory, including utility theory, subjective probability, approval voting, social choice, fairness, risk perception, stochastic dominance, and temporal preferences. A panel of co-authors and researchers influenced by Peter Fishburn will provide memorial comments and discuss Ramsey Medalist Fishburn's research legacy.

2 - Panelist
L Robin Keller, University of California, Irvine, Irvine, CA, 92697-3125, United States

3 - Panelist
David E. Bell, Harvard University, Boston, MA, 2163, United States

4 - Panelist
James S. Dyer, University of Texas-Austin, Austin, TX, 78712, United States

5 - Panelist
Ralph L. Keeney, Duke University, San Francisco, CA, 94111-1195, United States

6 - Panelist
Rakesh Kumar Sarin, University of California-Los Angeles, Los Angeles, CA, 90095, United States

■ SB03

CC Ballroom C / Virtual Theater 3

Hybrid ENRE Award Session

Sponsored: Energy, Natural Resources and the Environment

Sponsored Session

Chair: Benjamin D. Leibowicz, University of Texas-Austin, Austin, TX, 78712-1591, United States

1 - Uncertain Bidding Zone Configurations: The Role of Expectations for Transmission and Generation Capacity Expansion

Harry van der Weijde, Friedrich-Alexander-Universität, Erlangen-Nürnberg, Germany, Mirjam Ambrosius, Jonas Egerer, Veronika Grimm

Ongoing policy discussions on the reconfiguration of bidding zones in European electricity markets induce uncertainty about the future market design. This paper analyzes how this uncertainty affects market participants and their long-run investment decisions. We propose a stochastic multilevel model which includes uncertainty about the future bidding zone configuration. If potential future bidding zone configurations provide improved regional price signals, welfare gains materialize even if the change does not actually take place. As a consequence, welfare gains of an actual change of the bidding zone configuration are substantially lower due to those anticipatory effects.

2 - Promoting Solar Panel Investments: Feed-in-tariff versus Tax-rebate Policies

Safak Yucel, Georgetown University, Washington, DC, 20057, United States

We analyze the government's preference between feed-in-tariff and tax-rebate policies to promote households' solar panel investments in the presence of household heterogeneity with respect to generating efficiency, electricity price variability and investment cost variability. This paper has received the 2021 Best Publication Award in Environment and Sustainability from the INFORMS Section on Energy, Natural Resources and the Environment.

3 - Load Restoration in Islanded Microgrids: Formulation and Solution Strategies

Shourya Bose, University of California, Santa Cruz, CA, United States, Yu Zhang

Extreme weather events induced by climate change can cause significant disruptions to the normal operation of electric distribution systems (DS), including isolation of parts of the DS due to damaged transmission equipment. In this paper, we consider the problem of load restoration in a microgrid (MG) that is islanded from the upstream DS because of an extreme weather event. The MG contains sources of distributed generation such as microturbines and renewable energy sources, in addition to energy storage systems. We formulate the load restoration task as a non-convex optimization problem with complementarity constraints. We propose a convex relaxation of the problem that can be solved via model predictive control. In addition, we propose a data-driven policy-learning method called constrained policy optimization. The solutions from both methods are compared by evaluating their performance inload restoration, which is tested on a 12-bus MG.

4 - Impact of Carbon Pricing Policies on the Cost and Emission of the Biomass Supply Chain: Optimization Models and a Case Study

Taraneh Sowlati, University of British Columbia, Vancouver, BC, V6 T. 1Z4, Canada

Carbon tax, carbon cap-and-trade, and carbon offset are the main carbon pricing policies in practice. Several studies analyzed the impacts of these policies on optimum solutions of biomass supply chain models. However, due to the focus on specific case studies, insights from these studies may not be general. In this paper, the impact of carbon pricing policies on the optimum solutions of case-independent biomass supply chain models is studied. Several propositions that discuss the impact of carbon pricing policies on optimum cost and emissions of biomass supply chain models are presented and proved mathematically. Next, mathematical models are developed to determine the optimal feedstock mix of a biomass-fed district heating plant. The case study results are used to numerically confirm all propositions. When the carbon price increases, the models prescribe the replacement of natural gas with biomass. Carbon tax and carbon cap-and-trade models result inequal optimum decision variables and emissions for equal carbon prices. The carbon cap-and-trade model has less cost than the carbon tax model if the carbon price is more than the price of initial allowance. Careful allotment of the compliance target is important for the carbon offset model because it bounds the optimum emissions.

5 - Downstream Protection Value: Detecting Critical Zones for Effective Fuel-treatment under Wildfire Risk

Cristobal Pais, University of California - Berkeley, Berkeley, CA, 94709, United States

The destructive potential of wildfires has been exacerbated by climate change, causing their frequencies and intensities to continuously increase globally. Generating fire-resilient landscapes via efficient and calculated fuel-treatment plans is critical to protecting native forests, agricultural resources, biodiversity, and human communities. To tackle this challenge, we propose a framework that integrates fire spread, optimization, and simulation models. We introduce the concept of Downstream Protection Value (DPV), a flexible metric that assays and ranks the impact of treating a unit of the landscape, by modeling a forest as a network and the fire propagation as a tree graph. Using our open-source decision support system, custom performance metrics can be optimized to minimize wildfire losses, obtaining effective treatment plans. Experiments with real forests show that our model is able to consistently outperform alternative methods and accurately detect high-risk and potential ignition areas, focusing the treatment on the most critical zones. Results indicate that our methodology is able to decrease the expected area burned and fire propagation rate by more than half in comparison to alternative methods under ignition and weather uncertainty.

■ SB04

CC Ballroom D / Virtual Theater 4

Hybrid TIMES Best Working Paper Award

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

Chair: Evgeny Kagan, Johns Hopkins University

1 - Product Development in Crowdfunding: Theoretical and Empirical Analysis

Sidika Tunc Candogan, University College London, London, E14 5AA, United Kingdom, Philipp Cornelius, Ersin Korpeoglu, Bilal Gokpinar, Christopher Tang

Crowdfunding goes beyond raising funds. Entrepreneurs often use crowdfunding to solicit feedback from customers to improve their products. We show, both theoretically and empirically, that as the initial development level increases, the likelihood of product improvement during a campaign at first increases and then decreases. Also, while our theoretical model intuitively predicts that the likelihood of campaign success will always increase with the initial development level, our empirical analysis shows that there is first an increase but then an unexpected decrease. We find that this discrepancy can be explained by feature fatigue, and incorporate this effect into our theoretical model to generate prescriptions. While crowdfunding experts believe that products should be as developed as possible before a campaign, we show that this is not always the best strategy.

2 - Delegated Concept Testing in New Product Development

Jochen Schlapp, Frankfurt School of Finance & Management gGmbH, Frankfurt Am Main, 60322, Germany, Gerrit Schumacher

3 - WeStore or AppStore: Customer Behavior Differences in Mobile Apps and Social Commerce

Kejia Hu, Vanderbilt University, Nashville, TN, 37215-1710, United States, Nil Karacaoglu

4 - Learning Best Practices: Can Machine Learning Improve Human Decision-Making?

Park Sinchaisri, The Wharton School, University of Pennsylvania, Oakland, CA, 94612, United States, Hamsa Bastani, Osbert Bastani

■ SB05

CC Ballroom E / Virtual Theater 5

Hybrid Academic Job Search

Sponsored: Minority Issues Forum

Sponsored Session

Chair: Zahra Azadi, University of Miami Herbert Business School, Coral Gables, FL, 33158, United States

1 - Academic Job Search

Zahra Azadi, University of Miami Herbert Business School, Coral Gables, FL, 33158, United States

The purpose of this session is to bring visibility to the students and postdocs looking for academic positions. Panelists from both business and engineering schools will share their experiences. This panel discusses the academic interview process and do's and don'ts associated with the job search.

2 - Panelist
Masoud Kamalahmadi, University of Miami, Miami, FL, 33145, United States
3 - Panelist
Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, Ann Arbor, MI, 48108-1020, United States
4 - Panelist
Vikrant Vaze, Dartmouth College, Hanover, NH, 03755-3560, United States

■ SB06

CC Room 303A

In Person: Diversity/PSOR/MIF Diversity, Equity and Inclusion in OR/MS/Analytics. Innovations in Research and Practice I

General Session

Chair: Michael P Johnson, University of Massachusetts Boston, University of Massachusetts Boston, Boston, MA, 02125-3393, United States

1 - We're Here: Interviews with LGBTQ+ Members of the INFORMS Community
Tyler Perini, Georgia Institute of Technology, Atlanta, GA, 30318, United States

While it can be tempting to rely solely on quantitative metrics, it is also critical to humanize individuals when it comes to minority issues. This requires stories to be told, heard, and documented. The objective for this project is to use semi-structured interviews to survey, document, and report the individual stories that color and humanize data for LGBTQ+ issues. Choosing to be "out" in academia is a highly personal and nuanced decision, and it is one that is unique to the LGBTQ+ community. Where do ambitious students or early career faculty find an LGBTQ+ mentor in our field? What mentorship advice can be condensed and shared publicly? The aim of this work is to tackle these and other challenges with a document that is meant to be valuable for Queer and non-Queer audiences, alike. This is a work in progress sponsored by the INFORMS DEI Ambassador Program.

■ SB07

CC Room 201B

In Person: Renewable Energy

General Session

Chair: Alexandra M. Newman, Colorado School of Mines, Colorado School of Mines, Golden, CO, 80401-1887, United States

1 - Estimating the Value of Concentrating Solar Power under New Costs Paradigm
Kehinde Abiodun, Colorado School of Mines, Golden, CO, 80401, United States

There is a gap in knowledge regarding the value of Concentrating Solar Power (CSP). Extant studies on the value of CSP are mostly outdated. This paper takes a price-taker approach to calculate the value of CSP based on recent cost information. The estimated value is based not only on the value from energy services and storage, but also on the provision of ancillary services, including spinning reserves and firm capacity. This paper uses price data from the CAISO market, zone SP15 in California, and National Renewable Energy Lab (NREL's) System Advisor Model (SAM).

2 - Experience Curves and the Relatedness of Technologies: Offshore and Onshore Wind Energy
Christian Hernandez-Negron, University of Massachusetts Amherst, Amherst, MA, United States, Erin Baker, Anna Goldstein

We look at the impact of modeling offshore wind as (1) a fully new technology, (2) a direct offshoot of onshore wind, and (3) a hybrid. We chart the cumulative installed capacity of offshore wind on a global scale against the LCOE starting in 2010, and we find that assumptions about its relatedness to onshore wind are equally important as assumptions about future growth scenarios. We contrast these experience curve models with expert elicitations, which appear to underestimate recent trends in cost reduction for offshore wind. The results are consistent with the idea that experts view offshore wind as a direct offshoot of onshore wind. This research highlights a previously neglected factor in experience curve analysis, which may be especially important for technologies, such as offshore wind energy, that are expected to contribute significantly to climate change mitigation.

■ SB08

CC Room 303C

In Person: Algorithmic Advances in Location Science for Spatial Demands

General Session

Chair: Peiqi Wang, Northeastern University, Princeton, NJ, 08540, United States

1 - A Spatial Algorithm to Identify All Non-dominated Solutions in Coverage and Access Optimization
Alan Murray, Professor, University of California at Santa Barbara, CA, United States, Jiwoon Baik

Selecting a good location for an activity or service is fundamentally important. Many different approaches across a range of disciplines have been proposed, developed, and explored to address such strategic decision-making. This paper introduces a bi-objective strategic location problem to address maximal coverage and access. A mathematical model formulation is presented, and an optimal solution algorithm is developed. Application findings are reported for several case studies.

2 - Predicting Ambulance Call Demand by Space and Time: A Machine Learning Approach
R. Justin Martin, Assistant Teaching Professor, Wake Forest University, Winston Salem, NC, United States, Cem Saydam

In this study, spatially distributed hourly call volume predictions are generated using a multi-layer perceptron (MLP) artificial neural network model following feature selection using an ensemble-based decision tree model. K-Means clustering is applied to produce heterogeneous spatial clusters based on call location and associated call volume densities. The predictive performance of the MLP model is benchmarked against both a selection of traditional forecasting techniques. Results show that MLP models outperform time-series and industry forecasting methods, particularly at finer levels of spatial granularity where the need for more accurate call volumes forecasts is more essential.

3 - Geometric Optimization Approaches for Downsizing Logistics Problems
Peiqi Wang, Northeastern University, Boston, MA, United States

This paper focuses on a special case of location problems where the goal is to downsize the existing facilities. Recent trends towards e-commerce and the impact of the COVID-19 pandemic is forcing many companies to make downsizing decisions to endure under these largely unforeseen market conditions. Hence the survival of many companies depends on making downsizing decisions efficiently and correctly. Computational geometry and optimization approaches have been successfully used in many logistics problems including location problems. We introduce several optimization models for different variants of the downsizing problem, develop geometric optimization algorithms to solve them and conduct a theoretical analysis to measure the impact of downsizing.

■ SB09

CC Room 303D

In Person: Learning and Decision-Making on Networks

General Session

Chair: Yueyang Zhong, The University of Chicago Booth School of Business, Chicago, IL, 60637-1610, United States

1 - Fast Rates for the Regret of Offline Reinforcement Learning
Yichun Hu, Cornell University, New York, NY, United States, Nathan Kallus, Masatoshi Uehara

We study the regret of RL from offline data generated by a fixed behavior policy in an infinite-horizon discounted MDP. While existing analyses of common approaches suggest an $O(1/\sqrt{n})$ convergence for regret, empirical behavior exhibits much faster convergence. In this paper, we provide fast rates analysis for the regret convergence. First, we show that given any estimate for the optimal quality function Q*, the regret of the policy it defines converges at a rate given by the exponentiation of the Q*-estimate's pointwise convergence rate. The level of exponentiation depends on the level of noise in the decision-making problem. Second, we provide new analyses of FQI and Bellman residual minimization to establish the correct pointwise convergence guarantees. As specific cases, our results imply $O(1/n)$ rates in linear cases and $\exp(-(n))$ rates in tabular cases.

2 - The Value of Knowing Drivers' Opportunity Cost in Ride Sharing Systems

Ran I. Snitkovsky, Columbia Business School, New York, NY, United States, SRIBD, Shenzhen, China, Costis Maglaras, Jim Dai

We consider a ride sharing platform, and a large population of strategic potential drivers, heterogeneous in terms of their opportunity costs, who choose whether or not to work for the platform. The platform is endowed with knowledge about the different drivers' opportunity costs. How can the platform implement a matching policy that uses this knowledge in order to improve system efficiency? Can such improvement be quantified? We introduce an analytically-tractable mean field model and show that by integrating knowledge about drivers' opportunity costs in its matching policy, the platform can perform up to two times more efficiently than when not doing so.

3 - Learning the Scheduling Policy in Time-varying Multiclass Many Server Queues

Yueyang Zhong, The University of Chicago Booth School of Business, Chicago, IL, United States, John R. Birge, Amy R. Ward

We consider a scheduling problem with minimizing the long-run average abandonment and holding costs as objective, in a time-varying multiclass Mt/M/N+M queueing system, when the model parameters (arrival, service and reneging rates) are a priori unknown. We evaluate the performance by means of regret against the benchmark asymptotically optimal c / rule with parameter knowledge.We propose a Learn-Then-Schedule algorithm over T periods, which is composed of a learning phase where maximum likelihood estimators of the parameters are formed, and an exploitation phase where an empirically learned c / rule is followed. We show that the smallest regret for static priority policies is O(log T), and that our algorithm achieves a regret upper bound of O(log T), which matches the lower bound. We extend the analysis to time-homogeneous multiclass GI/M/N+GI queues.

■ SB10

CC Room 304B

In Person: Stochastic Online Optimization

General Session

Chair: Jiashuo Jiang, New York University, New York, NY, 10012-1106, United States

1 - Dynamic Matching: Characterizing and Achieving Constant Regret

Süleyman Kerimov, Stanford University, Stanford, CA, United States, Itai Ashlagi, Itai Gurvich

We study how to optimally match agents in a dynamic market with heterogeneous match values. A network topology determines the feasible matches in the market. We consider networks that are two-sided when all matches include two agents, or acyclic otherwise. An inherent trade-off arises between generating short- and long-term value.We find that when the network satisfies a general position condition, this trade-off is limited, and a simple periodic clearing policy (nearly) maximizes the total value simultaneously at all times. Central to our results is the general position gap, , which quantifies the stability or the imbalance in the network. No policy can achieve a regret that is lower than the order of 1/ at all times. This lower bound is achieved by a policy, which periodically resolves a natural LP, provided that the delay between periods is of the order of 1/ .

2 - Online Stochastic Optimization under Wasserstein-based Non-stationarity

Jiashuo Jiang, New York University

We consider a general online stochastic optimization problem with multiple budget constraints. In each time period, a reward function and multiple cost functions are drawn from an non-stationary unknown distribution, and the decision maker needs to specify an action. The objective of the decision maker is to maximize the total reward subject to the budget constraints. In this paper, we consider a data-driven setting where the true distribution is unknown but a prior estimate (possibly inaccurate) is available. We propose a Wasserstein-distance based measure to quantify the inaccuracy of the prior estimate. We propose a new algorithm, which takes a primal-dual perspective and integrates the prior information of the underlying distributions into an online gradient descent procedure in the dual space. We show the corresponding algorithm achieves a regret of optimal order.

3 - Dynamic Regret Minimization for Control of Non-stationary Linear Dynamical Systems

Yuwei Luo, Stanford University, Stanford, CA, United States, Varun Gupta, Mladen Kolar

We consider the problem of controlling an LQR system over a finite horizon T with fixed and known cost matrices Q, R, but unknown and non-stationary dynamics {At, Bt}. The sequence of dynamics matrices can be arbitrary, but with a total variation, VT, assumed to be o(T) and unknown to the controller. Under the assumption that a sequence of stabilizing, but potentially sub-optimal controllers is available for all t, we present an algorithm that achieves the optimal dynamic regret of O(VT2/5T3/5). With piece-wise constant dynamics, our algorithm achieves the optimal regret of O(√ ST) where S is the number of switches. The crux of our algorithm is an adaptive non-stationarity detection and restart approach developed for contextual multi-armed bandit problems. We argue that non-adaptive restart or static window size based approaches may not be regret optimal for the LQR problem.

■ SB11

CC Room 304C

In Person: Matching Markets

General Session

Chair: Sasa Pekec, Duke University, Durham, NC, United States

1 - Rank Dominance of Tie-Breaking Rules

Maxwell Allman, Stanford University, Stanford, CA, United States, Itai Ashlagi, Afshin Nikzad

: In many settings where scarce resources must be rationed, agents have given priorities for the resources and lotteries are used to break ties amongst agents with equal priority. Two commonly used and simple tie-breaking rules are Single Tie-Breaking (STB), where a common lottery is used to break ties for all resources, and Multiple Tie-Breaking (MTB), where an independent lottery is used to break ties for each individual resource. We show that under a multinomial-logit (MNL) choice model, if the resources are sufficiently over-demanded then STB dominates MTB in the sense that agents with any preferences prefer STB ex-ante. Furthermore, we show that under a nested-MNL choice model with multiple resource types, a hybrid tie-breaking rule that uses a common lottery amongst over-demanded types will dominate MTB.

2 - Search Approximates Optimal Matching

Mobin Y. Jeloudar, Stanford University, Stanford, CA, United States, Irene Y. Lo, Tristan Pollner, Amin Saberi

We consider matching settings where agents are long-lived, match repeatedly, and have heterogeneous, unknown, but persistent preferences. Match compatibility is probabilistic, is realized the first time agents are matched, and persists in the future. We show that a decentralized stable matching process gives a constant-factor approximation to the optimal online matching. Specifically, stable matching provides a 0.316-approximation to the optimal online algorithm for matching on general graphs, a $1/7$-approximation for many-to-one matching, a $1/11$-approximation for capacitated matching, and a $1/2k$ approximation for forming teams of size k. Our results rely on a novel coupling argument that decomposes the successful edges of the optimal online algorithm in terms of their round-by-round comparison with stable matching.

3 - Matching Costs in Centralized and Decentralized Markets

Naomi Utgoff, USNA, Annapolis, MD, United States

I explore the relationship between payments in a static matching mechanism and the opportunity cost of singlehood in a decentralized search and matching model. A number of auction-like matching mechanisms exist in which a central matchmaker announces a payment rule which incentivizes participants to reveal private information to the matchmaker, who in turn matches participants efficiently. (See Hoppe, Moldovanu and Sela, 2009; Johnson, 2013; Utgoff, 2020). A common criticism of these centralized markets is that matching outside the mechanism in a decentralized setting may be preferable to avoid paying the matchmaker. Existing results supporting this criticism disregard the cost of time and optimal stopping in a decentralized search and matching model. I offer a preliminary comparison of the two and suggest that the high cost of static mechanisms is not necessarily prohibitive.

■ SB12

CC Room 304D

In Person: Emerging Traffic Management Techniques in Manned and Unmanned Aviation System

General Session

Chair: Ang Li, University of California-Berkeley, Berkeley, CA, 94720-2392, United States

1 - Optimization Models for Flights Arrival Scheduling Incorporating Carrier Preferences

Yeming Hao, University of Maryland-College Park, College Park, MD, 20740-3161, United States
David J. Lovell, Michael O. Ball, Sergio Torres

This study presents results of a simulation of strategies to incorporate business-driven airline preferences in Time-based Flow Management metering operations. Traffic flow systems that balance demand versus capacity at airports assign Controlled Times of Arrival (CTAs) to incoming flights. We evaluate optimization models and heuristics to assign these CTAs based on user-provided information and priority preferences in a way that minimizes the total CTA delay cost. We quantify potential savings by comparing the results with the default first-come-first-served (FCFS) scheme. Simulations under a variety of realistic scenarios show that our proposed heuristic could reduce CTA delay costs between 20% and 30% relative to the FCFS baseline scheme.

2 - Using Flight Shifting to Mitigate Delay in Multiple Airport Regions

Ang Li, University of California-Berkeley, Berkeley, CA 94720-2392, United States, Mark M. Hansen, Bo Zou

This study aims to improve operational performance of a multiple airport region (MAR) by analyzing interdependent capacity scenarios of that MAR airports and redistributing airport traffic to make more efficient use of the available capacity. We identify MARs based on temporal distance between airports. Capacity interdependence in MAR is demonstrated by conducting clustering analysis on daily capacity profiles. Flight shift models are proposed in both tactical and strategic levels to reduce flight delays of all flights serving airports in the same MAR. Results show that by rescheduling flight landing airport and landing time, the total flight delay in the New York MAR could be significantly reduced in both models.

■ SB13

CC Room 201A

In Person: Global Optimization for MINLPs and its Applications

General Session

Chair: Harsha Nagarajan, Los Alamos National Laboratory, Los Alamos, NM, 87544-2747, United States

1 - Uncertainty Measures and Hierarchical Acquisition Functions for Tree-based Black-Box Optimization

Alexander Thebelt, Imperial College London, London, United Kingdom, Robert M. Lee, Nathan Sudermann-Merx, David Walz, Ruth Misener

Our recent work uses tree-based models, e.g., gradient-boosted trees, to optimize black-box functions with various input data types, e.g. discrete and categorical. Off-the-shelf solvers can globally optimize acquisition function containing such models. This presentation extends our existing approach ENTMOOT by proposing discrete uncertainty measures for search-space exploration that natively integrate with tree-based models. Moreover, we utilize hierarchical acquisition functions for usage in Bayesian optimization explicitly leveraging global solvers for simplified hyperparameter tuning.

2 - Post-QAOA Variational Quantum Algorithms: Balancing Classical Optimization and Quantum Expressivity

Joseph John Wurtz, Tufts University, Medford, MA, 68134, United States

Recently, variational quantum algorithms (VQA) have come under intense study as a means of using tomorrow's near term quantum devices for practical quantum advantage. Under the VQA approach, solutions to combinatorial optimization problems are encoded into the Hilbert space of some variational wavefunction ansatz, then parameters are classically optimized to yield good approximate solutions. Several ansätze have been proposed, most prevalently the quantum approximate optimization algorithm (QAOA) and quantum machine learning (QML) algorithms. The QAOA uses a repeated application of two unitaries, and is exact in the infinite depth limit. However, recent results suggest that the experimentally feasible low-depth regime has poor performance due to restrictions of locality and under-expressivity. Conversely, the more general ansätze of QML algorithms has the opposite problem: by being far more expressive, they may easily access good approximate solutions, but classical optimization may be difficult through phenomena such as barren plateaus. This talk proposes a sliding scale between expressivity and classical optimization. On one side, an ansatz may have high expressivity and theoretical performance, but difficult classical optimization. On the other it may have low expressivity and performance, but easy classical optimization. In the middle, a good hybrid algorithm balances between the two. Such a "classically optimal" hybrid algorithm may best utilize both classical and quantum resources by precomputing problem instance-specific circuits to increase expressivity, and draw inspiration from classical algorithms for classically-derived guarantees. By maximally leveraging both classical and quantum resources, these algorithms may be our first instance of quantum advantage. What is left to do is a creative merger of classical optimization algorithms, and quantum variational circuits.

3 - On the Structure of DD-representable MIPs with Application to Unit Commitment

Hosseinali Salemi, Iowa State University, Ames, IA, United States, Danial Davarnia

Over the past decade, a powerful solution framework called Decision Diagrams (DDs) was introduced and successfully employed to solve integer programs. However, the question on possibility of extending DDs to model mixed integer programs (MIPs) has been unanswered. In this talk, we first address this question by providing both necessary and sufficient conditions for a general MIP to be modeled by DDs, and then present a DD-based method to model and solve general MIPs. To show the practicality of our framework, we apply it to a stochastic variant of unit commitment problem. Computational experiments show that the proposed method improves the solution times in comparison to the outcome of modern solvers.

■ SB14

CC Room 201B

In Person: Complex Systems Modeling and Decision Making

General Session

Chair: Arvind Krishna, Georgia Institute of Technology, Atlanta, GA, 30318-5599, United States

1 - Does When and How Matter? Information Disclosure Strategy in Online Crowdfunding

Yoonseock Son, University of Notre Dame, Notre Dame, IN, United States

Crowdfunding has become an important financing model to help project creators get financial support from backers at an early stage. Most of the time, product quality is unknown to the backers, and this information asymmetry issue often leads to the failure of crowdfunding campaigns. To reduce the uncertainty of the backers, project creators can disclose project updates throughout the process. This study examines when and how the information disclosure timing influences the success of the crowdfunding project. Moreover, text analysis is conducted to understand the impact of information richness and content similarity on the funding results.

2 - A Regression-optimization Framework for Sequential Decision-making

Long Vu, IBM T.J. Watson Research Center, Yorktown Heights, NY, United States, Pavan Murali

This talk focuses on system-wide planning problems, wherein regression models are used to capture the dynamic behavior of various subcomponents. We model system dynamics using piecewise linear regression models, neural networks and random forests, and formulate the planning problem as a mixed-integer linear program that can additionally consume system and flow-based constraints. We demonstrate the use of this regression-optimization framework in generating policies that optimize system output, as well as in sequentially refining the policy trajectory by controlling for prediction error propagation.

■ SB15

CC Room 201C

In Person: Advances in Data Analytics for Operations Management and Decision

General Session

Chair: Yonggab Kim Making, Purdue University, West Lafayette, IL, United States

1 - Drone Delivery Vehicle Routing Problem with Multi-Flight Level Using Gradient Boosting

Yonggab Kim, Purdue University, West Lafayette, IL, United States, Hoyoung Jung, Seok Cheon Lee

Flight level and delivery efficiency come at a tradeoff. Placing drones higher requires more time, but the higher they are, the less detour they make due to the smaller number of buildings at higher altitudes. We propose a novel vehicle routing problem and solution approach using gradient boosting for multi-flight level drone delivery which aims to minimize delivery completed time.

2 - Interpretable Control with Synthetic Models

Yuting Yuan, University of Rochester, NY, Rochester, NY, United States

In operational planning problems, organizations collect data, learn the system, and take prompt actions. We identify three potential problems: noise in data, difficulty in counter-factual analysis, and lack of interpretability. To tackle these issues, we propose a new framework that prescribes a data-driven policy regularized by a synthetic model. We demonstrate through experiments that our approach outperforms the benchmark method.

3 - A Dynamic Resilience Management for Deep-Tier Automotive Supply Networks

Elham Taghizadeh, Wayne State University, Clinton Township, MI, 48035-5630, United States

We propose methods to optimize the resilience of deep tier automotive supply networks. Research confirms that complexity across supplier tiers of automotive supply networks can lead to vastly different network resilience in comparison with simpler supply networks. We integrate network analysis techniques combined with discrete-event simulation informed by secondary data sources and global supply risk databases for improving resilience management. We also demonstrate that optimal resilience strategies across the network.

■ SB16

CC Room 201D

In Person: Data Science for Complex Data in Healthcare

General Session

Chair: Nathan B. Gaw, Georgia Institute of Technology, Atlanta, GA, United States

1 - Predicting County-level Pandemic Risk and Relevant Risk Factors Using Machine Learning

Kevin Smith, University of Michigan, Ann Arbor, MI, United States, Brian T. Denton, Siqian Shen

We aim to determine whether United States (US) counties could be classified for coronavirus disease 2019 (COVID-19)-like disease outcomes using county-level predictive factors and which of those factors are most important to the classification model. We conduct a backward variance inflation factor selection procedure to remove significant multicollinearity among county-level socioeconomic, health, and demographic characteristics. We apply random forests and logistic regression to train models to predict five unique county-level COVID-19 outcome model scenarios. We compare the results of model scenarios using the Area Under the Receiver Operating Characteristic curve performance measure and report the average of this measure across five stratified cross-validation folds. Our models classify the presence of COVID-19 cases in early outbreak scenarios with excellent discrimination. Socioeconomic factors provide the largest score increases in risk stratification of US counties.

2 - Interpreting Deep Learning Model Predictions Using Shapley Values

Jay Shah, Arizona State University, Tempe, AZ, United States ASU-Mayo Center for Innovative Imaging, Tempe, AZ, United States, Catherine Chong, Catherine Chong, Todd Schwedt, Todd Schwedt, Visar Berisha, Jing Li, Katherine Ross, Gina Dumkrieger, Jianwei Zhang, Nathan B. Gaw, Simona Nikolova, Teresa Wu, Teresa Wu

More than 2 million people are diagnosed with concussions each year and one of the most common symptoms immediately following a concussive injury is Post-Traumatic Headache. We developed a Shapley value-based approach (SHAP) on top of a Multi-layer perceptron model to interpret and examine the underlying clinical features responsible for the classification of Post-Traumatic Headache vs Healthy control patients. The method is able to provide subject-level examination and interpretation.

3 - A Hybrid Computer Simulation Approach to Manage No-Shows in Primary Care Operations

Ammar Abdul Motaleb, University of Texas-Arlington, Arlington, TX, United States, Amith Viswanatha, Yuan Zhou, Yan Xiao, Kay Yut Chen, Ayse Gurses, PROMI S. Lab Investigators

Patient no-show and late cancellation disrupt the exasperated primary care operations. This practice has adverse ramifications such as decreased clinic resources utilization, increased healthcare costs, among others. To examine the impacts of such disruption on clinic operations and patient satisfactions, this study develops a hybrid computer simulation model that integrates discrete-event simulation (DES) and agent-based simulation (ABS) to represent the flow of patients and micro-level behaviors of clinic personnel. Further, this study designs a set of computer experiments to evaluate the effectiveness of various no-show handling strategies and sheds some lights on its implications in primary care operations management.

4 - Prediction of Inpatient Disaggregate Length of Stay for Heterogeneous Demand Using Machine Learning Algorithms and Survival Analysis

Jorge Andrés Acuña, University of South Florida, Tampa, FL, United States, Jose L. Zayas-Castro, Weimar Ardila

In the last decades, there has been increased interest in machine learning algorithms and survival analysis to improve hospital performance. Accurate prediction of patient length of stay is a critical metric for healthcare providers and hospital decision-makers. In this talk, we present a framework of prediction models to estimate patients' disaggregate length of stay. We also study the relationship between the total length of stay and the admission to different care units, such as ICU. Our results provide insights on how to mitigate admission to intensive units and improve patient access to care.

■ SB17

CC Room 202A

In Person: Robustness of Neural Networks

General Session

Chair: Somayeh Sojoudi, University of California-Berkeley, Berkeley, CA, 94530, United States

Chair: Brendon Anderson, University of California-Berkeley, Berkeley, CA, 94709-1543, United States

1 - Convex Formulation of Robust Two-layer Neural Network Training

Yatong Bai, University of California-Berkeley, Berkeley, CA, United States, Tanmay Gautam, Yu Gai, Somayeh Sojoudi

Recent work has shown that the training of a two-layer, scalar-output fully-connected neural network with ReLU activations can be reformulated as a finite-dimensional convex program. Leveraging this result, we derive convex optimization approaches to solve the "adversarial training" problem, which aims to train neural networks that are robust to adversarial input perturbations. These convex problems are derived for the cases when hinge loss and squared loss between the network output and the target are used to calculate the training cost. Our work provides an alternative adversarial training method over the current approximation methods, such as Fast Gradient Sign Method (FGSM) and Projected Gradient Descent (PGD). We demonstrate in different experiments that the proposed method achieves higher adversarial robustness than existing training methods.

2 - A Closer Look at Accuracy vs. Robustness

Yao-Yuan Yang, University of California, San Diego

Current methods for training robust networks lead to a drop in test accuracy, which has led prior works to posit that a robustness-accuracy tradeoff may be inevitable in deep learning. We take a closer look at this phenomenon and first show that real image datasets are actually separated. With this property in mind, we then prove that robustness and accuracy should both be achievable for benchmark datasets through locally Lipschitz functions, and hence, there should be no inherent tradeoff between robustness and accuracy. Through extensive experiments with robustness methods, we argue that the gap between theory and practice arises from two limitations of current methods: either they fail to impose local Lipschitzness or they are insufficiently generalized.

3 - Data-Driven Certification of Neural Networks with Random Input Noise

Brendon Anderson, University of California-Berkeley, Berkeley, CA, 94709-1543, United States

A novel robustness certification method is introduced that lower-bounds the probability that neural network outputs are safe when the input is subject to random noise from an arbitrary probability distribution. The bound is cast as a chance-constrained optimization problem, which is then reformulated using input-output samples to make the optimization constraints tractable. We develop sufficient conditions on the number of samples needed to make the robustness bound hold with overwhelming probability, and we show for a special case that the proposed optimization reduces to an intuitive closed-form solution. Synthetic, MNIST, and CIFAR-10 case studies experimentally demonstrate that this method is able to certify robustness against various input noise regimes over larger uncertainty regions than prior state-of-the-art techniques.

■ SB18

CC Room 202B

In Person: Energy Systems Integration (Macro-Energy Systems)

General Session

Chair: Wilson Ricks, Princeton University, Princeton, NJ, United States

1 - Modeling Potential Roles for Nuclear Power in Microgrid Settings with Integrated Heat and Power Systems

Ruaridh Macdonald, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, John E. Parsons

Small nuclear reactors, with 10MWe output or less, have been proposed for deployment in remote communities. Their reliability and ability to provide combined heat and power at high temperatures could potentially reduce energy costs and emissions. However, there is uncertainty about the range of circumstances for which this is true. In this work, we extended the GenX capacity expansion model to be able to optimize integrated heat and electricity systems. We then used this to investigate the impact of introducing small nuclear reactors to several representative Alaskan communities with a variety of heat and electricity demand profiles and degrees of integration between the two.

2 - The Impact of Flexible Operations and Energy Storage on the Long-term Deployment Potential of Enhanced Geothermal Systems

Wilson Ricks, United States

Enhanced Geothermal Systems (EGS) are an emerging energy technology with the potential to provide clean, firm electricity generation across much of the western United States. While EGS has traditionally been envisioned as providing baseload power, these systems are in fact capable of operating flexibly by storing energy as pressure within the engineered subsurface reservoir. Past work has shown that this flexibility can deliver significant additional value. In the present work, we develop novel approach by which constraints describing the unique flexible geothermal technology can be incorporated into the GenX electricity systems optimization model. Analysis indicates that flexible operations can significantly increase the deployment of EGS power in the Western Interconnection and reduce total system costs.

■ SB19

CC Room 203A

In Person: Interface between Healthcare and Criminal Justice/Learning in Healthcare

General Session

Chair: Pengyi Shi, Purdue University, West Lafayette, 47907, United States

1 - Causal Inference with Selectively Deconfounded Data

Kyra Gan, Carnegie Mellon University, Forbes Avenue Tepper School Of Business Center Dr, Pittsburgh, PA, 15205, United States, Andrew Li, Zachary Lipton, Sridhar R. Tayur

We consider the benefit of incorporating a large confounded observational dataset (confounder unobserved) alongside a small deconfounded observational dataset (confounder revealed) when estimating the Average Treatment Effect (ATE). We show that the inclusion of confounded data can significantly reduce the quantity of deconfounded data required to estimate the ATE to within a desired accuracy level. Moreover, when we could retrospectively select samples to deconfound, we demonstrate that by actively selecting these samples based upon the (already observed) treatment and outcome, we can reduce our data dependence further. Our theoretical results establish that the worst-case relative performance of our approach (vs. a natural benchmark) is bounded while our best-case gains are unbounded. We perform extensive experiments to validate our theoretical results.

2 - From Data to Prescriptions: An Optimization Framework for Treatment Personalization

Holly Mika Wiberg, Massachusetts Institute of Technology, Cambridge, MA, 02144-2603, United States, Dimitris Bertsimas

Personalized treatment involves several complex decisions, particularly in the presence of multiple treatment options and continuous dosages. We propose a joint machine learning and optimization framework for treatment prescriptions, in which we leverage ML to learn treatment effects from data and formulate a mixed-integer programming model to identify promising regimens from the ML models. The approach generalizes to multiple treatment objectives and risk tolerances, as well as additional clinically-derived constraints. We demonstrate the method in chemotherapy as well as chronic disease management.

3 - Prioritizing Substance Abuse Treatment in Community Corrections Centers.

Iman Attari, Indiana University, Bloomington, IN, United States
Pengyi Shi, Jonathan Eugene Helm, Nicole Adams

With overcrowding becoming more common in correctional centers due to the increasing trend in substance abuse, it is becoming increasingly important to take measures to prevent relapse and recidivism for community corrections clients. Although different treatment options have been found to be effective, particularly for clients suffering from substance use disorder, correctional organizations have a limited budget to deploy these interventions. In this study, we propose a modeling framework to support substance abuse treatment prioritization decisions in community corrections centers. Specifically, we propose a Markov Decision Process modeling framework for identifying the timing and target of treatment interventions among community corrections clients, capturing the resulting impact on overcrowding and societal benefits from client recovery.

■ SB20

CC Room 203B

In Person: Capacity Management in Healthcare and Care Coordination in Health Systems

General Session

Chair: Christos Zacharias, University of Miami, Coral Gables, FL, 33146-2000, United States

Chair: Salar Ghamat, Wilfrid Laurier University, Waterloo, N2L 3C5, Canada

1 - Dynamic Inter-day and Intra-day Scheduling

Christos Zacharias, University of Miami, Coral Gables, FL, 33146-2000, United States, Nan Liu, Mehmet A. Begen

We present novel theoretical results and the first tractable optimization framework for the dynamic inter-day and intra-day scheduling problem. In our analysis we built upon the findings of Truong (2015) and Zacharias and Yunes (2020), we prove theoretical connections between them, and we prove novel results in discrete convex analysis regarding constrained multimodular function minimization. We leverage these novel results and dynamic programming tools to characterize an optimal policy. We derive theoretical upper and lower bounds for the problem, based on which we develop a heuristic solution with a theoretically guaranteed optimality gap. The gap is demonstrated numerically to be less than 1% for practical instances of the problem.

2 - Influencing Primary Care Antibiotic Prescription Behavior Using Financial Incentives

Salar Ghamat, Wilfrid Laurier University, Waterloo, ON, Canada, Mojtaba Araghi, Lauren Cipriano

Antibiotic resistance is an ongoing public health crisis that is escalated by overuse and misuse of antibiotics. The goal of this paper is to examine the impact of incentive payments on reducing inappropriate antibiotic prescription. We develop a stylized physician compensation model to study the interaction between a payer that aims to reduce social harm from antibiotic resistance, and a provider who makes antibiotic prescription decisions for heterogeneous patients. We show that when there is no information asymmetry between the parties, an incentive payment can achieve the first-best policy even when incentive payments affect diagnosis behaviour of the provider. However, when the payer does not know the costs incurred by the provider the first-best policy is not possible when incentive payments affect provider's diagnosis behaviour.

■ SB21

CC Room 204A

In Person: Empirical Research in Emerging Services

General Session

Chair: Kejia Hu, Vanderbilt University, Nashville, TN, 37215-1710, United States

1 - Caring for an Aging Population in a Post-pandemic World: Emerging Trends in the U.S. Older Adult Care Industry

Matthew Walsman, Rutgers Business School, Berkeley Heights, NJ, 07922-2110, United States, Lu Kong, Kejia Hu

This paper examines older adult care services during the outbreak of the COVID-19 global pandemic. We investigate emerging trends initiated or accelerated by the pandemic and predict their permanence in a post-pandemic world. We collected primary empirical data from both older adult care providing organizations (supply) and individuals receiving or considering care (demand) in the United States. We also collect qualitative data from various sources to supplement our quantitative surveys.

2 - Westore or Appstore: Customer Behavior Differences in Mobile Apps and Social Commerce

Kejia Hu, Vanderbilt University, Nashville, TN, 37215-1710, United States, Nil Karacaoglu

Social commerce is rapidly growing and attracting new customer segments. This channel is different from traditional retail channels in that it relies on peer-to-peer communication for product discovery in a social media platform. We examine customer behavior and search patterns in an emerging social commerce channel, namely the WeChat mini-programs, and in retailers' native apps. We find that WeChat customers have higher fixed search costs yet smaller marginal search costs compared to App customers. Moreover, customer characteristics such as their user level and time of search impact search costs. We propose two channel-specific strategies that leverage customers' search costs differences across channels. Both strategies can significantly increase conversion rate and profit for retailers.

3 - Trips for Tips? An Investigation of the Role of Passengertips in Drivers' Relocation Decision-making Process

Li Ding, Georgia Tech, Atlanta, GA, United States, Basak Kalkanci

Using a large-scale and granular taxi trip dataset and structural estimation, we analyze the role of passenger tips in drivers' relocation decision-making process. We show heterogeneous sensitivity to tips among new and experienced drivers, drivers below and above the income target. Through counterfactual analysis, we find that although increasing tip salience improves drivers' income, it also reduces platform efficiency.

■ SB22

CC Room 204B

In Person: Optimization and Model-based Approaches to Genetic Screening and Genetic Decision Making

General Session

Chair: Kanix Wang, University of Chicago Booth School of Business, Chicago, IL, 60637-6877, United States

1 - Optimal Genetic Screening for Cystic Fibrosis

Hussein El Hajj, Virginia Tech, Blacksburg, VA, 24061-1019, United States, Ebru Korular Bish, Douglas R. Bish

Cystic fibrosis is among the most prevalent life-threatening genetic disorders. Early diagnosis improves quality of life and reduces healthcare expenditures. Most cystic fibrosis newborn screening processes start with a bio-marker test; followed by a genetic test, ending with diagnostic testing, which corrects false positives. On the other hand, a false negative represents a missed cystic fibrosis diagnosis. An important decision is which variants to include in the screening panel to reduce the false negative probability under a testing budget. We develop novel stochastic optimization models, and identify key structural properties of optimal panels, and use these properties to develop efficient algorithms.

2 - Enhancing Field Trials of Genetically Modified Organisms with Optimization

Valeri Vasquez, Berkeley, Berkeley, CA, United States

Optimization is crucial to defining effective deployment strategies for genetically engineered mosquitoes (GEMs). These transgenic organisms are designed for use as public health interventions; release details can be calibrated to save on implementation costs, to avoid the ecological consequences of excessive deployments, or to mitigate the potential epidemiological shortcomings of inadequate scheduling. I develop a nonlinear mathematical program to optimize field trial deployments of GEMs in a variety of environmental contexts. The model incorporates realistic resource constraints and ecological data and is parameterized by laboratory-informed genetic inheritance patterns.

■ SB24

CC Room 205A

In Person: Transformation of Urban Mobility and Its Implications

General Session

Chair: Hale Erkan, United States

1 - Toward Sustainable Cities: Bike Lane Planning with Endogenous Demand and Traffic Congestion

Jingwei Zhang, University of California-Los Angeles, Los Angeles, CA, 90024-7212, United States, Sheng Liu, Auyon Siddiq, Keji Wei

We study an urban bike lane planning problem considering endogenous demand and traffic congestion. Building bike lane attracts commuters to cycling and reduces traffic congestion, but narrows driving lanes and worsens traffic congestion. To investigate the net effect of bike lane construction on traffic congestion and improve cycling adoption, we formulate the network design problem as a bilevel programming problem. As model input, we structurally estimate travel time and mode choice model based on traffic equilibrium using data collected from multiple sources in downtown Chicago. As a result, we provide prescriptions on bike lane construction in the existing road network.

2 - Free Rides in Dockless, Electric Vehicle Sharing Systems

Bobby Nyotta, UCLA Anderson School of Management, 25369 Avenida Ronada, Los Angeles, CA, 91355-3203, United States, Fernanda Bravo, Jacob Feldman

We study free-ride policies as a mechanism to incentivize users of a dockless or free-floating electric vehicle sharing system (EVSS) to park vehicles at charging stations in order to maintain a charged fleet.We develop an infinite horizon dynamic program to analyze free-ride policies. We build on this initial formulation to construct a mixed-integer program that outputs intuitive, battery-threshold rules for when to offer free rides.In a discrete-event simulation model using real data from an EVSS, we compare the performance of this simple policy against other sophisticated policies, including the commonly used fine-based policy. Our simulation reveals this three-dimensional trade-off between customer satisfaction, revenue, and operational complexity. Our results are robust under many demand patterns and under a variety of network settings.

■ SB25

CC Room 205B

In Person: Sharing Economy and Green Technology/Volunteer Management Policies

General Session

Chair: Kamalini Ramdas, London Business School, London, NW1 4SA, United Kingdom

1 - Competitive Industry's Response to Environmental Taxation for Green Technology Adoption

Anton Ovchinnikov, Queen's University, Smith School of Business, Kingston, ON, Canada, Dmitry Krass

We consider market response to environmental taxes by firms producing a commodity good with a polluting by-product. The firms are asymmetric (heterogeneous) with respect to production efficiency and pollution control technology. Cournot (quantity) competition is assumed and two demand functions are considered: iso-elastic and linear. In this setting, two kinds of responses are considered: market response, where firms choose production quantities given their technology choices, and technology response, where firms also choose among a discrete set of available pollution abatement technologies. We are mainly interested in examining the limitations of using environmental taxes as a mechanism to incentivize "green" technology choice.

2 - Nonprofit Operations: Managing Volunteers and Paid Workers

Lei Li, Purdue University, West Lafayette, IN, United States, Gemma Berenguer, William Haskell

Nonprofit organizations run a workforce composed of a mix of volunteers, part-time workers, and full-time workers. We study this NPO's staffing problem to determine the optimal initial staff planning and per period hiring and assignment decisions given uncertain supply of volunteers and part-time workers. Our goal is to study how to solve this problem in a way that is effective and easy to implement. We demonstrate that a prioritization assignment policy and a hire-up-to policy for part-time workers can be conveniently applied and are close to optimal. These policies are, in fact, optimal under staff scarcity and staff sufficiency. We further suggest two easy-to-implement heuristics and observe that both heuristics have low relative optimality gaps.

■ SB28

CC Room 207B

In Person: Exploiting Structure in Zeroth-order Optimization

General Session

Chair: Daniel Mckenzie, University of California, Los Angeles, United States

Chair: HanQin Cai, University of California, Los Angeles, United States

1 - Curvature-Aware Derivative Free Optimization

Bumsu Kim, University of California-Los Angeles, Los Angeles, CA, United States

In this work, we present new algorithms for derivative-free optimization which exploit approximate curvature information. The first algorithm, coined Curvature-Aware Random Search (CARS), uses an estimate of the curvature along a search direction to approximate the optimal step size in the given direction. Furthermore, we propose a novel stochastic estimator of the Hessian inverse to construct a new search direction whose expectation is parallel to the Newton vector. This estimator is employed by our second algorithm, coined Stochastic Hessian Inverse Projected Search (SHIPS), to yield a derivative-free approximation to Newton's method. We benchmark CARS and SHIPS on the MuJoCo control problems and the adversarial attack. The numerical results compare favorably with the other state-of-the-art methods.

2 - Zeroth-order Regularized Optimization (ZORO): Approximately Sparse Gradients and Adaptive Sampling

HanQin Cai, University of California-Los Angeles, Los Angeles, CA, United States

We consider the problem of minimizing a high-dimensional objective function, which may include a regularization term, using only (possibly noisy) evaluations of the function. Such optimization is also called derivative-free, zeroth-order, or black-box optimization. We propose a new Zeroth-
Order Regularized Optimization method, dubbed ZORO. When the underlying gradient is approximately sparse at an iterate, ZORO needs very few objective function evaluations to obtain a new iterate that decreases the objective function. Under a novel approximately sparse gradient assumption and various different convex settings, we show the convergence rate of ZORO is only logarithmically dependent on the problem dimension. Numerical experiments show that ZORO outperforms existing methods with similar assumptions, on both synthetic and real datasets.

■ SB29

CC Room 207C

In Person: Advances in Resource Allocation under Uncertainty

General Session

Chair: Sebastian Perez-Salazar, Georgia Institute of Technology, GA, United States

Chair: Alfredo Torrico, Polytechnique Montreal, Montreal, QC, H2V 4G9, Canada

1 - Order Fulfillment under Pick Failure in Omnichannel Ship-from-store Programs

Sagnik Das, Carnegie Mellon University, Pittsburgh, PA, United States, R. Ravi, Srinath Sridhar

We consider the order fulfillment problem in omnichannel retailing, where in-store and online demand channels cause inventory inaccuracy leading to pick failure at stores. We propose order fulfillment models for every sparse/dense combination of online and in-store demands to optimize labor, shipping, cancellation, and lost-sales costs while accounting for pick failure at stores. We establish structural results for our models and exploit them to optimize over fulfillment policies efficiently. We demonstrate the value of modeling pick failure on data from our collaborating solutions provider to top North American omnichannel retailers.

2 - Multiagent Assortment Optimization in Sequential Matching Markets

Alfredo Torrico, Polytechnique Montreal, Montreal, QC, H2V 4G9, Canada, Margarida Carvalho, Andrea Lodi

We study a general version of the two-sided sequential matching model. The setting is the following: we (the platform) offer a menu of suppliers to each consumer. Then, every consumer selects, simultaneously and independently, to match with a supplier or to remain unmatched. Suppliers observe the subset of consumers that selected them,and choose either to match a consumer or leave the system. Finally, a match takes place if both the consumer and the supplier sequentially select each other. Each agent's behavior is probabilistic and determined by a regular discrete choice model. Our objective is to choose an assortment family that maximizes the expected revenue of the matching. We show several provable guarantees for the general model, which in particular, significantly improve the approximation factors previously obtained.

3 - Adaptive Bin Packing with Overflow

Sebastian Perez Salazar, Georgia Institute of Technology, Atlanta, GA, 30309-4245, United States

Driven by the allocation of VMs into servers, we consider the online problem of packing items with random sizes into unit-capacity bins. Upon an item's arrival, it's actual size is unknown and only its probabilistic information is available to us. We must irrevocably pack the item into an available bin or pack it in a new bin. After this, we observe the item's size, and a bin overflow can occur. An overflow incurs a penalty cost and renders the corresponding bin unusable. The goal is to minimize the expected cost given by the sum of the number of opened bins and the overflow penalty. We give an algorithm with expected cost at most a constant factor times the cost incurred by the optimal packing policy when item sizes comes from an i.i.d. sequence.

■ SB30

CC Room 207D

In Person: Deep Learning for Quality Assurance in Manufacturing Systems

General Session

Chair: Xiaowei Yue, Virginia Tech, Blacksburg, VA, 24061, United States

Chair: Abdallah A Chehade, University of Michigan-Dearborn, Dearborn, MI, 48128-2406, United States

1 - Deviation-aware Segmentation and Active Landmarks Selection for 3d Printing

Weizhi Lin, University of Southern California, Los Angeles, CA, United States, Qiang Huang

In 3D printing, geometric quality control demands a reliable deviation representation. The characterization of shape deviation requires the non-rigid registration between the designed and printed products. Manual landmark detection is usually the first step to find this registration, especially for complicated shapes like teeth. To increase the efficiency, we present an automatic landmark selection method in this work. By integrating the geometric properties, a 3D shape will be first segmented via a novel density-based geodesic clustering method. Segment-wise landmarks selection is achieved through an active Gaussian process to ensure most of the landmarks' geometric information.

2 - Generalized Additive Models For Prediction and Compensation of Shape Deviation of Large-scale Additive Manufactured Products

Cesar Ruiz, University of Southern California-Los Angeles, CA, 90007, United States, Davoud Jafari, Tom Vaneker, Qiang Huang

Wire and arc additive manufacturing (WAAM) has become an increasingly economically viable way to manufacture components made of high-value materials. WAAM provides an effective method for applications involving large near-net parts with short lead times and millimeter resolution such as the aerospace and oil industries. Due to high residual stresses, current WAAM technologies have poor shape accuracy and high surface roughness, which limit the wide use of this technology in the industry. We propose a tensor product bases expansion to model both the low-order shape distortion and high-order roughness of the manufactured parts. The proposed model enables the optimal compensation of the design of the part to minimize shape distortion. Experimental validation on hollow cylinders shows the effectiveness of the proposed framework.

3 - A Collaborative Gaussian Process Regression Model for Transfer Learning of Capacity Trends Between LI-ION Battery Cells

Abdallah A. Chehade, University of Michigan-Dearborn, Hpec,Dearborn, Dearborn, MI, 48128-2406, United States, Ala Hussein

A transfer learning method is proposed for forecasting the capacity of lithium-ion battery cells. The proposed approach uses the multi-output Gaussian process regression framework to collaboratively model multiple battery cells. Besides the high prediction accuracy and robustness of the proposed method, it provides uncertainty information, and it has the capability to cross-correlate capacity trends between different battery cells. These two merits make the proposed method a very reliable and practical solution for applications that use battery cell packs with a large number of interconnected battery cells. The proposed method is derived, verified, and compared to benchmark methods on three experimental lithium-ion battery cell datasets. The results show the effectiveness of the proposed method.

■ SB31

CC Room 208A

In Person: Interpretable and Fair Machine Learning/Spatial & Temporal Analytics and Applications II

General Session

Chair: Na Zou, Texas A&M University, College Station, TX, 77845, United States

Chair: Jian Liu, University of Arizona, Tucson, AZ, 85719-0505, United States

1 - Presenter
Na Zou, Texas A&M University, College Station, TX, 77845, United States

Attribution methods have been developed to understand the decision making process of machine learning models, especially deep neural networks, by assigning importance scores to individual features. Existing attribution methods often built upon empirical intuitions and heuristics. There still lacks a general and theoretical framework that not only can unify these attribution methods, but also theoretically reveal their rationales, fidelity, and limitations. To bridge the gap, in this paper, we propose a Taylor attribution framework and reformulate seven mainstream attribution methods into the framework. Based on reformulations, we analyze the attribution methods in terms of rationale, fidelity, and limitation with three principles. Finally, we empirically validate the Taylor reformulations on benchmarking real-world datasets.

2 - Spatial-temporal Pose Estimation in Robotic Assembly Process
Yinwei Zhang, University of Arizona, Tucson, AZ, 85705-4772, United States, Jian Liu

Robotic assembly process usually relies on accurate 6-DoF (Degree of Freedom) pose estimation of the workpieces from streaming images collected by moving robots. The performance of conventional pose estimation methods based on feature extraction may not be accurate in uncertain implementation environment, such as an assembly station with noisy lighting condition. In order to achieve robust estimation, a new method is proposed based on a deep learning model. The proposed method incorporates 3-Dimension CAD models and takes the temporal correlation of consecutive images into consideration. The simulation results show that the proposed method gives improved pose estimation accuracy in the noisy manufacturing environment.

■ SB32

CC Room 208B

In Person: New Topics in Revenue Management/First-Price Auctions in Online Advertising Markets

General Session

Chair: Can Kucukgul, The University of Texas at Dallas, Richardson, TX, 75080, United States

1 - Learning in Repeated First-price Auctions
Zhengyuan Zhou, Stern School of Business, New York University, New York, NY, 10012, United States

First-price auctions have very recently swept the online advertising industry, replacing second-price auctions as the predominant auction mechanism on many platforms. This shift has brought forth important challenges for a bidder: how should one bid in a first-price auction, where unlike in second-price auctions, it is no longer optimal to bid one's private value truthfully and hard to know the others' bidding behaviors? We discuss our recent online learning based approaches to this problem, with the goal of maximizing the cumulative surplus (valuation minus the bid) over time.

2 - Contextual First-Price Auctions with Budgets
Rachitesh Kumar, Columbia University, New York, NY, United States, Santiago Balseiro, Christian Kroer

The internet advertising market is a multi-billion dollar industry, in which advertisers buy thousands of ad placements every day by repeatedly participating in auctions. In recent years, the industry has shifted to first-price auctions as the preferred paradigm for selling ad slots. A ubiquitous feature of these auctions is the presence of campaign budgets, which specify the maximum amount the advertisers are willing to pay over a specified time period. We present a new contextual model to study the equilibrium bidding strategies in first-price auctions for advertisers who satisfy budget constraints on average. We show the existence of a natural value-pacing-based Bayes-Nash equilibrium under mild assumptions, and study its structural properties. Furthermore, we generalize the existence result to standard auctions and prove their revenue equivalence.

3 - Intertemporal Pricing via Nonparametric Estimation: Integrating Reference Effects and Consumer Heterogeneity
Hansheng Jiang, University of California, Berkeley, Albany, CA, 94706-2651, United States, Junyu Cao, Zuo-Jun Max Shen

We consider intertemporal pricing in the presence of reference effects and consumer heterogeneity. Our research question encompasses how to estimate heterogeneous consumer reference effects from data and how to efficiently compute the optimal pricing policy. We propose a demand model that allows arbitrary joint distributions of valuations, responsiveness to prices, and responsiveness to reference prices among consumers. To learn consumer heterogeneity from transaction data, we use a nonparametric estimation method. We investigate the structure of optimal pricing policies and prove the sub-optimality of constant pricing policies even when all consumers are loss-averse according to the classical definition. We validate our model using real data from JD.com, a large E-commerce retailer and find empirical evidence of consumer heterogeneity.

4 - Advertisement Policies with Consumer Privacy Concerns
Shouqiang Wang, The University of Texas at Dallas, Naveen Jindal School Of Man., Richardson, TX, 75080-3021, United States, Can Kucukgul, Ozalp Ozer

The hallmark feature of digital advertisement platforms is their capability of keeping track of users' online browsing activities and using this information to personalize advertisements. Various regulations are established to grant users of these platforms the right to privacy, i.e., they can choose whether to share their personal data with the platforms for advertising purposes. Using an information design framework, we study how an online advertisement platform should design its advertisement policy under such regulatory provisions. We show that when the platform and users' incentives are sufficiently aligned, it is optimal for the platform to adopt a personalized advertisement policy. Perhaps surprisingly, when the incentives are sufficiently aligned, we find that the right to privacy may in fact reduce the overall user surplus.

■ SB33

CC Room 209A

In Person: Revenue Management in Online Matching Platforms

General Session

Chair: Siddhartha Banerjee, Cornell University, Ithaca, NY, 14853-3801, United States

1 - Dynamic Matchmaking on Gaming Platforms
Judy Gan, Columbia University, New York, NY, 10027-6945, United States, Yash Kanoria, Will Ma

We consider a dynamic matching model for gaming platforms. Players arrive stochastically with a skill attribute, the ELO rating. The distribution of ELO is known but the individual's rating is only observed upon arrival. Matching two players with different skills incurs a match cost. The goal is to minimize a weighted combination of waiting cost and match cost in the system. We investigate a popular heuristic in industry, the Bubble algorithm. The algorithm places arriving players on the ELO line with a growing bubble around them. When two bubbles touch, the two players get matched. We show that, with the optimal bubble expansion rate, the Bubble algorithm achieves a constant factor ratio against the offline optimal cost when the match cost (resp. waiting cost) is a power of ELO difference (resp. waiting time). We use data from a gaming start-up to validate our approach.

2 - A Fluid Approximation for a Matching Network with Reneging
Angelos Aveklouris, The University of Chicago Booth School of Business, Chicago, IL, 60637-1610, United States, Amy R. Ward

Motivated by service platforms, we study a two-sided network where heterogeneous demand and supply arrive randomly over time to get matched and may be lost if forced to wait too long for a match. We develop a fluid model that approximates the evolution of the stochastic model and it is shown that a fluid-scaled state descriptor approaches a solution of the fluid model. Moreover, we study the long-run behavior of a fluid model solution by characterizing the invariant points and showing that a fluid model solution approaches an invariant point in the steady-state. Further, the fluid and steady-state limits can be interchanged. When matches have different values and letting demand and supply wait be costly, we propose a matching policy and show that it is asymptotically optimal on the fluid scale.

3 - Capacity Scaling Augmented with Unreliable Machine çLearning Predictions

Daan Rutten, Georgia Institute of Technology, Atlanta, GA, çUnited States

Modern data centers suffer from immense power consumption. As a result, data center operators have heavily invested in capacity scaling solutions, which dynamically deactivate servers if the demand is low and activate them again when the workload increases. We analyze a continuous-time model for capacity scaling, where the goal is to minimize the weighted sum of flow-time, switching cost, and power consumption in an online fashion. We propose a novel algorithm, called the Adaptive Balanced Capacity Scaling (ABCS) algorithm, that has access to black-box machine learning predictions. ABCS aims to adapt to the predictions and is also robust against unpredictable surges in the workload. In particular, we prove that the ABCS algorithm is (1 +)-competitive if the predictions are accurate, and yet, it has a uniformly bounded competitive ratio even if the predictions are completely inaccurate.

4 - Presenter

Siddhartha Banerjee, Cornell University, 229 Rhodes Hall, Ithaca, NY, 14853-3801, United States, Sean Sinclair

■ SB34

CC Room 209B

In Person: Simulation-I

General Session

Chair: Raghu Pasupathy, Purdue University, West Lafayette, IN, 47907-2067, United States

1 - Encouraging Modal Shift Through Green Technologies: çA Multiobjective Simulation Optimization Approach

Sebastian Rojas Gonzalez, Postdoctoral Research Fellow, Hasselt University, Hasselt, Belgium, and Postdoctoral Research Fellow, Ghent University, Ghent, Belgium, Maximiliano Udenio, Hamed Jalali, Inneke Van Nieuwenhuyse

In this work we consider the problem of inland multimodal transportation of perishable goods involving multiple stakeholders (ports, carriers, and shippers), whose interests are in conflict. We model the problem as a multiobjective optimization, where both financial and sustainability considerations drive the decision making. In particular, we investigate the effect of introducing a green technology for inland barge transport, aimed at increasing modal shift from trucks to barges by lowering the carbon footprint of the latter. As the problem is highly stochastic and analytically intractable, we propose to use a novel multiobjective simulation optimization algorithm to seek for solutions that not only reveal the essential trade-offs, but also account for the intrinsic noise in the observed performance.

2 - Confidence Sets for Parameters Estimated from Time Series

Raghu Pasupathy, Purdue University, Department of Statistics, West Lafayette, IN, 47907-2067, United States, Peter W. Glynn

We present a procedure for constructing confidence sets using time series data on a "parameter" residing in a metric space. Application contexts include quantile field estimation, nonhomogeneous Poisson process rate estimation, parameter estimation for an ARMA(p,q) process, and stochastic optimization. Since dependence is an important complication to contend, the main instrument that enables the confidence set construction is batching. We detail several set estimators whose weak convergence to what we call OB Type statistics depends on the nature and extent of data batching. In demonstrating the approach's breadth, we include numerical illustrations on constructing confidence sets in diverse contexts. We also present tables for OB Type distributions analogous to the classical Student's t distribution.

■ SB35

CC Room 210A

In Person: Advances in Material Handling/Stochastic Optimization

General Session

Chair: Ali Tolooie, Manhattan, KS, 66502, United States

1 - Combining Predictive and Prescriptive Techniques for Optimizing Electric Vehicle Fleet Charging

Ehsan Mahyari, Ph.D. Student in Operations Management, The University of Alabama, Tuscaloosa, AL, United States

We develop a rolling-horizon approach that combines predictive models and traditional optimization techniques for minimizing the charging cost of an electric vehicle fleet. We use predictive models to account for the uncertainty in vehicle arrivals. The underlying mathematical programming model is NP-hard. Thus, we develop a simple heuristic to generate initial feasible solutions for a problem instance and use the heuristic to warmstart the mathematical programming model. Experiments based on data for a real mass transit fleet suggest that our approach offers benefits with respect to cost and grid sustainability.

2 - Stochastic Models for Optimizing Unmanned Aerial Vehicle Delivery on Last-mile Logistics

Ali Tolooie, Kansas State University, Manhattan, KS, United States, Ashesh Kumar Sinha

We propose a two-stage stochastic mixed-integer programming model to design a reliable and efficient supply chain network. The proposed network includes charging stations to extend the delivery coverage of drones. We handle stochasticity in the problem by developing Markov decision process models that evaluate tradeoffs between the number of batteries and drones in the last-mile logistics system. To overcome difficulties computationally, we propose different novel decomposition-based approaches for each problem to provide an exact analysis for our logistics network.

■ SB36

CC Room 210B

In Person: Using Health Data to Inform Decision Making

General Session

Chair: Pooyan Kazemian, Case Western Reserve University, Cleveland, OH, 44114, United States

1 - Mining Temporal Patterns for Prediction a Mixed-integer Programming Approach

Farzaneh Mansourifard, Oregon State University

Temporal patterns are sets of feature abstractions sequenced by the time that can be used as variables in prediction models. The current state of the art is to select those pattern defining parameters independent to the construction of the prediction model. In this work, we propose a mixed-integer programming framework to determine optimal pattern defining parameters and prediction model coefficients simultaneously.

2 - Site Reassignment for Mobile Outreach Teams: Investigating the Effectiveness of Decentralized Decision-making

Lisanne van Rijn, PhD Candidate, Erasmus School of Economics, Rotterdam, Netherlands, Harwin de Vries, Luk N. Van Wassenhove

To improve access to healthcare, mobile outreach teams of healthcare workers visit remote sites to provide healthcare services. Dynamics in demand and supply cause once rational site-to-team assignment decisions to become suboptimal. This paper considers the problem to reassign sites to maximize effectiveness. Outreach teams commonly have much decision-making autonomy, but reassignment requires coordination. To study whether and when a decentralized approach is effective, we examine the trade-off between centralization and effectiveness and study how design choices and information gaps induced by centralization affect this trade-off. We use empirical data from six country outreach programs of NGO MSI Reproductive Choices. Our results suggest that simple decision-making systems, when properly designed, tend to perform close to centralized decision-making.

3 - Periodic Vaccination Against SARS-CoV-2: Some Projections for the United States

Jade Xiao, Georgia Institute of Technology, Atlanta, GA, United States, Turgay Ayer, Jagpreet Chhatwal

With the U.S. nearing the end of its inaugural wave of COVID-19 vaccinations, public health authorities are turning their attention to post-pandemic management. The SARS-CoV-2 virus is expected to become endemic. Given that waning immunity to the virus is highly probable, periodic mass vaccination will be necessary for continual outbreak prevention. However, the exact duration of immunity conferred by both vaccines and natural infection is still unknown, making it difficult at present to plan revaccination efforts. We model different periodic vaccination strategies within an SEIR framework based on the COVID-19 Policy Simulator (www.covid19sim.org) to assess their effect on disease burden over the next several years. This study provides qualitative conclusions to aid policymakers in post-pandemic management of COVID-19.

4 - Data-driven Adaptive Robust Optimization for Resource Sharing During a Pandemic

Pooyan Kazemian, Case Western Reserve University, Cleveland, OH, 02114-2509, United States, Esmaeil Keyvanshokooh, Mohammad Fattahy, Maryam Zokaeinikoo, Mark P. Van Oyen, Kenneth Freedberg

Amid local outbreaks of COVID-19, many US hospitals canceled elective procedures to preserve ventilator capacity for COVID-19 patients. The virus spreads at varying rates, causing demand for care to peak at different times across different regions. Hence, sharing scarce portable resources can help alleviate local capacity shortfalls. We develop a data-driven adaptive robust simulation optimization method for allocating and relocating ventilators among different regions of multiple states to satisfy demand with fewer total ventilators. We conduct a case study of sharing ventilators among regions in Ohio and Michigan during the pandemic's first peak in 2020. We demonstrate that ventilator demand could be satisfied using 22%-65% fewer ventilators with ventilator sharing than no sharing (status quo), thereby allowing hospitals to preserve more elective procedures.

■ SB37

CC Room 210C

In Person: Incentives for Collaborative Innovation

General Session

Chair: Sina Moghadas Khorasani, University of California-San Diego, San Diego, CA, 92130-2843, United States

Co-Chair: Sanjiv Erat, University of California-San Diego, La Jolla, CA, 92093, United States

Lakshmi Nittala,

1 - Optimal Feedback in Contests

Sina Moghadas Khorasani, University of California San Diego, La Jolla, CA, 92130-2843, United States, Jeffrey Ely, George Georgiadis, Luis Rayo

We derive an optimal dynamic contest for environments where the principal monitors effort through a coarse, binary performance measure and chooses prize-allocation and termination rules together with a real-time feedback policy. The optimal contest takes a stark cyclical form: contestants are kept fully apprised of their own successes, and at the end of each fixed-length cycle, if at least one agent has succeeded, the contest ends and the prize is shared equally among all successful agents regardless of when they succeeded; otherwise, the designer informs all contestants that nobody has yet succeeded and the contest resets.

2 - Best or Right? Positioning and Authentication in Online Matching Platforms

Sreekumar R. Bhaskaran, Southern Methodist University, Cox School of Bus. Dallas, TX, 75275-0333, United States, Amit Basu, Rajiv Mukherjee

A firm seeking a business partner, or an individual searching for a life partner, can use an online matching platform not only to efficiently search for available candidates, but also to address two related challenges. First, a match-seeker may not know what candidates would be compatible with them. And second, particularly in the online setting, candidates may misrepresent their credentials. In this paper, we model and analyze whether an online matching platform's decisions should enhance search with a positioning capability that helps match-seekers determine the subjective compatibility of potential matches (horizontal differentiation), and also whether it should offer an authentication service that enables match-seekers to reliably signal their objective quality (vertical differentiation).

3 - Learning and Doing in Contests

Lakshminarayana Nittala, University of Dayton, Anderson Center Dayton, OH, 45469, United States, Sanjiv Erat

Innovation contests have been studied primarily as a mechanism to obtain extreme valued solutions. In the current work we propose that the conceptualization of innovation contests needs to be expanded to also consider the long term benefits from the knowledge/capabilities generated by the contestants' efforts. We offer a novel model that explicitly includes the generation and utilization of knowledge by participants in an innovation contest and discuss implications for the design of contests.

■ SB38

CC Room 210D

In Person: Mitigating Climate Risk in the Energy Sector — Emerging Business Models and Regulatory Interventions

General Session

Chair: Joonho Bae, University of Michigan Ross School of Business, Ann Arbor, MI, 48104, United States

1 - Uncertainty in Carbon Tax Policy and its Effect on Investment in Renewable Electricity Generating Capacity

Thomas Palley, Indiana University, Bloomington, IN, United States, Asa Palley, Owen Wu

We develop a model to study the effects of carbon policy uncertainty on utility investments in renewable generation to replace carbon-intensive generating capacity. We also consider uncertainty for a policymaker in setting a price on carbon given imprecise information about the true cost of a marginal unit of emissions. Numerically, we explore our analytical findings for a representative utility in the United States. Broadly, we find that utilities invest less in renewables when uncertainty is greater, preferring to wait until future periods when the uncertainty is resolved.

2 - Investment Decisions for a Microgrid Price Dependent and Independent Demand Cases

Fariba Farajbakhsh Mamaghani, Tulane University, New Orleans, LA, United States, Metin Cakanyildirim

Traditional electric grids can be improved in terms of competition, reliability and availability of transmission capacity by building microgrids. A microgrid is a group of local generators and consumers that primarily transact with each other, buy excess demand from the grid and sell excess supply thereto. It comes in a variety of sizes and costs depending on its size. Its gains and losses from transactions with the grid are related to demand and price dependency as well as its size. Finding the optimal capacity by considering demand randomness and dependency factors is a challenge. In this paper, we provide a profit maximization formulation for a microgrid and reveal the effect of demand and price dependency on the optimal capacity and the investment decisions.

3 - Performance-Based Contracts for Energy Efficiency Projects

Ali Shantia, Toulouse Business School, Jourdain, Toulouse, 31000, France, Sam Aflaki, Roman Kapuscinski, Liang Ding

Energy Service Companies use performance-based contracts for Energy Efficiency projects. The performance of these contracts, however, is unverifiable by the clients. The achieved efficiency also encourages the client to consume more energy (the rebound effect). We show that the mentioned effects, along with the client's risk aversion, diminish the performance of such contracts; therefore, they never achieve the first-best (FB) outcomes. We define and characterize a group of piece-wise linear contracts that perform reasonably well when FB outcome is difficult to achieve.

4 - Cost-saving Synergy: Demystifying Energy Stacking with Battery Energy Storage Systems

Joonho Bae, University of Michigan Ross School of Business, Ann Arbor, MI, United States, John M. Silberholz, Roman Kapuscinski

Despite the great potential of a battery energy storage system (BESS) to an electrical grid, most stand-alone use of BESS is not economical due to its high upfront cost and batteries' limited lifespan. Energy stacking, a strategy providing more than two applications simultaneously with a single BESS, has been of great interest to improve profitability. However, some key questions remain unanswered in the literature. Using the two typical battery applications, we show that there always exists cost-saving synergy, which explains why stacking may be beneficial. This paper is the first to use analytical modeling to systematically characterize the stacking synergy and establish general lessons.

■ SB39

CC Room 211A

In Person: Food & Agriculture Supply Chain Analytics

General Session

Chair: Retsef Levi, MIT, Cambridge, MA, 02142-1320, United States

1 - Leverage Data Science to Assess Market-level Food Safety and Zoonotic Disease Outbreak Risks in China

Qihua Gao, Research Associate, Massachusetts Institute of Technology, Cambridge, MA, United States

Many zoonotic outbreaks in China (e.g., COVID-19) and significant food-safety risks have been associated with wholesale markets (WSMs) and wet markets (WMs). This first-of-its-kind work offers an alternative pragmatic approach, by showing correlation between these two types of risks. Leveraging a massive, self-constructed dataset of food safety tests, market-level food-safety risk scores are created through machine learning techniques. Analysis shows that provinces selling more animals through high-risk markets have more human cases of zoonotic flu. Additionally, specific markets associated with zoonotic disease are high-risk, and high-risk markets have more negative news stories related to management deficiencies. This approach may offer a new way of understanding zoonotic disease risks, as well as informing regulatory approaches to reduce them.

2 - Informal Cross-border Trade in Africa: Operations, Policy, and Opportunities

Karthik Murali, Oregon State University, Corvallis, OR, 97331, United States, Michael Lim, Jimin Park

Informal cross-border trade (ICBT) refers to illegal activities of cross-border commerce conducted by unregistered small-scale traders. While ICBT is a customary trading practice pervasive in most countries in Africa, local governments exert costly effort to prohibit such activities due to concerns of public safety and shrinking tax revenues. We examine the operations, policy implications, and the key market dynamics of the ICBT process. Guided by UN directives, we also propose alternative trading schemes and policy guidelines to improve the welfare of various stakeholders in this context.

3 - Understanding and Preventing Avian Influenza Outbreaks in Live Poultry Markets in China

El Ghali Ahmed Zerhouni, MIT, Cambridge, MA, 02141, United States, Retsef Levi, Nicholas J. Renegar

Highly Pathogenic Avian Influenza (HPAI) is widely considered to be a potential source for the next global pandemic. Here we analyze China's poultry supply chain and present an epidemiological model to explain the central role of live poultry markets in HPAI outbreaks. We find that even with negligible infection rates at the farms level, environmental infection can produce disease amplification within markets, thus explaining empirical observations about HPAI outbreaks and disease rates that have not been explained in previous models. Our results imply that sanitation and other interventions targeted at lowering the environmental infection within markets could significantly lower the likelihood of future HPAI outbreaks.

■ SB40

CC Room 211B

In Person: Empirical Operations Management Job Market Candidates

General Session

Chair: RJ Niewoehner, UNC Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States

1 - Mitigating the Negative Effects of Customer Anxiety through Access to Human Contact

Michelle A. Shell, Boston University, Dover, MA, 02030-1820, United States

Through a series of lab and field experiments, conducted in the high-anxiety domain of financial services, we document the negative effects of anxiety on customer performance and demonstrate how providing customers with access to human contact can improve customers' willingness to engage, elevate choice satisfaction and engender trust in companies.

2 - Searching for the Best Yardstick: Cost of Quality Improvements in the U.S. Hospital Industry

Jong Myeong Lim, The Wharton School, Philadelphia, PA, 19104, United States, Kenneth Moon, Sergei Savin

The Hospital Value-Based Purchasing (VBP) Program is Medicare's implementation of yardstick incentives applied to hospitals in the U.S. Under the VBP Program, 2% of all Medicare payments, estimated to be US$1.9B in FY2021, are withheld and redistributed based on relative performance in the quality of delivered care. We develop a dynamic equilibrium model in which hospitals are engaged in a repeated competition under yardstick incentives. Using structural estimation methods, we recover key parameters that govern hospitals' decisions to invest in quality improvement, including the financial and non-financial costs and uncertain outcomes of investment. Our counterfactual analyses explore the benefits, on the one hand, of modifying the overall size of the yardstick incentives and, on the other hand, of implementing a more focused program tailored to hospital type.

3 - Focusing Provider Attention: An Empirical Examination of Incentives and Feedback in Flu Vaccinations

RJ Niewoehner, UNC Kenan-Flagler Business School, McColl Building, Chapel Hill, NC, 27599, United States, Bradley R. Staats

Influenza imposes heavy societal costs through healthcare expenditures, missed days of work, and numerous hospitalizations each year. Considering these costs, the healthcare and behavioral science literature offers suggestions on increasing patient demand for flu vaccinations. And yet, the adult flu vaccination rate fluctuated between 37% and 46% between 2010 and 2019. In this paper, we investigate how to improve clinic vaccination rates by altering provider behavior. We implement and study a flu vaccine intervention among 145 clinics from 9 different states. We find clinics that received relative performance feedback outperformed all others. Moreover, we also find clinics in this group exhibit rank response behavior, specifically Last-Place Aversion. Overall, we find that clinic-level performance feedback can effectively drive operational improvement.

■ SB41

CC Room 212A

In Person: Energy Infrastructure Resilience and Economic Impacts

General Session

Chair: Mohamad Darayi, The Pennsylvania State University-Great Valley, Malvern, PA, 19355-1488, United States

1 - Enhancing Electric Power Network Resilience: Decision Making under Uncertainty

Mohamad Darayi, The Pennsylvania State University-Great Valley, Malvern, PA, 19355-1488, United States

The resilience of the electric power network is crucial for the economic productivity of the states and the broader country. This work integrates a network flow formulation with an economic interdependency model to quantify the multi-industry impacts of a disruption in the power network and proposes a decision-making model to help policymakers allocate resources under uncertainty to enhance the power network resilience.

2 - A Multiple-drones-multiple-trucks Routing Problem for Disruption Assessment

Nazanin Morshedlou (Tajik), PhD, Mississippi State University, Starkville, MS, 39769, United States, Alireza Ermagun

We propose a Multiple-Drones-Multiple-Trucks (MDMT) routing problem to assess infrastructure in the areas of disruption epicenters. The information about the number of disrupted infrastructure components, the level of disruption, and the stochasticity of disruption distribution are not entirely known. Therefore, the information collected by drones also forms the base of belief systems that guides drones to more vulnerable/disrupted areas. For large-scale problems, we propose a local search heuristic algorithm to obtain near-optimal solutions in a timely manner. The sensitivity analyses prove the efficiency of the algorithm in unknown environments.

■ SB42

CC Room 212B

In Person: Artificial Intelligence I

Contributed Session

Chair: Michael Mark, EPFL, Switzerland

1 - Creating a Self-sufficient Virtual Platform for Medical Visits For Expectant Mothers Using High-reliability Organizations and the Human-organization-technology Model

Arianne Gleiser, University of Southern California, Los Angeles, CA, United States, Nikhil Patel, Yalda Khashe

Since the COVID-19 pandemic, Digital Health has been widely adopted in several medical fields. The CDC reported a 154% increase in telehealth visits between March 2019 and March 2020, demonstrating that virtual visits are the future of medicine. Past studies show a correlation between virtual visits, High-Reliability Organizations, and Maslow's Hierarchy of Needs and create Key Performance Indicators (KPI) for these visits to be successful. We decided to create a platform that will include an appointment scheduler, virtual video, and instant messaging tool, discussion board for women, and vital monitoring software, developed with Artificial Intelligence while incorporating the latter KPIs.

2 - What Went Wrong? Signals and Mechanisms for Unintended Consequences in AI
Madhav Sharma, Oklahoma State University, Stillwater, OK, United States, David P. Biros, Corey Baham

The technologies that we have come to know as Artificial Intelligence (AI) are becoming general-purpose technologies. However, that impact has not been entirely positive. This research seeks to uncover common signals and mechanisms that lead to unintended consequences in AI. Using a grounded theory approach, we propose a unifying theoretical framework for unintended consequences in AI projects. We analysed 840 quotes from key informants about 30 unique AI cases using multiple news articles for each case. Our analysis of media discourses revealed signals of intended actions concerning the implementation of AI tools, which led to unintended consequences through various linking mechanisms.

3 - Dynamic Probabilistic Deep Learning Forecasting Models for Traffic Congestion
Pedro Cesar Lopes Gerum, Cleveland State University, Cleveland, OH, United States

We provide a new framework for the dynamic prediction of traffic density distributions using deep learning. The proposed models provide accurate transient distributions by extending and improving state-of-the-art sequential deep learning models. Moreover, they are flexible and work for both distributional and quantile forecasts. The models are validated using three different data sets, and the results suggest that the proposed models are general and can outperform an extensive list of common models for probabilistic time series forecasting.

4 - A Reinforcement-learning Approach to Credit Collections
Michael Mark, EPFL, Cugy Vd, Switzerland, Naveed Chehrazi, Thomas A. Weber

This paper develops a dynamic reinforcement-learning agent capable of finding high-quality policies for the practice of debt collections. At its core, the agent effectively learns how to control a stochastic self-exciting point process in order to maximize an asynchronously obtained reward. Because we use a general formulation of the problem as an agent-environment interaction our results are readily extensible beyond the presented application. Furthermore, with the growing need for interpretable machine-learning models we augment the learning procedure with a monotonicity regularizer which makes learned policies intuitively understandable for human decision makers.

■ SB43

CC Room 213A

In Person: Socio-economic Impacts of Digital Technology

General Session

Chair: Nils Van den Steen, Southern Methodist University Cox School of Business, Dallas, TX, 75275

1 - Dynamic Pricing to Balance On-demand Vehicle Rental Networks: Empirical Evidence from Carsharing
Karsten Schroer, University of Cologne, Cologne, Germany, Muhammed Demircan, Wolfgang Ketter

Dynamic pricing has been proposed as a theoretically appealing way to manage demand and supply imbalances that occur in on-demand vehicle rental networks. Literature on imperfect information markets and platform lock-in, however, indicates that price adjustment may fail to materially influence demand in such systems. We resolve this tension by means of a large-scale econometric investigation of transaction-level carsharing data. Our analysis of the causal effect of price on vehicle utilization paints a nuanced picture. We show that price premiums reduce vehicle utilization, while price reductions have no significant effect indicating highly asymmetric price sensitivity. Finally, we derive recommendations for improving the effectiveness of dynamic pricing policies in rental networks.

2 - The Peril of Free Product Sampling on Online Crowdfunding Platforms
Zibo Liu, University of Washington, Seattle, WA, 98105-5835, United States, Weijia You, Yong Tan

Crowdfunding market has developed fast recent years. However, the problem of information asymmetry in the market is still an issue. In this paper, we study the impact of a novel mechanism in crowdfunding market, free product sampling, on crowdfunding projects. Leveraging a rich data set from a large online crowdfunding platform in China, we construct a structural model considering both demand side and supply side of the market. We find that sampling campaign hurts crowdfunding projects in every stage of the campaign, namely Application Stage, Trial Stage, and Report Stage. Backers' strategic delay and the negative impact of revealed information on projects results in this surprising result. Our research fills the research gap of free product sampling in crowdfunding market and provides meaningful managerial implications to both fundraisers and crowdfunding platforms.

3 - Digital Technology Choices by Buyers and Sellers for Open Market Business-to-Business Transactions
Nils Van den Steen, SMU Cox School of Business, Dallas, TX, United States, Steve Muylle, Amit Basu, Willem Standaert

Firms that use digital technologies to support their transactions in an open market, where any firm can access the market as a buyer or a seller, can make those digitalization decisions independently. As a result, candidate transaction counterparties in an open market could end up missing each other or fail to realize the full benefits from their digitalization efforts because they made different choices. Based on an empirical analysis of buyer-seller dyads this study examines the relation between the technology choices by the buyer and the seller in an open market transaction and the benefits that both firms realize from their digitalization efforts.

■ SB44

CC Room 213B

In Person: Supply Chain Management and Revenue/Yield Management

Contributed Session

Chair: Sophia Huang, Vistex, Inc, Kent, WA, 98032, United States

1 - Contingency Planning for Combined Adaptation of Healthcare and Commercial Supply Chains for a Pandemic Response
Oleg Gusikhin, Ford Motor Company, Dearborn, MI, United States, Xingyu Li, Dmitry Ivanov, Kathryn E. Stecke

During the COVID-19 pandemic, severe shortages have been observed in healthcare production entailing ad hoc supply chain (SC) adaptation by using capacities of commercial companies. Time delays, high preparation efforts, and long shortage periods have been seen during these adaptations. We hypothesize that some collaborative preparedness to the contingent structural SC adaptation with development of upfront plans for combining commercial and healthcare SCs should result in higher efficiency and effectiveness. Using optimization and simulation methodology, the value of collaborative structural adaptation is examined in the context of different industrial infrastructures.

2 - Multiechelon, Multicommodity Supply Chain Design with Uncertain Demand From a Climate Change Mitigation Perspective
Reza Alizadeh, University of Oklahoma, Norman, OK, United States, Janet K. Allen, Farrokh Mistree

According to the US EPA, companies with a supply chain (SC) generate about 42% of greenhouse gas. Thus, designing a green supply chain (GSC) is a reasonable solution to mitigate climate change. To design a GSC, we model the SC as a network of customers, stores, and warehouses. The number and location of stores are determined to find a low-cost and low emission configuration. A multi-echelon, multi-commodity SC with different warehouses and stores is designed. Using socio-spatial data, demand is predicted. The multi-echelon multi-commodity supply chain distribution and inventory systems are then considered in the proposed model for different carbon policies.

3 - Strengthening the Resilience of Seaport Terminals for Disruption Management
Weimar Ardila, University of South Florida, Tampa, FL, United States, Alex Savachkin, Devashish Das, Daniel Romero

The implementation of resilience strategies is essential to ensure the regular operation of supply chains. Nonetheless, many actions that can increase resilience conflict with traditional business goals. The main research objective is to propose an initial approach for a Markov Decision Process (MDP) formulation to enhance a system's response by minimizing the cost of implementing actions that can reduce a system's total recovery time. A testbed based on the seaport terminals operation in Barranquilla (Colombia) will be used to validate and assess this approach's performance.

4 - Lift Estimates and Schedule Optimization for Trade Promotion Planning
Sophia Huang, Senior Data Scientist, Vistex, Inc., Chicago, IL, United States, Maarten Oosten

Trade promotions consist of the multi-level promotional activities of a manufacturer. The manufacturer tries to promote their products to the consumers but since the retailers are the intermediate parties that sell and promote the products they must be incentivized to execute the promotions. After all, if the promotion is not attractive for the retailer, there won't be a promotion. Therefore, the manufacturer should model the behavior of the consumers as well as that of the retailers. In this presentation we discuss the challenges this poses in both the estimation of the promotion effects as well as the optimization of the promotion schedule and propose models that address these challenges.

■ SB45

CC Room 213C

In Person: Influence of Supply Chain Practices on Emerging Economies

General Session

Chair: Sanyukta Deshpande, University of Illinois at Urbana-Champaign, Champaign, IL, United States

1 - Fair Scheduling of Heterogeneous Customer Populations

Justin Mulvany, University of Southern California, Los Angeles, CA, 90007-2558, United States, Ramandeep Randhawa

When managing congested service systems, it is common to use priority rules based on some operational criteria. In this paper, we consider the societal implications of such individual-focused priority policies, when individuals are considered as members of broader population groups. We find that optimal resource allocation policies such as the c -rule in scheduling can lead to significant inequity across different population groups. We propose policies that can mitigate this inequity and can even generate completely equitable outcomes across populations with little, or at times, even no additional system cost. Thus, we find that it can be possible to achieve more equitable outcomes while ensuring operational efficiency.

2 - Capacity Management in a Pandemic Incorporating Patient Choices and Evolving Severities

Sanyukta Deshpande, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Siddharth Prakash Singh, Lavanya Marla, Alan Scheller-Wolf

Motivated by Emergency Department (ED) operations under COVID-19, we study a medical provider that operates both an ED and a clinic in a pandemic. Patients can be COVID or non-COVID, and can belong to one of three severities. All patients enter queues after comparing their own risk perceptions for entering a queue (e.g., wait time, contagion) versus their anticipated benefits: they enter a facility with highest anticipated benefit. The hospital system's objective is to allocate service capacity across facilities and direct patients to minimize costs from loss of patients due to mortality or impatience. We model the system using a fluid approximation over multiple periods; preliminary results suggest that optimal capacity allocation trades off current high severity patients with preventative care of medium severity patients whose severity could later increase

■ SB46

CC Room 213D

In Person: Health Care, Public Health II

Contributed Session

Chair: Surya Bhaskar Ayyalasomayajula, Oklahoma State University, Stillwater, OK, 74074, United States

1 - Optimal Distribution of Mass Doxycycline Prophylaxis for Plague Control in a Resource-constrained Setting

Giovanni S.P. Malloy, Stanford University, Stanford, CA, United States, Margaret L. Brandeau

Plague has caused some of humanity's worst pandemics. Recent outbreaks have in some cases caused substantial numbers of illness and deaths. Plague control measures include insecticide to control flea populations, treatment of infected individuals with doxycycline, and doxycycline prophylaxis for uninfected individuals. We develop an analytical decision rule to determine when mass prophylaxis is cost-effective. We evaluate the decision rule performance using Monte Carlo simulations of a stochastic SEIR model and compare the performance to popular machine learning classification algorithms.

2 - Enabling Mental Healthcare Delivery to Underserved Populations: An Empirical Analysis of the Equity Advancing Effect of Mobile Apps

Yi Tang, Carlson School of Management, Minneapolis, MN, United States, Adam Moen, Kingshuk K. Sinha

The gap between the supply and demand for mental health care is raising alarms in the U.S. and around the world. Certain populations are suffering more by having significantly less-than-average treatment rates and treatment efficacy. Mobile health technologies such as mobile apps are believed to have the potential to reduce the disparities by breaking the geographical and temporal barriers and by reducing stigma through a psychologically safe environment for people in need. In this study, we document empirical evidences that mobile apps can create capacity in a mental healthcare supply chain so as to reduce the disparities associated with gender, sexual orientation, and race-ethnicity.

3 - Continually Improving Diabetes Education Based on Patients Social Media Interactions Using Text Analytics

Surya Bhaskar Ayyalasomayajula, Oklahoma State University, Stillwater, OK, United States, Dursun Delen

The pressing need for diabetes patient's education is addressing their concerns about medicines, insulin injection, and usage of glucose monitoring devices. In this paper, we employ text mining on a popular diabetes support group used by diabetes patients in UK. We find that the expert advice and education based on research and clinical trials, is not sufficient for addressing the diabetes patient concerns. We describe and evaluate a new process and decision support system for diabetes patient concerns identification and prioritization. Our findings provide insights into how text analytics can improve diabetes education for patients and healthcare providers.

Sunday, 9:45AM=10:45AM

■ Plenary - 01

CC Ballroom E /Virtual Theater 1

Plenary: Challenges and Opportunities in Crowdsourced Delivery Planning and Operations

Plenary Session

1 - Plenary: Challenges and Opportunities in Crowdsourced Delivery Planning and Operations

Martin W.P. Savelsbergh, ISyE Georgia Tech, School of Industrial and Systems Engineering, Atlanta, GA, 30332-0205, United States

Some of the most visible and impactful societal changes of the last decade are the rapid evolution of the shared and gig economy. Companies at the forefront of these changes are AirBNB and Uber. Their business models have fundamentally changed our society. We focus on one aspect of the evolving gig economy: crowdsourced delivery. How to best deliver goods to consumers has been a logistics question since time immemorial. However, almost all traditional delivery models involved a form of company employees, whether employees of the company manufacturing the goods or whether employees of the company transporting the goods. With the growth of the gig economy, however, a new model not involving company employees has emerged: crowdsourced delivery. The Oxford dictionary defines crowdsourcing as ``the practice of obtaining information or input into a task or project by enlisting the services of a large number of people, either paid or unpaid, typically via the internet''. Crowdsourced delivery, therefore, involves enlisting individuals to deliver goods and interacting with these individuals using the internet. In crowdsourced delivery, the interaction with the individuals typically occurs through a so-called platform. A prototypical example of such a platform is the one provided by Grubhub, which links restaurants, diners, and individuals willing to deliver meals from a restaurant to a diner. The platform handles everything from facilitating the ordering of meals, to the scheduling of the delivery of the meal, to the associated payments (collecting payments for meals, distributing payments to restaurants, and distributing payments to crowdsourced drivers). Importantly, the crowdsourced drivers are not employed by the platform or by the restaurants. Crowdsourced delivery has fundamentally changed the planning and execution of the delivery of goods: the delivery capacity is no longer under (full) control of the company managing the delivery. This implies that certain aspects of goods delivery that were simple and straightforward in the traditional model are no longer so simple and straightforward. How do you plan when delivery capacity is uncertain? How do you execute when delivery capacity is uncertain? How can you ensure that you meet your service promises to your customers? Does it make sense to rely on (only) crowdsourced delivery capacity? Etc. Etc. These, and many other questions will be raised and partially answered in this presentation.

Sunday, 11:00AM-12:30PM

■ SC01

CC Ballroom A / Virtual Theater 1

INFORMS TutORial Response-guided Dosing in Cancer Radiotherapy

Tutorial Session

Chair: John Gunnar Carlsson, University of Southern California, Los Angeles, CA, 90089, United States

1 - Response-guided Dosing in Cancer Radiotherapy

Archis Ghate, University of Washington, Seattle, WA, 98105, United States

The goal in radiotherapy for cancer is to maximize tumor-kill while limiting toxic effects on nearby healthy anatomies. This is attempted via spatial localization of radiation dose, temporal dispersion of radiation dose, and radiation modality selection. The spatial component involves prescribing a high dose to the tumor and putting upper limits on the dose delivered to the healthy anatomies. The radiation intensity profile is then optimized to meet this treatment protocol as closely as possible. This is called fluence-map optimization. The temporal component of the problem involves breaking the total planned dose into several treatment sessions called fractions, which are administered over multiple weeks. This gives the healthy tissue some time to recover between sessions, as it possesses better damage-repair capabilities than the tumor. The key challenge on this temporal side is to choose an optimal number of fractions and the corresponding dosing schedule. This is called the optimal fractionation problem, and has been studied clinically for over a hundred years. Radiotherapy can be

administered using different modalities such as photons, protons, and carbon ions. The choice of a modality depends on its physical characteristics and its radiobiological power to damage cells. This tutorial provides a detailed account of mathematical models that utilize the ubiquitous linear-quadratic (LQ) dose-response framework to guide decisions in the fractionation and modality selection problems. The tutorial emphasizes efficient exact solution methods developed in the last five years, and touches upon diverse methodological techniques from linear, nonlinear, convex, inverse, robust, and stochastic dynamic optimization. A brief overview of work that integrates the spatial and temporal components of the problem, and also of mathematical methodology designed to adapt doses to the tumor's observed biological condition, is included. Potential directions for future research are outlined. Since treatment decisions in this tutorial are driven by a dose-response model, it fits within a paradigm called response-guided dosing, interpreted in a broad sense.

■ SC02

CC Ballroom B / Virtual Theater 2

Hybrid Improving Rail Share of Intermodal Freight: Roundtable Discussion

Sponsored: Railway Applications

Sponsored Session

Chair: Bruce W. Patty, Veritec Solutions, Mill Valley, CA, 94941-3032, United States

1 - Improving Rail Share of Intermodal Freight
Bruce W. Patty, Veritec Solutions, Mill Valley, CA, 94941-3032, United States

This year's Roundtable focuses on opportunities to increase the rail share of Intermodal traffic in the United States. Because of the proximity of Anaheim to two of the largest ports in the United States, additional focus will be placed on increasing the rail share of Intermodal traffic that enters the country via ports. Speakers will cover such topics as: • Improving Rail transit reliability • Use of on-dock and off-dock loading facilities • Transloading opportunities • Trade-offs between trucking and rail The Roundtable will span two sessions at the Conference. Presentations will be made during the first session and the second session will be used for an interactive session with the audience where questions can be delved into more fully than in a traditional session.

2 - Panelist
Adriene Bailey, Oliver Wyman, Dallas, TX, United States

3 - Panelist
Michael Leue, Alameda Corridor Transportation Authority, Long Beach, CA, United States

■ SC03

CC Ballroom C / Virtual Theater 3

Hybrid ENRE Inaugural Harold Hotelling Medals for Lifetime Achievement

Sponsored: Energy, Natural Resources and the Environment

Sponsored Session

Chair: Alexandra M Newman, Colorado School of Mines, Colorado School of Mines, Golden, CO, 80401-1887, United States

1 - Opening Remarks on the History of the Award
Hayri Onal, University of Illinois, Urbana, IL, 61801-9015, United States

2 - Presentation of Awards Committee, Selection Process, Introductions
Alexandra M. Newman, Colorado School of Mines, Golden, CO, 80401-1887, United States

3 - Award Presenter
Benjamin Field Hobbs, Johns Hopkins University, Baltimore, MD, 21218, United States

4 - Award Presenter
Shmuel S. Oren, University of California-Berkeley, Berkeley, CA, 95708, United States

5 - Award Presenter
Andres P. Weintraub, Universidad de Chile, Santiago, 8370439, Chile

6 - Closing Remarks
Miguel F. Anjos, University of Edinburgh, Edinburgh, EH9 3FD, United Kingdom

■ SC04

CC Ballroom D / Virtual Theater 4

Hybrid MSOM Student Paper Competition I

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Vishal Agrawal, Georgetown University, Washington, DC, 20057, United States

Chair: Dragos Florin Ciocan, INSEAD, Fontainebleau, France

Chair: Yanchong (Karen) Zheng, Massachusetts Institute of Technology, Cambridge, MA, 02142-1508, United States

1 - Searching for the Best Yardstick: Cost of Quality Improvements in the U.S. Hospital Industry
Jong Myeong Lim, The Wharton School, Philadelphia, PA, 19104, United States, Sergei Savin, Kenneth Moon

The Hospital Value-Based Purchasing (VBP) Program is Medicare's implementation of yardstick incentives applied to hospitals in the U.S. Under the VBP Program, 2% of all Medicare payments, estimated to be US$1.9B in FY2021, are withheld and redistributed based on relative performance in the quality of delivered care. We develop a dynamic equilibrium model in which hospitals are engaged in a repeated competition under yardstick incentives. Using structural estimation methods, we recover key parameters that govern hospitals' decisions to invest in quality improvement, including the financial and non-financial costs and uncertain outcomes of investment. Our counterfactual analyses explore the benefits, on the one hand, of modifying the overall size of the yardstick incentives and, on the other hand, of implementing a more focused program tailored to hospital type.

2 - Optimal Pricing with a Single Point
Achraf Bahamou, Columbia University, New York, NY, 10027, United States, Omar Besbes, Amine Allouah

We study the following fundamental data-driven pricing problem. How can/should a decision-maker price its product based on observations at a single historical price? The decision-maker optimizes over (potentially randomized) pricing policies to maximize the worst-case ratio of the revenue she can garner compared to an oracle with full knowledge of the distribution of values when the latter is only assumed to belong to a broad non-parametric set. In particular, our framework applies to the widely used regular and monotone non-decreasing hazard rate (mhr) classes of distributions. For settings where the seller knows the exact probability of sale associated with one historical price or only a confidence interval for it, we fully characterize optimal performance and near-optimal pricing algorithms that adjust to the information at hand. The framework we develop is general and allows to characterize optimal performance for deterministic or more general randomized mechanisms, and leads to fundamental novel insights on the value of information for pricing. As examples, against mhr distributions, we show that it is possible to guarantee 85% of oracle performance if one knows that half of the customers have bought at the historical price, and if only 1% of the customers bought, it is still possible to guarantee 51% of oracle performance.

3 - How Does Telemedicine Shape Physician's Practice in Mental Health?
Manqi Li, University of Michigan, Ann Arbor, MI, 100091, United States, Shima Nassiri, Xiang Liu, Chandy Ellimoottil

In this work, we study whether the adoption of telemedicine has an impact on physicians' behavior in terms of scheduling related follow-up visits. We use a changes-in-changes (CIC) model to estimate the effect of adopting telemedicine on the length of the interval between two related visits, namely, the related visit interval (RVI). We show that physicians schedule related visits with shorter RVIs in the short term after adopting telemedicine. As a result, physicians can admit more patients to their panel. Thus, in the long run, adoption of telemedicine results in experiencing a heavier workload and scheduling related visits with longer RVIs. The adoption also affects the decision made during in-office visits with a decrease in RVI length in the short term and an increase in the long term. Also, physicians schedule more frequent follow-up visits after a telemedicine visit.

■ SC05

CC Ballroom E / Virtual Theater 5

Hybrid Strategies for Successfully Passing Tenure Track

Sponsored: Minority Issues Forum

Sponsored Session

Chair: Zahra Azadi, University of Miami Herbert Business School, Coral Gables, FL, 33158, United States

1 - Strategies for Successfully Passing Tenure Track
Zahra Azadi, University of Miami Herbert Business School, Coral Gables, FL, 33158, United States

The purpose of this session is to bring visibility to assistant professors on the tenure track. Panelists, including the department chair, professor, and associate professor, will share their experiences. This panel discusses the tenure process and tips for a successful promotion.

2 - Panelist
Wedad Jasmine Elmaghraby, University of Maryland, College Park, MD, 20742-1815, United States

3 - Panelist
Eduardo Perez, Texas State University, San Marcos, TX, 78666, United States

4 - Panelist
Iris V. Rivero, Rochester Institute of Technology, Rochester, NY, 14623-5603, United States

■ SC06

CC Room 303A

In Person: Humanitarian Operations and Disaster Management II

General Session

Chair: Christopher W. Zobel, Virginia Tech, Blacksburg, VA, 24061-0235, United States

1 - Improving Fuel Terminal Throughput During Natural Disasters: A Discrete Event Simulation Approach
Shraddha Rana, Massachusetts Institute of Technology, Cambridge, MA, United States, Jarrod D. Goentzel, Justin J. Boutilier

During natural disasters the increased demand for fuel is met with distribution infrastructure and processing constraints. We use discrete event simulation to model the movement of gasoline from fuel terminals to retail stations, via tanker trucks, in Florida. Our objective is to identify bottlenecks in the downstream distribution network and quantify how various interventions can increase throughput of fuel to aid hurricane evacuation and relief activities. This tool is aimed be used by policy makers to build intuition on effectiveness of response strategies. We find that by improving process rates, the existing distribution infrastructure can handle high demand without requiring additional facility locations.

2 - Game Theoretic Algorithm for Decentralized Network Restoration
Alireza Rangrazjeddi, University of Oklahoma, Norman, OK, 73019-1022, United States, Kash Barker, Andres David Gonzalez

A sustainable society critically demands a reliable interdependent infrastructure network. Due to the existence of interdependency among various networks, systems are highly sensitive to any incapacitation. Although the traditional point of view focused on optimizing critical interdependent infrastructure networks considering centralized analysis, having one actor as a decision-maker in the system is broadly biased from the actual environment. Therefore, in this study, we address the concern of having multiple decision-makers in the system with various reward functions by proposing a decentralized game theory algorithm for network restoration in post-disaster situations.

■ SC09

CC Room 303D

In Person: Applied Probability and Machine Learning

General Session

Chair: Chang-Han Rhee, Northwestern University, Chicago, IL, 60613-5364, United States

1 - A Proximal Bundle Type Method for Smooth and Nonsmooth Convex Optimization and Stochastic Programming
Jiaming Liang, Georgia Institute of Technology, Atlanta, GA, 30308-1214, United States, Renato D. C. Monteiro

This talk presents a proximal bundle (PB) method for solving convex smooth and nonsmooth composite optimization problems. Like other proximal bundle variants, PB solves a sequence of prox bundle subproblems whose objective functions are regularized composite cutting-plane models. Moreover, PB uses a novel condition to decide whether to perform a serious or null iteration which does not necessarily yield a function value decrease. Iteration-complexity bounds for PB are established for a large range of prox stepsizes. We further extend PB to the stochastic setting where the objective function only has stochastic first-order oracle. To the best of our knowledge, this is the first time that a proximal bundle variant has been shown to be effective to solve convex stochastic programming problems.

2 - Eliminating Sharp Local Minima From SGD with Truncated Heavy-Tailed Noise
Chang-Han Rhee, Northwestern University Chicago, IL, 60613-5364, United States

The empirical success of deep learning is often attributed to SGD's mysterious ability to avoid sharp local minima in the loss landscape, which are known to be associated with poor generalization. Recently, empirical evidence of heavy-tailed gradient noise was reported in many deep learning tasks; under the presence of such heavy-tailed gradient noise, SGD can escape sharp local minima, providing a partial explanation to the mystery. In this talk, we analyze a popular version of SGD where gradients are truncated above a fixed threshold. We show that this SGD is not only capable of escaping sharp local minima but also effectively eliminates sharp local minima from its training trajectory. We prove that, under appropriate structural conditions, the dynamics of this SGD with small learning rates closely resemble those of a Markov jump process that never visits any sharp minima.

■ SC10

CC Room 304B

In Person: Topics in Monte Carlo Methods and Rare Event Sampling

General Session

Chair: Michael Conroy, University of North Carolina, Chapel Hill, Carrboro, NC, 27510, United States

1 - Importance Sampling for Maxima on Trees
Michael Conroy, University of Arizona, Tucson, AZ, 27510, United States, Mariana Olvera-Cravioto, Bojan Basrak, Zbigniew Palmowski

We develop an unbiased and strongly efficient importance sampler for tail events of solutions to max-type stochastic fixed point equations that are constructed on weighted, marked Galton-Watson processes. These solutions are also describable as the all-time maximum of a branching random walk with a perturbation. The sampler is based on a representation of the tail events after a change of measure, generalizing non-branching representations that are standard in Cramer-Lundberg theory. Related to spine changes of measure often used in the branching process literature, the new measure tilts only one path of the walk, inducing a structure on the underlying branching process that suggests even more efficient algorithms to approximate tail events for branching random walks.

2 - Approximating Quasi-stationary Distributions with Interacting Reinforced Random Walks
Adam Waterbury, UC-Santa Barbara, Santa Barbara, CA, United States

We propose two numerical schemes for approximating quasi-stationary distributions (QSD) of finite state Markov chains with absorbing states. Both schemes are described in terms of certain interacting chains in which the interaction is given in terms of the total time occupation measure of all particles in the system. The schemes can be viewed as combining the key features of the two basic methods for approximating QSD originating from the works of Fleming and Viot (1979) and Aldous, Flannery, and Palacios (1998), respectively. I will describe the two schemes, discuss their convergence properties, and present some exploratory numerical results comparing them to other QSD approximation methods.

■ SC11

CC Room 304C

In Person: Fairness in Operations

General Session

Chair: Vahideh Manshadi, Yale University, Quincy, MA, 02169-4688, United States

Co-Chair: Rad Niazadeh, Chicago Booth School of Business, CA, 94305-5008, United States

Co-Chair: Scott Rodilitz, Yale, New Haven, CT, 06511-2572, United States

1 - Bias and Discrimination in Machine Learning: Automated Employment Screening as a Case Study
Manish Raghavan, Cornell University

The use of algorithmic decision-making in socially consequential domains has raised fundamental questions over what constitutes "fair" or "unbiased" decision-making. In this talk, I will situate these questions in the context of data-driven hiring decisions. I'll give an overview of how algorithms are used in hiring, discuss how vendors of algorithmic tools operationalize notions of non-discrimination, and map the legal and policy challenges in that arise in combatting algorithmic discrimination.

2 - Fairness in Hiring and Beyond
Swati Gupta, Fouts Family Early Career Professor, Georgia Institute of Technology, Atlanta, GA, 30332, United States, Jad Salem, Deven R. Desai

The introduction of automation into the hiring process has put a spotlight on a persistent problem: discrimination in hiring on the basis of protected-class status. Left unchecked, algorithmic applicant-screening can exacerbate pre-existing societal inequalities and even introduce new sources of bias; if designed with bias-mitigation in mind, however, certain group-aware interventions can be construed as illegal due to requirements of U.S. anti-discrimination law. In this work, we will focus on selection algorithms used in the hiring process (e.g., resume-filtering algorithms) given access to a "biased evaluation metric", i.e., we assume that the method for numerically scoring applications is inaccurate in a way that adversely impacts certain demographic groups. We will conclude the talk by ways to argue legal feasibility of our proposed interventions.

3 - Discrimination, Diversity, and Information in Selection Problems
Faidra Monachou, Stanford University, Stanford, CA, 94305-7224, United States

We study the role of information, access, and privilege in capacity-constrained selection problems with fairness concerns. We introduce a theoretical framework that formalizes the trade-off between the informativeness of a feature and its exclusionary nature when members of different social groups have unequal access to this feature.We extend the model to study the role that differential privilege and the correlation between skill and privilege play in discrimination.Our framework finds a natural application to recent policy debates on dropping standardized testing in admissions, soft affirmative action, and randomized admission policies.

4 - Order Symmetry of Assignment Mechanisms
Rupert Freeman, University of Virginia, Charlottesville, VA, 22901, United States, Geoffrey Pritchard, Mark Curtis Wilson

We introduce a new average-case fairness criterion, order symmetry, for assignment mechanisms. We argue for its importance, clarify its relationship to other axiomatic properties, and analyze the performance of the Top Trading Cycles (TTC), Serial Dictatorship, Naive Boston and Adaptive Boston mechanisms with respect to order symmetry. We define some basic measures of order bias, or lack of order symmetry. Low order bias is a necessary but not sufficient condition for high egalitarian welfare. We study order bias under several preference distributions and show that for sufficiently symmetric distributions, TTC is order symmetric while the other three mechanisms we consider are not.

■ SC12

CC Room 304D

In Person: AAS Best Student Presentation Competition

Award Session

Chair: Kai Wang, MIT Sloan School of Management, Boston, MA, 02215-4212, United States

1 - Trajectory Planning for Mission Survivability of Autonomous Vehicles in Moderately to Extremely Uncertain Environments
Fanruiqi Zeng, Georgia Institution of Technology, Atlanta, GA, United States, Husni R. Idris, John-Paul Clarke

In this work, we propose a receding horizon control strategy with novel trajectory planning policies that enable dynamic updating of the planned trajectories of autonomous vehicles operating in environments where potential conflicts are, from a statistical perspective, either partially known or completely unknown. The proposed policies utilize two metrics: (1) the number of feasible trajectories; and (2) the robustness of the feasible trajectories. We measure the effectiveness of the suggested policies in terms of mission survivability. Our findings have significant implications for achieving safe aviation autonomy.

2 - Traffic Management and Resource Allocation for UAV-Based Parcel Delivery in Low Altitude Urban Airspace
Ang Li, University of California-Berkeley, Berkeley, CA, 94720-2392, United States

As the development in e-commerce presents the major driver for drone-based deliveries, the need for and importance of efficiently managing UAV traffic in urban airspace is arising. This research proposes a framework of UAV system traffic management in the context of parcel delivery in low-altitude urban airspace, including clustering-based UAV path planning, systematic UAS traffic management with conflict resolution, and mechanism design for airspace resource allocation. Extensive numerical analysis is conducted with San Francisco as the case study area. Our results show the effectiveness of the proposed framework and the scalability of traffic management model.

3 - Using Submodularity Within Column Generation to Solve the Flight-to-Gate Assignment Problem
Yijiang Li, Georgia Institute of Technology, Atlanta, GA, United States, John-Paul Clarke, Santanu Subhas Dey

In this paper, we provide a column generation-based approach for solving the airport flight-to-gate assignment problem, where the goal is to minimize the on-ground portion of arrival delays. Specifically, we use a set covering formulation for the master problem and decompose the pricing problem such that each gate is the basis for an independent pricing problem. We use a combination of an approximation algorithm based on the submodularity of the underlying set and dynamic programming algorithms to solve the independent pricing problems. We also design and employ a rolling horizon method and block decomposition algorithm to solve large-sized instances.

4 - Data-Driven Robust Aircraft Assignment to Minimize Delay Propagation
Wei Liu, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27516-8361, United States, Vinayak V. Deshpande, Vidyadhar Kulkarni

We propose a new approach to reduce the delay propagation by optimizing the assignment between incoming and outgoing flights flown by an airline at a given airport. Specifically, we provide a data-driven approach to estimate the arrival delay distribution, and then derive several assignment policies based on the estimated distribution. We show that the assignments derived from the data-driven approach can offer a verifiable improvement compared to the optimal assignment (FIFO) derived in the deterministic setting by using the real data of Delta Airlines at Atlanta airport.

5 - Sequential Prediction of Flight Anomaly Using Real-time Data: A Case Study for Go-around
Lu Dai, University of California, Berkeley, Berkeley, CA, United States
Lu Dai, National Center of Excellence for Aviation Operations Research, Berkeley, CA, United States, Mark M. Hansen

Disruptions caused by flight anomaly increase the workload for operators, and leading to more developing risks. As a case study, we encapsulate predictive analytics to provide real-time sequential prediction of go-arounds by fusing multiple real-time data sources and developing learning models to estimate the probability of go-arounds near the airport. We demonstrate our framework on a real-time feed emulator and compare the performance of learning models trained on datasets with different proportions of synthetic go-around sequences which are generated by different augmenting techniques. This research accelerates predictive analytics for aviation safety in the real-time arena.

■ SC13

CC Room 201A

In Person: Optimization with Noisy Intermediate-Scale Quantum 1

General Session

Chair: Tamás Terlaky, Lehigh University, Bethlehem, PA, 18015-1518, United States

1 - A Quantum Interior Point Method for Sum of Squares Optimization

Brandon Augustino, Lehigh University, PA, United States

We present a provably convergent quantum interior point method for Sum of Squares (SOS) optimization problems, building on recent advances in quantum linear system solvers. By quantizing an IPM that solves the SOS problem directly, we are able to avoid using semidefinite optimization heirarchies which leads to a better dependence on the dimension of the problem. The quantization of classical interior point methods is the subject of several recent papers in the literature. We compare the theoretical performance of classical and quantum interior point methods with respect to various input parameters.

2 - Large-scale Inference of Sparsely-varying Markov Random Fields

Salar Fattahi, Assistant Professor, University of Michigan, Ann Arbor, MI, 94702-2147, United States, Andres Gomez

We study the problem of inferring time-varying Markov random fields (MRF), where the underlying graphical model is both sparse and changes sparsely over time. Most of the existing methods for the inference of time-varying MRFs rely on the regularized maximum likelihood estimation, that typically suffer from weak statistical guarantees and high computational time. Instead, we introduce a new class of constrained optimization problems for the inference of sparsely-changing MRFs. The proposed optimization problem is formulated based on the exact L0 regularization, and can be solved in near-linear time and memory. Moreover, we show that the proposed estimator enjoys a provably small estimation error. Our proposed method is extremely efficient in practice: it can accurately estimate time-varying graphical models with more than 500 million variables within one hour.

3 - Improving QAOA With Warm-start Initializations and Custom Mixers

Reuben Tate, Georgia Institute of Technology, Atlanta, GA, United States, Bryan Gard, Greg Mohler, Swati Gupta

In this talk, we consider bridging classical optimization techniques with quantum algorithms. We propose using classical warm-starts (obtained via solutions to low-rank semidefinite programming relaxations) in order to initialize the starting state of the Quantum Approximate Optimization Algorithm (QAOA) in the context of the MAX-CUT problem. In addition to changing the initial state, we also consider changing the mixing Hamiltonian in a way that allows us analyze QAOA through the lens of quantum adiabatic algorithms. Our experiments suggest that this modified version of QAOA is robust against quantum noise and is able to yield improved cuts over standard QAOA or the Goemans-Williamson algorithm, even with low-circuit depth and limited training time for most instances. We provide simulation and theoretical results on the performance of the proposed framework.

4 - Inexact Feasible Interior Point Method (IF-IPM) for Linear Optimization (LO) with High Adaptability to Quantum Computers

Tamás Terlaky, Lehigh University, Bethlehem, PA, 18015-1518, United States, Mohammadhossein Mohammadisiahroudi, Ramin Fakhini, Luis F. Zuluaga

Quantum computing offers Quantum Linear System Algorithms (QLSAs) to solve Newton systems in IPMs. Since QLSAs inherently produce inexact solutions, and their computational complexity heavily depends on the condition number of the Newton System, an IF-IPM is proposed for LO problems using a novel system that allows inexact computation, but warrants feasible steps. We also discuss how QLSAs can be used efficiently in an Iterative Refinement (IR) scheme to find an exact solution efficiently while using QLSAs. Our IF-QIPM enhanced with IR enjoys better time complexity than other quantum and classical IPMs w.r.t the dimension.

■ SC14

CC Room 201B

In Person: Statistical Properties of Machine Learning Methods

General Session

Chair: Namjoon Suh, Georgia Institute of Technology, Atlanta, Georgia, United States

1 - K-class Classification Problem and Properties of Convolutional Neural Nets Trained by Gradient Descent

Hyunouk Ko

Recent advances in classification problems using deep learning models have yielded state-of-the-art results in various domains. In this talk, I will first review current literature on neural networks that study their optimization and generalization properties along with their limitations such as constraints on data and network architecture. Then, I will discuss k-classification problem using the mostly widely used form of CNN and illustrate its convergence behavior when trained by (stochastic) gradient descent algorithm. I will further consider conditions under which we are in a linear regime,and how we can obtain generalization guarantees that do not rely on uniform convergence bounds.

2 - Asymptotic Theory of 1-Regularized PDE Identification from a Single Noisy Trajectory

Namjoon Suh, Georgia Institute of Technology, Atlanta, GA, United States

We prove the support recovery for a general class of linear and nonlinear evolutionary partial differential equation (PDE) identification from a single noisy trajectory using 1 regularized Pseudo-Least Squares model (1-PsLS). In any associative R-algebra generated by finitely many differentiation operators that contain the unknown PDE operator, applying 1-PsLS to a given data set yields a family of candidate models with coefficients c( ) parameterized by the regularization weight ≥ 0. The trace of {c( )} ≥0 suffers from high variance due to data noises and finite difference approximation errors. We provide a set of sufficient conditions which guarantee that, from a single trajectory data denoised by a Local-Polynomial filter, the support of c( ) asymptotically converges to the true signed-support associated with the underlying PDE for sufficiently many data and a certain range of . We also show various numerical experiments to validate our theory.

3 - Analyzing Manufacturing Variation with Complex-Structured Data

Anh Tuan Bui, Virginia Commonwealth University, Richmond, VA, 23284, United States, Daniel Apley

We present a dissimilarity-based manifold learning framework for discovering unknown systematic variation sources from complex manufacturing data structures. Visualizing individual variation patterns based on the learned manifold provides diagnostic information on the root causes of the variation sources. We discuss two applications of the framework for stochastic textured surfaces (e.g., material microstructures) and unstructured point clouds.

4 - Q-learning for Online Nonparametric Monitoring of High-dimensional Heterogeneous Data Streams

Haoqian Li, PhD Student, University of Wisconsin-Madison, Madison, WI, United States

High-dimensional data streams are becoming common in various applications nowadays. Meanwhile, the resource constraints often restrict the observability of data streams which poses challenges for statistical process control and quality improvement. In this article, we propose an algorithm based on Q-learning to monitor and quickly detect abnormalities occurring to heterogeneous data streams in the context of limited resources, where only a subset of observations is available at each acquisition time. In particular, we integrate Q-learning with a global threshold learned through a nonparametric cumulative sum (CUSUM) procedure. This algorithm also promotes a wide range of applicability based on the reward scheme. Both simulations and a case study are comprehensively conducted to evaluate the performance and demonstrate the superiority of the proposed method.

■ SC15

CC Room 201C

In Person: Advances in Medical Informatics

General Session

Chair: Xiaochen Xian, University of Florida, Gainesville, FL, 32608-1012, United States

1 - Functional Regression Based Quantification of Interruptive Effects for Resuscitation Events in Hospital Emergency Departments
Xiaochen Xian, University of Florida, Gainesville, FL, 53719-2450, United States

Large-scale service systems experience disruptive events that cause diversions of resources, which poses a challenge in maintaining high-quality services. The paper focuses on modeling data-driven large-scale service systems and proposing a metric to quantify the disruption effects of certain interruptive events. A functional regression based modeling and analysis scheme is applied to accurately model the system service status and fully understand possible disruptive effects. The effectiveness of the proposed method is validated via a real case study from ED of a hospital.

2 - Optimal Intervention Portfolio to Improve Health Equity Response in the Coronavirus Pandemic
Yueran Zhuo

The Coronavirus (COVID-19) pandemic hit the United States tremendously with the shock heavily fallen into the underrepresented communities. The purpose of this research is to help these organizations find the optimal strategy to serve the underrepresented communities through the COVID pandemic. Specifically, we aim to help them understand the difference between underrepresented communities and regular communities regarding their need for preventive awareness, testing and medical/supportive care. This will make a step to our ultimate goal of generalizing these findings to any health equity response program.

3 - Synthesizing Data-driven Sepsis Treatment Strategy Using Longitudinal EHR Data
Akash Gupta, California State University, Northridge, CA, 91324, United States, Michael Lash, Senthil Nachimuthu

Sepsis is one of the leading causes of death in Intensive Care Units (ICU). The strategy for treating sepsis involves the infusion of intravenous (IV) fluids and administration of antibiotics. Because of the rapid change in patient's health, determining the optimal quantity of IV fluids is a challenging problem. In this study, we capture the longitudinal EHR data to develop data-driven treatment strategies.

4 - Atomic Clique: A Novel Network Model to Analyze Comorbidity Progression
Parisa Sahraeian, Oklahoma State University, Stillwater, OK, United States

Detection and characterization of comorbidity progression is an invaluable decision aid and a prominent challenge in healthcare research and practice. Comorbidity progression can be modeled as temporal disease networks (TDNs). The objective of this study is to detect comorbidity progression patterns among TDNs. In this regard, a new network model, Atomic Clique, and an associated optimization problem, Atomic Clique Partition (ACP) problem, were proposed. The effectiveness of the model was demonstrated using two case studies on C. Diff and stroke.

5 - Effect of Clinical Measurement Errors on Tuberculosis Treatment Outcomes Prediction
Maryam Kheirandish, University of Arkansas, Fayetteville, AR, United States, Shengfan Zhang

In this research, the effect of predictors' measurement error on Tuberculosis (TB) treatment outcomes prediction is investigated. Since there are no biomarkers to assess progression of TB burden in patients, many studies developed prediction models to predict TB treatment outcomes using clinical data to help to assess the effectiveness of treatment plans. Although RF models are shown in many studies that perform well in treatment outcomes prediction, there are significant measurement errors and heterogeneity in laboratory test results which affect reliability of these models. This study explores how these errors affect performance of RF models and how these effects could be neutralized to achieve more reliable predictions.

■ SC16

CC Room 201D

In Person: Optimization in Machine Learning

General Session

Chair: Moontae Lee, University of Illinois at Chicago, Chicago, IL, 60607, United States

1 - Causal Inference for Panel Data with General Treatment Patterns
Tianyi Peng, MIT, Cambridge, MA, United States, Andrew A. Li, Vivek Farias

We consider the problem of causal inference for panel data with general treatment patterns, a paradigm with broad applications in areas ranging from program evaluation to e-commerce. We propose a novel treatment effect estimator for this problem that we show to be rate-optimal and asymptotically normal under general conditions on the treatment pattern. Our work thus generalizes the synthetic control paradigm to allow for general treatment patterns. Our recovery guarantees are the first of their type in this general setting. Computational experiments with our estimator on synthetic and real-world data show a substantial advantage over competing matrix completion based estimators.

2 - Generalized and Scalable Optimal Sparse Decision Trees
Chudi Zhong, Duke University, NC, United States

With the widespread use of machine learning, the importance of interpretability has become clear for high-stake decisions. In this talk, I will focus on a fundamental and important problem in the field of interpretable machine learning: optimal sparse decision trees. We propose an algorithm that produces optimal sparse binary-split classification trees through a special combination of branch-and-bound and dynamic programming. It leverages several important theorems to reduce the size of the search space. It generalizes decision tree optimization to handle various objectives including F-score and AUC convex hull and exposes a high degree of computational reuse when modeling continuous features.

3 - On-the-fly Rectification for Robust Large-vocabulary Topic Inference
Moontae Lee, University of Illinois Chicago, Chicago, IL, United States

Co-occurrence statistics are powerfully informative. By transforming unsupervised learning into decompositions of co-occurrence, spectral algorithms provide transparent and efficient algorithms for posterior inference such as latent topic analysis and community detection. As object vocabularies grow, however, it becomes rapidly more expensive to store and run inference algorithms on co-occurrence statistics. Rectifying co-occurrence, the key process to uphold model assumptions, becomes increasingly more vital in the presence of rare terms, but current techniques cannot scale to large vocabularies. We demystify previously unknown theories behind the rectification, and then we propose novel approaches that simultaneously compress and rectify co-occurrence statistics, scaling gracefully with the size of vocabulary and the dimension of latent space.

4 - Surrogate "Level-Based" Lagrangian Relaxation for MILP Problems
Mikhail A. Bragin, Assistant Research Professor, University of Connecticut, Storrs, CT, United States

Combinatorial optimization plays a prominent role in Operations Research. To efficiently solve "separable" combinatorial problems, we developed a decomposition and coordination "level-based" surrogate Lagrangian relaxation method with adaptive adjustment of the "level" estimate of the optimal dual value for faster convergence; the key is faster multiplier "oscillation detection" based on a novel auxiliary "dual-convergence-feasibility" problem. Testing results for generalized assignment problems (GAP) demonstrate high computational efficiency and high solution quality (e.g., with the cost of 97825 within 20 min. for the GAP instance d201600) as well as stability and robustness.

■ SC18

CC Room 202B

In Person: Energy Equity

Flash Session

Chair: Ogechi Nwadiaru, University of Massachusetts, Boston, MA, United States

1 - The Energy Equity Gap: Unveiling Hidden Energy Poverty
Destenie Nock, Assistant Professor, Carnegie Mellon University, Pittsburgh, PA, 15207-1120, United States, Shuchen Cong, Lucy Yueming Qiu

Income-based energy poverty metrics, miss people's behavior patterns. Our Energy Equity Gap metric measures energy poverty based on user consumption patterns. Specifically, we use a residential electricity consumption dataset from Arizona to determine the temperature at which households turn on their home cooling systems. The Energy Equity Gap reveals that low income households wait 4-7°F longer than high income households to turn on their air conditioning units. In our region of study, the EEG widened between 2015 and 2019. This reveals demand elasticity in low income communities, and may be caused by delayed effects of residential electricity price changes.

2 - Environmental and Economic (In)Justice Considerations When Decarbonizing a Power System
Paola Furlanetto, University of Massachussets

We investigate the interaction of environmental and equity goals in a network-constrained power system, to identify scenarios where an increase in overall environmental quality may lead to unjust consequences. Using a deterministic unit commitment model, we layer environmental and socioeconomic data over IEEE power flow test cases. We examine the impact of greenhouse gas emissions constraints on air pollution in marginalized neighborhoods and energy burden reflected by locational prices.

3 - Hydrogen as a Transition Alternative for Oil-and Gas- Dependent Countries A Nigeria Case Study
Ayoola Fola

To mitigate significant damages from our changing climate, CO2-equivalent emissions must reach net-zero by 2050. This can be achieved only by reducing emissions from fossil fuel consumption. Currently, about 70% of this consumption is of oil and gas, making fossil-fuel-dependent countries such as Nigeria, uniquely vulnerable. My work uses a macroeconomic analysis framework with energy systems modeling tools to explore the potential of a hydrogen economy as an alternative to the oil and gas economy for Nigeria in a low-carbon future, with the utilization of currently flared natural gas. The scale of infrastructure required is determined, as well as competition in a global commodity market.

4 - Air Pollution Consequences of Vehicle Electrification in India
Tapas Peshin, Stanford University, Stanford, CA, United States

Transportation related emissions account for approximately a third of particulate matter pollution in India, and a somewhat higher proportion of nitrogen oxides, another set of compounds harmful to human health. A move towards vehicle electrification can be perceived as sustainable, but the net health and distributional impacts will also be determined by the increase in emissions profile from the coal heavy electric grid. Through this work, we determine that moving towards a sustainable, low carbon and low pollution electricity grid is a requirement to make a widespread transportation electrification case for India aimed at achieving equitable energy goals.

5 - Impact of Electricity Storage Ownership Structures on Community Equity Outcomes
Ogechi Vivian Nwadiaru, University of Massachusetts, Amherst, MA, United States

The work evaluates different ownership structures on a set of predetermined outcomes. We examine the objective function of decision makers in different storage ownership patterns ranging from community storage to utility owned systems. Specifically we identify reliability, autonomy and cost as a priority for stakeholders.

■ SC19

CC Room 203A

In Person: Data-driven Approaches for Combating Healthcare Challenges

General Session

Chair: Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States

1 - Optimal Unlabeled Set Partitioning with Application to Risk-based Quarantine Policies
Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States, Jiayi Lin, Su Li, Hadi El-Amine

We consider the problem of partitioning a set of items into subsets so as to optimize an additive objective. Under an arbitrary objective, this family of problems is known to be an NP-complete combinatorial optimization problem. We study this problem under a broad family of functions characterized by elementary symmetric polynomials. By analyzing a continuous relaxation of the problem, we identify conditions that enable the use of a reformulation technique in which the problem is cast as a more tractable shortest path problem. We demonstrate the impact of the methodology through a novel and timely application of quarantining heterogeneous populations in an optimal manner. Our case study on COVID-19 data reveals significant benefits over conventional measures in terms of both spread mitigation and economic impact, underscoring the importance of data-driven policies.

2 - Risk Reduction and Prevention of Epithelial Ovarian Cancers
Michael J. Hintlian, PhD Student, University of Southern California, Los Angeles, CA, United States, Julia L. Higle

Epithelial ovarian cancers (EOCs) account for approximately 95% of ovarian cancers and are the leading cause of gynecological cancer deaths. Screening for ovarian cancer has not proven to be cost-effective, but studies identify the fallopian tube epithelium as the origin of most high-grade serous carcinoma (the most common, and lethal, EOC). This presents the possibility for opportunistic and prophylactic risk-reducing procedures (e.g., salpingectomy the removal of the fallopian tubes). We examine the effectiveness of such procedures via model-based analysis.

3 - Heuristic Policies for Spatiotemporal Vaccine Allocation Based on a Compartmental Model with Behavioral Feedback
Julius Barth, University of Texas at Austin, Austin, TX, United States, Diwakar Gupta

Motivated by the COVID-19 pandemic, we study how a government agency may dynamically allocate vaccines from a limited stockpile to different jurisdictions. A generalized SEIR model with behavioral feedback is proposed. Behavioral feedback depends on time varying local transmission rates, which can be extracted from reported death counts. The SEIR model is used to evaluate a variety of implementable allocation policies (e.g., pro-rata policy, allocation proportional to infection rate, allocation proportional to number of susceptible individuals or allocation focused on regions with highest infection rates) in terms of their efficiency and fairness.

■ SC20

CC Room 203B

In Person: Stochastic Optimization in Healthcare

General Session

Chair: Behshad Lahijanian, University of Florida, Gainesville, FL, 32611-6595, United States

1 - Survival Optimization Problems for Cardiac Arrests
Dmitry Anokhin, George Washington University, Washington, DC, 22209-3210, United States, Miguel Lejeune

We propose new survival optimization models (SOMs) that implement the idea of survival function in emergency healthcare. The key feature of the SOM models is the incorporation of the survival function, which is an isotone function of the overall response time. The response time is defined as the sum of the travel and waiting times. We model the waiting time as an endogenous source of uncertainty in order to capture the impact of decisions on the waiting time.

2 - Health Insurance Plan Selection under Uncertainty using Stochastic Integer Programming

Behshad Lahijanian, University of Florida, Herbert Wertheim College Of Engineering, Industria, Gainesville, FL, 32611-6595, United States, Michelle M. Alvarado

Selecting a health insurance plan can be complicated for individuals or families. It is due to lots of available plans in the marketplace and how they split the cost in a year. A stochastic program model is developed to determine the health insurance selection model by considering different network types that can help people to understand, compare, and choose the right health insurance plan to suit their individual needs. We present a solving algorithm to minimize the total costs including covered and uncovered expenses in a year.

3 - Capacity Allocation in Cancer Centers Considering Demand Uncertainty

Maryam Keshtzari, University of San Diego, San Diego, CA, 79416-1752, United States, Bryan A. Norman

Capacity allocation in cancer centers is an important but challenging problem due to the high variability in patient demand and requirements. This study proposes a stochastic chance-constrained model to consider uncertainties in new and returning patient demand. The proposed model finds the optimal specialization mix for oncologists based on demand distribution by cancer type to avoid potential mismatches between oncologists' specializations and the demand distribution by cancer type. To demonstrate the capability of the proposed model to answer important operational and tactical questions in cancer centers, the model is solved using data collected from our collaborating cancer center.

■ SC21

CC Room 204A

In Person: System Modeling to Inform Health Policy Making

General Session

Chair: Yu-Hsin Chen, Pennsylvania State University, State College, PA, United States

1 - Multi-resource Allocation and Sequence Assignment in Patient Care Management: A Stochastic Programming Approach

Xinyu Yao, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, Rema Padman, Karmel S. Shehadeh

The emergence of Real-Time Location System (RTLS) technologies has enabled healthcare organizations to collect highly granular location data on people and medical assets in the clinical environment. Using RTLS data from healthcare delivery settings, this study aims to minimize the waiting in the system by developing optimization models and methods to allocate and sequence medical resources for major patient care trajectories. We employ the two-stage stochastic programming model with the Monte Carlo Optimization approach to demonstrate improved patient and resource management strategies in complex care delivery settings. The results indicate that our model can significantly reduce waiting time for patients in the clinic by 60%, on average, with acceptable computational resource requirements and time complexity.

2 - An Analysis of Structured Optimal Policies for Hypertension Treatment Planning: The Tradeoff Between Optimality and Interpretability

Wesley J. Marrero, Harvard University, Cambridge, MA, 48105-2419, United States, Gian-Gabriel P. Garcia, Lauren N. Steimle

Markov Decision Process (MDP) models are commonly used tools for optimizing sequential decisions under uncertainty in medical decision making. If the parameters of an MDP satisfy certain assumptions, the optimal policy is guaranteed to be monotone. Unfortunately, these assumptions are not always satisfied. In this research, we define the price of interpretability (PI), which measures the gap between the optimal and an interpretable policy. We assess the PI for the best-performing monotone policy (BMP) and the novel class-ordered monotone policy (CMP), which preserves interpretability along user-defined state and action classes. Within the context of hypertension treatment, we demonstrate that the CMP can be computed faster and achieves greater total quality-adjusted life years across a population of 66.5 million people in the US, compared to the BMP.

3 - Optimal Risk Threshold for High-Risk Screening under Capacity

Yu-Hsin Chen, Pennsylvania State University, State College, PA, United States, Qiushi Chen

Autism Spectrum Disorder (ASD) is a developmental disorder that affects 1 in 54 children in the US. The recommendation of universal ASD screening for children 18-24 months old has been widely debated, since it may instead increase the diagnosis delay due to unnecessary diagnostic evaluations in extra false-positive cases. In this study, with the risk of ASD identified before the screening, we developed a finite-horizon stochastic MDP model that determined the optimal risk threshold for screening which balanced between early diagnosis rate and diagnosis delay for young children under 30 months old. The simulation demonstrated that the optimal high-risk screening policy outperformed the universal screening.

■ SC22

CC Room 204B

In Person: Advances in Health Care Policy

General Session

Chair: Steven Foster, Virginia Tech, Blacksburg, VA, 24060, United States

1 - Outcome-based Pharmaceutical Contracting with Heterogeneous Patient Groups

Andrew El Habr, Georgia Tech, Atlanta, GA, 30318-8272, United States, Can Zhang, Turgay Ayer

We study under what market conditions and drug characteristics payers and pharmaceutical manufacturers are better off engaging in an outcomes-based contract, an agreement that links payments for drugs to drug effectiveness, over a nominal-pricing contract when there are heterogenous patient groups. One finding is that drugs that are more effective for the larger patient group can be good candidates for outcomes-based contracts. We also find that drugs that are not highly valuable to patients can be good candidates for outcome-based contracts in this setup.

2 - Ed Triage: An Empirical Study of Fast-track Admission and its Implication for Patient Outcomes

Shuai Hao, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Yuqian Xu, Zhankun Sun

As an effective way to improve emergency department throughput efficiencies, many hospitals have opened a separated fast-track service line that is dedicated to low acuity patients. However, these hospitals don't have consistent routing policies and systematic routing criteria. This largely due to the fact that the impact of fast-track routing decisions on patient outcomes for heterogeneous patients hasn't been well determined. Utilizing a unique data set from three urban hospitals in Canada, we first identified the behavior bias within fast-track routing decision-making process. We came up with an instrumental variable related to this bias to help us quantify the impact of routing decisions on patients with different severity levels whom we classified using a data-driven approach.

3 - COVID Response: Sanitizer Deployment

Steven Foster, Clemson University, Clemson, SC, United States, Tyler O'Brien, Emily L. Tucker, Sudeep Hegde

COVID-19 has forced universities to create strategies to combat infections in their student populations. To allow students to return to traditional instruction, Clemson University has deployed hand-sanitizing dispensers across campus to reduce viral transmissions, limit outbreaks, and promote adherence to CDC health guidelines. This study integrates optimization modeling and human factors methods to maximize usage of these hand-sanitizing dispensers. The facility location model presented uses door-access data to determine optimal dispenser locations within 37 buildings across campus. Interviews are used to define behavioral uncertainty and stakeholder decision-making to better direct the model to enhance future dispenser allocation.

■ SC23

CC Room 204C

In Person: INFORMS Optimization Society Prize Talk Session

Award Session

Chair: Andrea Lodi, Polytechnique de Montréal, Montreal, QC, H3C 3A7, Canada

1 - Award Presenter

Andrea Lodi, Polytechnique de Montréal, Montreal, QC, H3C 3A7, Canada

2 - Award Presenter

Shixuan Zhang, Georgia Institute of Technology, Atlanta, GA, 30339, United States

3 - Sufficient Conditions for Exact SDP Reformulations of QCQPs

Alex Wang, Carnegie Mellon University, Pittsburgh, 15213, United States

Quadratically constrained quadratic programs (QCQPs) are a fundamental class of optimization problems well known to be NP-hard in general. In this talk, we discuss sufficient conditions under which the standard semidefinite program (SDP) relaxation of a QCQP satisfies objective value exactness (the condition that the optimal values of the two programs coincide) or a stronger notion of exactness, convex hull exactness (the condition that the convex hull of the QCQP epigraph coincides with the projected SDP epigraph). We will additionally highlight applications and point to extensions of these results in follow-up work.

■ SC24

CC Room 205A

In Person: Applied Machine Learning in Operation

General Session

Chair: Gad Allon, University of Pennsylvania, Philadelphia, PA, 19104-3615, United States

1 - Learning to Recommend Using Non-uniform Data
Wanning Chen, Stanford University, Stanford, CA, United States, Mohsen Bayati

Learning user preferences for products based on their past purchases or reviews is at the cornerstone of modern recommendation engines. One complication in this learning task is that some users are more likely to purchase products or review them, and some products are more likely to be purchased or reviewed by the users. This non-uniform pattern degrades the power of many existing recommendation algorithms, as they assume that the observed data is sampled uniformly at random among user-product pairs. We design a theory-driven weighted matrix completion method that restores the non-uniformity and, using real data, we show that it boosts the prediction performance of user preferences.

2 - Can AI Impact What We Eat in a Restaurant?
Dmitrii Sumkin, INSEAD, Singapore, 138676, Singapore, Pavel Kireyev, Serguei Netessine

We analyze 920 outlets of restaurants in Southeast Asia observed for almost over 2 years. They replaced paper menus with tablets, installed kiosks for ordering, and facilitated mobile phone usage to place an order on the website. The check level panel data include the sequence of goods added in a cart with their customization options regarding the dish size and toppings added. Staggered timing of AI implementation that gives recommendations along the ordering process allows identifying the causal impact of AI on customer's choice. We study whether AI increases the check's size and assortment and how it depends on the type of recommendation, type of order, the device used for the order, and other factors.

3 - Machine Learning and Prediction Errors in Causal Inference
Daniel Chen, University of Pennsylvania, Philadelphia, PA, United States, Gad Allon, Zhenling Jiang, Dennis J. Zhang

Machine learning is a growing method for causal inference. In machine learning settings, prediction errors are a commonly overlooked problem that can bias results and lead to arbitrarily incorrect parameter estimates. We consider a two-stage model where (1) machine learning is used to predict variables of interest, and (2) these predictions are used in a regression model for causal inference. Even when the model specification is otherwise correct, traditional metrics such as p-values and first-stage model accuracy are not good signals of correct second-stage estimates when prediction error exists. We show that these problems are substantial and persist across simulated and empirical data. We propose general methods to identify when prediction errors are biasing estimates and provide consistent corrections for the case where an unbiased subset of the data is available.

■ SC25

CC Room 205B

In Person: Nonlinear Optimization and Applications I

General Session

Chair: Jinwook Lee, Drexel University, Berwyn, PA, 19312-2512, United States

1 - Accelerating Quadratic Optimization With Reinforcement Learning
Bartolomeo Stellato, Assistant Professor, Princeton University, Princeton, NJ, United States, Jeff Ichnowski, Paras Jain, Goran Banjac, Michael Luo, Joseph E. Gonzales, Ion Stoica, Francesco Borrelli, Ken Goldberg

First-order methods for quadratic optimization such as OSQP are widely used for machine learning and embedded optimal control, where many related problems must be rapidly solved. These methods face two main challenges: hyperparameter tuning and convergence time to high-accuracy solutions. To address these, we explore how Reinforcement Learning can learn a policy to adapt hyperparameters to accelerate convergence. Our RL policy, RLQP, generalizes well to previously unseen problems with varying dimension and structure from different applications, including the QPLIB, Netlib LP, and Maros-Meszaros problems. RLQP outperforms state-of-the-art QP solvers including Gurobi and OSQP.

2 - Decision Making for the Disrupted Supply Chain Using Timestamped Location Graph Representation
Lanqing Du, Drexel University, Philadelphia, PA, United States, Jinwook Lee

COVID-19 has posted a profound influence on the flexibility and resilience of the supply chain management. Those factors will urge logistics industries to seek flexible routing strategies to build resilience and mitigate disruptions. Third-party logistics services are widely used within the logistics industry, and it would be considered as one of many essential logistics fulfillment alternatives when facing the rising demand, disruption uncertainty, and related ripple effect. Accordingly, this paper studies the influence of disruptions on the logistics industry, considering the existence of third-party logistics services. We investigate related qualitative studies and structural analyses of the logistics network to understand how the ripple effect of disruption influences the supply chain network.

3 - A Disruptive Peer-to-peer Network System for Operations and Fintech in the Food Industry
Jinwook Lee, Drexel University, Berwyn, PA, 19312-2512, United States, Sejong Yoon, Lanqing Du, Paul Moon Sub Choi

For transparency in the supply chain, we apply and extend the existing notions of distributed ledger technology and internet-of-things to enhance authenticity verification radically. Additionally, we use novel stochastic optimization techniques for optimal rewards and fees of a P2P network. We also model the supply chain as a P2P network to robustly identify changes in a food information network. Using the suitable evaluation of peers' effort, we calculate optimal rewards based on a utility function of rewards and effort. Furthermore, we evaluate the optimal structure within rewards and fees to maximize participants' utility while guaranteeing network sustainability.

■ SC26

CC Room 206A

In Person: Global Optimization/Optimization with Noisy Intermediate-Scale Quantum 2

General Session

Chair: Brandon Augustino, Lehigh University, Landing, NJ, 07850, United States

1 - Characterization and Mitigation of Errors in Quantum Computing via Consistent Bayesian
Muqing Zheng, Lehigh University, Bethlehem, PA, 18015, United States

Various noise models have been developed in quantum computing studies to describe the propagation and effect of the noise due to the imperfect implementation of hardware. While measurement errors are widely accepted to be modeled classically, the actual behaviors of gate errors are harder to identify. As a result, methods like Randomized Benchmarking (error characterization) and Randomized Compiling (error mitigation) are two that do not require the knowledge of gate error channels by taking the advantage of average behaviors. Different from those existing schemes, in this talk, we are going to stochastically model the error propagation and obtain its probabilistic information.

2 - An Inexact-Infeasible Quantum Interior Point Method (II-QIPM) for Linear Optimization
Mohammadhossein Mohammadisiahroudi, Lehigh University, Bethlehem, PA, 18015, United States

Quantum Linear System Solvers (QLSAs) have the potential to solve Newton systems in QIPMs much faster than classical solvers w.r.t dimension. However, the use of QLSAs in IPMs comes with many challenges, such as the impact of having ill-conditioned systems and the accuracy of QLSAs. We explore efficient use QLSAs in QIPMs. Accordingly, an II-QIPM is developed to solve LO problems. We also discuss how we can get an exact solution by Iterative Refinement without excessive time of QLSAs. Finally, the results of implementing our quantum method using quantum simulators are analyzed.

3 - Exact Global Optimization of Frame Structures for Additive Manufacturing
Oguz Toragay, Research Assistant, Auburn University, Auburn, AL, United States, Daniel F. Silva, Alexander Vinel, Nima Shamsaei

The problem of designing the lightest load-carrying planar frame structures for additive manufacturing (AM) is concerned with minimizing the structure weight by selecting discrete design elements and their continuous diameters. We focus on globally optimal solutions for the problem that is known to be computationally challenging, as it combines integer variables and non-convex constraints. We adapt existing formulations to allow for AM constraints and propose a new (non-convex) quadratic version. In numerical experiments, we show that with advanced solvers, the quadratic model performs best, even though it is still restricted to relatively small problem sizes.

4 - Improving Searchability in Evolutionary Algorithms: A Novel SFDM Method
Reza Gharoie Ahangar, University of North Texas, Denton, TX, United States, Rebert Pavur

This study proposes a search field division method (SFDM) to improve the searchability in evolutionary algorithms (EAs). To validate the proposed technique's performance, we examine the diversity and exploration-exploitation search behaviors of the SFDM approach. The findings show that the proposed SFDM method can improve the performance of all EAs with different single-modal, multi-modal, and unimodal benchmark functions. This novel approach increases efficiency in EAs to find the best global optimal points to solve real-world industry problems.

■ SC27

CC Room 206B

In Person: Network Optimization: Network Games

General Session

Chair: Soham Das, Bryan, TX, 77801, United States

1 - Network Connectivity Game

Darko Skorin-Kapov, Professor, R.B. Willumstad School of Business, Adelphi University, Garden City, NY, United States, Jadranka Skorin-Kapov

We investigate the cost allocation strategy associated with the problem of providing service between all pairs of network nodes. There is a cost associated with each link and the communication between any pair of nodes can be delivered via paths connecting those nodes. A cost efficient solution which provides service for all node pairs is a (non-rooted) minimum cost spanning tree. The cost of such a solution should be distributed among users (node pairs) who might have conflicting interests. The objective of this paper is to formulate the above cost allocation problem as a cooperative game, to be referred to as a Network Connectivity (NC) game, and efficiently find some core cost allocations.

2 - Decentralized Fictitious Play in Near-potential Games with Time-varying Communication Networks

Sarper Aydin, Texas A&M University, College Station, TX, United States, Sina Arefizadeh, Ceyhun Eksin

We study the convergence properties of decentralized fictitious play (DFP) for the class of near-potential games where the incentives of agents are nearly aligned with a potential function. Agents share information only with their current neighbors in a sequence of time-varying networks, keep estimates of other agents' empirical frequencies, and take actions to maximize their expected utility functions computed with respect to the estimated empirical frequencies. We show that empirical frequencies of actions converge to a set of strategies with potential function values that are larger than the potential function values obtained by approximate Nash equilibria of the closest potential game.

3 - Greedy Algorithms to Maximize Anti-coordination in Network Games

Soham Das, Texas A&M University, College-station, TX, United States, Ceyhun Eksin

In an anti-coordination network game, players are encouraged to differentiate their actions from their neighbors. Since, despite incentives, selfish agents may fail to do so, our goal is to eliminate all active coordination links by controlling a minimum set of players. We motivate the problem by an epidemic game where people (healthy and sick) decide to take the costly action, e.g. taking protective measures vs. free riding. The player selection problem is combinatorial with a submodular objective. Hence, we consider greedy algorithms that exploit behavior cascades on the network. Numerical experiments show that the greedy algorithms are near optimal and outperform centrality based heuristics.

■ SC28

CC Room 207B

In Person: Recent Advances in Nonconvex Optimization II

General Session

Chair: Lijun Ding, Cornell University, Ithaca, NY, 14850-2842, United States

1 - Rank Overspecified Robust Matrix Recovery: Subgradient Method and Exact Recovery

Liwei Jiang, Cornell University, Ithaca, NY, United States

We study the robust recovery of a low-rank matrix from grossly corrupted measurements, with no prior knowledge on the intrinsic rank. We employ a robust ℓ_1 loss function and deal with the challenge of the unknown rank by using an overspecified factored representation of the matrix variable. We then solve the associated nonconvex nonsmooth problem using a subgradient method with diminishing step sizes. We show that under a regularity condition on the sensing matrices and corruption, which can be verified for Gaussian measurements under independent or adversary sparse corruptions, even with rank overspecified, the subgradient method converges to the exact low-rank solution at a sublinear rate. Moreover, our result is more general in the sense that it automatically speeds up to a linear rate once the factor rank matches the unknown rank.

2 - Full-low Evaluation Methods for Derivative-Free Optimization

Oumaima Sohab, Lehigh University, Bethlehem, PA, United States

We propose a new class of directional methods for Derivative-Free Optimization that considers two types of iterations. The first type is expensive in function evaluations but exhibits good performance in the smooth, non-noisy case. The second type is cheap in function evaluations, more appropriate under the presence of noise or non-smoothness. The resulting Full-Low Evaluation method is globally convergent even in the non-smooth case and yields the appropriate rates in the smooth case for the unconstrained case. Results show that is efficient and robust across problems with different levels of smoothness and noise.

■ SC29

CC Room 207C

In Person: Optimal Decision Making via Large Deviations Principles

General Session

Chair: Bart Paul Gerard Van Parys, MIT Sloan School of Management, Cambridge, MA, 02139, United States

1 - Optimal Data-driven Decision-making With Any Desired Out-of-sample Guarantees

Mohammed Amine Bennouna, PhD Student, Operations Research Center, MIT, Cambridge, MA, United States, Bart Paul Gerard Van Parys

We study the problem of designing optimal approaches for stochastic optimization problems when only data is available. Most prior works construct estimators of the true unknown expectation using data and derive out-of-sample bounds to guarantee the quality of the estimator. We follow a different route. We formalize what are the desirable properties of estimators used for stochastic optimization problems and seek to find the "optimal" estimator verifying these properties. For any desired out-of-sample guarantee, we construct explicitly a Distributionally Robust (DR) estimator that is uniformly closer to the true cost than any other estimator verifying such guarantee, making it optimal. We exhibit three different regimes depending on the strength of the guarantee for which the optimal DR estimator has uncertainty set all probability simplex, KL ball and ellipsoid.

2 - Optimal Transport in the Face of Noisy Data

Bart Paul Gerard Van Parys, MIT. Sloan School of Management, Cambridge, MA, 02139, United States

Optimal transport distances are popular and theoretically well understood in the context of data-driven prediction. A flurry of recent work has popularized these distances for data-driven decision-making as well although their merits in this context are far less well understood. This in contrast to the more classical entropic distances which are known to enjoy optimal statistical properties.This begs the question when, if ever, optimal transport distances enjoy similar statistical guarantees. Optimal transport methods are shown here to enjoy optimal statistical guarantees for decision problems faced with noisy data.

■ SC30

CC Room 207D

In Person: Latest Developments in Scheduling and Supply Chain/Managing Complex Projects

General Session

Chair: Chenman Ellie Cheng, Seattle, WA, 98109, United States

1 - Tasking Scheduling Problems with Progress Control on Parallel Machines

Weiya Zhong, Shanghai University, School of Management, Shanghai, 200444, China, Jia Cui

In this talk, we introduce parallel-machine task scheduling problems with progress control. For each job, there are multiple milestones at which a penalty will occur if the completed amount of this job is below a given satisfactory level. The goal is to minimize the total penalty for all the jobs at their multiple milestones. If the processing of a job can be overlapped on different machines and the penalty functions are convex and decreasing, the problem can be solved in polynomial time. If the overlap for a job's processing is not allowed, we prove that this problem is NP-hard and formulate an MP model for this problem. We propose a branch-and-price algorithm to solve the case when the penalty functions are linear decreasing. Using randomly generated data, we conduct numerical studies to evaluate the performance of the proposed solution approach.

2 - Scheduling Reviews in Stochastic Serial Projects

Chenman Ellie Cheng, University of Washington, Seattle, WA, 98109, United States, Shi Chen, Theodore D. Klastorin

We consider the problem of monitoring an ongoing stochastic project to determine if corrective actions are needed to minimize the expected total cost of the project (consisting of direct resource costs, indirect/overhead costs, review costs, and delay/penalty costs). We initially model this problem as a two stage serial project when task durations are exponential; a review occurs either at a predetermined time or when the first stage is completed. We show that merely scheduling a review can extend the expected makespan of a project and determine conditions for additional second stage compression. We also discuss extensions of this model to multiple stages and other task distributions.

■ SC31

CC Room 208A

In Person: Analysis of Sensor Networks with High-dimensional Data for Data-driven Decision Raking

General Session

Chair: Ana Maria Estrada-Gomez, Georgia Institute of Technology, Atlanta, GA, 30318, United States

1 - Adaptive Partially-observed Sequential Change Point Detection for Covid-19 Hotspots Detection

Jiuyun Hu, Arizona State University, Tempe, AZ, United States, Hao Yan

The authors derive an algorithm to detect the hotspots in Covid-19 case. The challenge is the limited resources and how to distribute next day's tests based on previous data. The algorithm uses Bayesian weighted update to get the posterior distribution of test statistics, then use Upper Confidence Bounds (UCB) to get the optimal distribution of next day, and finally use CUSUM statistics to detect the hotspots. The authors also compare the algorithm to the benchmark of evenly distributed tests and distribute all tests once a county. In Washington State example, the hotspot detected is Yakima County.

2 - Online Monitoring of Dynamic Spectral Functional Graphical Models

Ana M. Estrada Gomez, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Kamran Paynabar

Many important problems can be modeled as a system of interconnected entities producing time-dependent streaming data. In these problems, it is critical to learn the complex cross-correlation structure between the system's entities and to monitor for changes in the structure due to system evolution. In this paper, we propose an online structural change-point detection methodology. We exploit the spectral information contained in the data to learn sparse functional probabilistic graphical models over time. We enforce the similarity of the graphs to detect structural changes in the system. An efficient method based on ADMM is proposed for online optimization and change-point detection. The effectiveness of the proposed methodology is demonstrated through a simulation study and a real case study using neurological data.

■ SC32

CC Room 208B

In Person: Coupling Techniques for Online Decision-Making

General Session

Chair: Siddhartha Banerjee, Cornell University, Ithaca, NY, 14853-3801, United States

1 - Sequential Fair Allocation: The Envy-Efficiency Uncertainty Principle

Sean Sinclair, Cornell University, Ithaca, NY, 14853, United States

We consider the problem of dividing limited resources to individuals arriving over T rounds. Each round has a random number of individuals arrive, and individuals can be characterized by their type. A standard notion of fairness in this setting is that an allocation simultaneously satisfy envy-freeness and efficiency.We show that in the online setting, the two desired properties are in direct contention, in that any algorithm achieving additive envy-freeness up to a factor of L_T necessarily suffers an efficiency loss of at least 1 / L_T. We complement this uncertainty principle with a simple algorithm, HopeGuardrail, which allocates resources based on an adaptive threshold policy.

2 - Overbooking with Bounded Loss

Jiayu Zhao, PhD Student, MIT, Cambridge, MA, 611700, United States, Daniel Freund

We study a classical problem in revenue management: quantity-based single-resource revenue management with no-shows. In this problem, a firm observes a sequence of T customers drawn independently from a known distribution of k different types, and the firm needs to decide whether to accept or reject in an online fashion given resource capacity B. Each accepted service request yields a type-dependent revenue and has a type-dependent probability of requiring a resource (or, be a no-show) once all arrivals have occurred. If the number of resources required exceeds B at the end of the horizon, the firm pays a fixed compensation for each unfulfilled request. With a clairvoyant, that knows all arrivals ahead of time, as a benchmark, we provide an algorithm with a uniform additive loss bound (i.e., independent of B and T). This improves upon prior works achieving $\Omega(\sqrt{\ };)$ guarantees.

3 - Multiple Objectives in Online Problems

Alberto Vera, Amazon, Seattle, WA, 10016, United States

We consider an online problem where resources and customers arrive over time and we must allocate resources to customers. The traditional objective is maximizing reward, given by the customers' preferences over products. On the other hand, it is also interesting to consider the minimization of holding cost. We present an algorithm that, when correctly tuned, achieves good performance on both objectives simultaneously.

■ SC33

CC Room 209A

In Person: Experimental Design in Marketplaces

General Session

Chair: Hannah Li, Stanford University, Palo Alto, CA, 94306-3949, United States

Chair: Yonatan Gur, Stanford University, Stanford, CA, 94305-7216, United States

1 - Bypassing the Monster: A Faster and Simpler Optimal Algorithm for Contextual Bandits under Realizability

Yunzong Xu, Massachusetts Institute of Technology, Cambridge, MA, United States, David Simchi-Levi

We consider the general (stochastic) contextual bandit problem under the realizability assumption, i.e., the expected reward, as a function of contexts and actions, belongs to a general function class F. We design a fast and simple algorithm that achieves the statistically optimal regret with only O(log T) calls to an offline regression oracle across all T rounds. Our results provide the first universal and optimal reduction from contextual bandits to offline regression, solving an important open problem in the contextual bandit literature. A direct consequence of our results is that any advances in offline regression immediately translate to contextual bandits, statistically and computationally. This leads to faster algorithms and improved regret guarantees for broader classes of contextual bandit problems.

2 - Experimental Design in Two-sided Platforms

Hannah Li, Stanford University, Stanford, CA, 94306-3949, United States, Ramesh Johari, Inessa Liskovich, Gabriel Weintraub, Geng Zhao

Two-sided marketplace platforms often run experiments to test the effect of an intervention before launching it platform-wide. It is well known that estimates of the treatment effect obtained in these experiments can be biased, due to interference arising from marketplace competition. We develop market models to capture such dynamics and use the model to investigate the effect of competition on the bias and variance of different designs and estimators. First, we show that the bias of commonly used estimators (in demand-side and supply-side randomized designs) depends on market balance. Second, we introduce a novel class of experimental designs based on two-sided randomization (TSR) and propose estimators with lower bias across wide ranges of market balance. Finally, we study how platforms can minimize both bias and variance through their choices in experiment designs.

■ SC34

CC Room 209B

In Person: Data Analytics and Simulation

General Session

Chair: Ankit Shah, University of South Florida, Tampa, FL, 33620, United States

1 - A Simulation-based Movement Intelligence Model for Building Threat Intelligence

Jalal Ghadermazi, University of South Florida, Tampa, FL, United States, Ankit Shah

Recently, advancements in the development of Intelligence, Surveillance, and Reconnaissance systems have seen a significant increase. The bottleneck in this process is the cognitive overload on the analysts to find patterns and connections to identify suspicious activities. There exists a critical need to develop a decision-support methodology that can assist the analysts in building this threat intelligence. In this study, first, we develop a discrete-event simulation model for the generation of the movement intelligence (MOVINT) data and social intelligence (SOCINT) data. Next, we propose a machine learning-based methodology to build threat intelligence from the collected data. In this talk, we will demonstrate the effectiveness of our approach in the detection of threat signals using the MOVINT and SOCINT data.

2 - Data Augmentation for Object Detection Models: A Case Study
Mohammad Noroozi, University of South Florida, Tampa, FL, United States, Ankit Shah

Small object detection is a challenging problem found in many application domains. An imbalance with respect to any input property associated with the images can significantly affect the performance of the object detection models. In this talk, we will go over the data sampling and data augmentation techniques that can be used to better train deep learning models. We present our approach by augmenting a small object dataset by synthesizing images for object detection and demonstrate our results using the YOLOv4 deep learning model.

■ SC35

CC Room 210A

In Person: On demand Mobility: Operation and Competition

General Session

Chair: Daniel Vignon, University of Michigan, Ann Arbor, MI, 48109-2125, United States

1 - Fleet Sizing for Automated Mobility-on-Demand Services
Michael Hyland, University of California, Irvine, Irvine, CA, 92697-3600, United States

Fleet sizing for automated mobility-on-demand (AMOD) services have significant cost and service quality implications for AMOD users as well as congestion and emissions implications for society. While this problem has received considerable attention recently, a powerful modeling approach has been overlooked in the literature and in practice—the time-dependent transshipment problem (TDTP). This study shows how the TDTP can be adapted to determine the optimal fleet size for an AMOD service considering both purchasing and operating costs. The study also compares the TDTP approach with the state-of-the-art minimum path cover formulation approach, in terms of their ability to provide a reasonable bound for minimum fleet sizing. Bounds from both approaches are then compared with the results of an agent-based stochastic dynamic AMOD simulation model.

2 - Should Ubers be Used as Flexible Shuttles?
Partha S. Mishra, PhD Student, Northwestern University, Evanston, IL, United States, Sunil Chopra, Sebastien Martin, Karen Smilowitz

Today, larger corporations are looking for fast and economic commute alternatives for their employees. While there has been a boom in the variety of options, which now range across shuttles, micro-transit services and transit-on-demand services, the right mix of modes of transit and their scheduling has become a challenging task. This paper evaluates how the choice of the trade-off between capacity, cost and speed affects the mode of transit and its schedule amidst inherent variability. In particular, we make the case for the use of transit-on-demand services in combination with regular shuttles.

3 - Competition and Congestion in the Ride-for-hire Market
Daniel Vignon, University of Michigan, Ann Arbor, MI, United States

Comparatively little attention has been paid to the welfare-effects of competition in the ride-for-hire market, especially with respect to congestion. Thus, we model and investigate competition in the ride-for-hire market, its effect on congestion and the resulting market equilibrium. We especially focus on competition between two ridesourcing platforms, on one hand, and between a ridesourcing and a taxi company on the other. The outcomes of both scenarios are compared and contrasted with each other and with the outcome from a monopolist ridesourcing platform. Then, we propose and evaluate welfare-enhancing regulations and discuss practical policy implications for the ride-for-hire market.

■ SC36

CC Room 210B

In Person: Innovative Transportation and Urban Planning

General Session

Chair: Yiling Zhang, University of Minnesota, Minneapolis, MN, 55455-0141, United States

1 - Impact of Congestion on Mobility Choices: A Semiparametric Machine Learning Approach
Aron Brenner, Student, MIT, Cambridge, MA, United States, Manxi Wu, Saurabh Amin

In this paper, we propose a class of semi-parametric machine learning methods to predict travelers' aggregate mode choices between public transit and driving using real-time data of congestion delay in a transportation network. Our prediction method combines a parametric binary mode choice model, and a class of non-parametric machine learning tools used for reducing the data dimensionality. Our method also outputs a weight on each road segment, which reflects the impact of travel time delay of that segment on travelers' mode choices. We apply this method to predict the ratio between driving and subway ridership in the San-Francisco Bay area, and achieve less than 2% RMSE during morning rush hours.

2 - Learning and Inference of Travelers' Route Choice Preferences from Network Level Data
Guarda Pablo, Carnegie Mellon University, Pittsburgh, PA, United States, Sean Z. Qian

This study extends classical bilevel formulations to learn travelers' multi-attribute utility functions from traffic data and conduct hypothesis testing on the parameters' estimates. Via the formulation of a non-linear least squares problem and experiments on synthetic data, we showed that the parameters of the utility function were consistently recovered. The realization of a pseudo-convex objective function motivated the integration of normalized gradient descent with standard second order optimization methods used in prior literature. The theory was deployed at a large scale using real-world traffic data in Fresno, CA

3 - Analytics-Driven Inspection Operations for Post-Disaster Infrastructure Damage Assessment
Mathieu Dahan, Assistant Professor, Georgia Institute of Technology, Atlanta, GA, 30309, United States, Andrew Lee, Saurabh Amin

Delayed identification of storm-induced damages across coastal infrastructures often contributes to high economic and societal costs. To reduce the impact of damage, we address a critical knowledge gap by developing an analytics-driven approach for inspection of large-scale infrastructure networks in the aftermath of disaster events. Our approach integrates flexible diagnostic information from fixed and aerial sensors to design inspection crew routing strategies for rapid post-disaster damage identification. Using drainage network inspection data following 2017's Hurricane Harvey, we show that prioritizing inspection based on damage indicators leads to significant cost and time savings.

4 - Incorporating Kinematic Wave Theory Into a Deep Learning Method for Traffic Speed Estimation
Bilal Thonnam Thodi, PhD Student, New York University Abu Dhabi, Abi Dhabi, United Arab Emirates

We present a kinematic waves-based Deep Convolutional Neural Network (Deep CNN) for estimating high-resolution traffic speed fields using sparse probe vehicle trajectories. Two key notions incorporate traffic physical constraints into the learning framework. Firstly, the use of anisotropic traffic kernels in the Deep CNN model an architecture modification aimed to explicitly capture the space-time correlations in free-flow and congested traffic. These correlations are guided by the Kinematic Wave Theory of traffic flow. Secondly, simulation-based training the use of simulated data as a surrogate to real-world data for training. This implicitly honors traffic physical constraints underlying the simulated data, and hence the simulation model. Speed field estimations for two real-world datasets show promising results.

■ SC38

CC Room 210D

In Person: New Strategies and Technologies in the Operations/Finance Interface & Social Responsibility and Risk in Supply Chain

General Session

Chair: Sergio Camelo, Stanford University, Stanford, CA, 94305, United States

Co-Chair: Parshan Pakiman, University of Illinois-Chicago, Chicago, IL, 60605, United States

1 - The Analysis of Blockchain-based Decentralized Exchanges
Ruizhe Jia, Columbia University, NY, United States, Agostino Capponi

We investigate the market microstructure of Automated Market Makers (AMMs), the most prominent type of blockchain-based decentralized exchanges. We show that the order execution mechanism yields token value loss for liquidity providers if token exchange rates are volatile. AMMs are adopted only if their token pairs are of high personal use for investors, or the token price movements of the pair are highly correlated. A pricing curve with higher curvature reduces the arbitrage problem but also investors' surplus. Pooling multiple tokens exacerbates the arbitrage problem. We provide statistical support for our main model implications using transaction-level data of AMMs.

2 - Matching Platforms for Smallholder Supply Chains
Sergio Camelo, Stanford University, Stanford, CA, 94305, United States, Dan Iancu, Joanne de Zegher

We design a centralized platform that matches smallholder farmers with middlemen that provide transportation for their fruit. The platform sells the fruit and uses its revenue to pay both parties. Payments are designed to ensure that participating in the platform is more profitable for both farmers and middlemen than working outside of it. To model the profits that both parties could obtain

outside of the platform we use historical data on thousands of fruit pickups, gathered through GPS trackers installed on middlemen trucks in our field site in Sumatra. To account for uncertainty in data collection, we rely on a distributionally robust optimization approach based on the Wasserstein metric. We show that such a platform can reduce transportation costs, while also easing the digitization of agricultural data and improving the transparency of smallholder supply chains.

3 - Internet of Things-enabled Information, Dual Sourcing and Supplier Competition

Tao Lu, PhD, University of Connecticut, CT, United States, Brian Tomlin

Internet of Things (IoT) technologies have been increasingly used to monitor production and transportation processes, thereby predicting a potential supply disruption. In this study, we examine the impact of IoT-enabled supply information on a buyer sourcing from two competing suppliers: an unreliable supplier subject to disruption risks and a reliable one. We show that the buyer may or may not benefit from the IoT-enabled information. While the IoT information enables the buyer to place an emergency order with the reliable supplier if needed, it may soften the competition between suppliers. Our model extensions further discuss the cases when the IoT information is not accurate and when the unreliable supplier can resolve a detected supply issue (with a certain probability).

■ SC40

CC Room 211B

In Person: Advanced Game-theoretic Models in Energy Market and Policy Design

General Session

Chair: Nathan Boyd, College Park, MD, United States

1 - Modeling a Co2 Tax at the Margin Combined with a Subsidy Scheme for the Dutch Industry

Marit Van Hout, Netherlands Environmental Assessment Agency, Den Haag, Netherlands, Bert W. Daniels, Robert Koelemeijer

During this presentation we will illustrate the use of state-of-the-art modeling at the Netherlands Environmental Assessment Agency (PBL) applied annually for the Dutch Climate and Energy Outlook. More in particular, the focus is on the modeling of the Dutch industry and the interplay between the Dutch CO2 levy and EU ETS prices on the one hand, and subsidy schemes on the other. The model applied is a hybrid simulation and optimization (LP) model where interactions with other relevant segments and markets (such as refineries and electricity) are included in an iterative fashion by exchanging modeling results.

2 - Optimal Pricing in the Long-run in Electricity Markets with Non-convex Costs

Conleigh Byers, ETH Zurich, Brunnwiesenstrasse 40, Zurich, 8049, Switzerland, Gabriela Hug

Non-convex costs are critical in electricity markets, as startup costs and minimum operating levels yield a non-convex optimal value function over demand levels. We evaluate the performance of different non-convex pricing frameworks by determining long-run adapted resource mixes associated with each pricing framework while fully preserving the non-convex operations. We frame optimal pricing in terms of social surplus achieved and transfer of consumer to producer surplus in adapted long-run market equilibria. We find that approximate convex hull pricing achieves the highest social and consumer surplus, while other methods tend to over-compensate inframarginal units. We find that marginal prices with fixed integer variables can achieve high consumer surplus, but near-optimal solutions significantly affect performance.

3 - Privacy Impact on Generalized Nash Equilibrium in Peer-to-peer Electricity Market

Ilia Shilov, Inria, Paris, France, Hélène Le Cadre, Ana Busic

We consider a peer-to-peer electricity market, where agents hold private information. The problem is modeled as a noncooperative communication game, in the form of a Generalized Nash Equilibrium Problem, where the agents determine their randomized reports, while anticipating the form of the peer-to-peer market equilibrium. We characterize the equilibrium of the game, prove the uniqueness of the Variational Equilibria and provide an expression for the privacy price. Numerical illustrations are presented on the 14-bus IEEE network.

4 - Game Theoretic Modeling for Improved Management of Water And Wastewater Resources Using Equilibrium Programming and Feedback Mechanisms

Nathan Boyd, University of Maryland, College Park, MD, United States, Steven A. Gabriel, George Rest, Tom Dumm, Doug Murphy

This work investigates the modeling of novel market-based management approaches for improved cooperation among independent water resources users using equilibrium programming techniques (e.g., MCPs, MPECs). Such cooperation is not naturally incentivized because the actions beneficial to upstream users can often negatively impact downstream users. These asymmetrical benefits can lead to non-cooperative behavior in three key areas: 1) water withdrawal rights, 2) water quality responsibilities, and 3) risks associated with flooding. The approach is applied to a case study in the Duck River Watershed to promote economic development and ecological preservation.

■ SC41

CC Room 212A

In Person: Recent Advancement of Optimization Methodology in Energy Systems

General Session

Chair: Guyi Chen, Evanston, IL, United States

1 - Stochastic Planning of Joint Power and Gas System Against Extreme Weather and Climate Events

Wenjing Su, PhD Candidate, The Pennsylvania State University, State College, PA, United States

Physical infrastructure systems including power grids and natural gas systems become increasingly tightly coupled. The energy infrastructure systems have shown great susceptibility to more frequent and severe extreme weather and climate events. The low-probability and high-impact natural disasters as well as the interdependence between power and gas system need to be taken into consideration in the energy system planning process to ensure its reliability. In this study, the vulnerability of joint electricity and natural gas system under spatially correlated failures induced by extreme weather and climate events and uncorrelated failures are compared. A two-stage stochastic optimization model is proposed to enhance the resilience of joint power and gas system against spatially correlated failures.

2 - Private Risk and Social Resilience

Han Shu, Cornell University, Ithaca, NY, United States, Jaob Mays, Michael Craig, Lynne Kiesling, Joshua Macey, Blake Shaffer

Energy-only electricity markets rely on the decentralized investment decisions of market participants to provide an efficient level of reliability. During an exceptionally cold winter storm in February 2021, ERCOT experienced shortfalls on an unprecedented scale, with nearly half of the generation fleet experiencing outages. The depth of the resulting blackouts invites questions as to the ability of systems relying on decentralized planning to appropriately prepare for and withstand rare events. Based on two mild assumptions, risk-aversion among investors and incomplete risk trading, we explain why decentralized markets may lead to underinvestment in resilience to rare events. We describe the nature of the incomplete risk trading that arises in the context of electricity markets and discuss potential market, market-like, and non-market remedies.

3 - Parameter Estimation in an Energy Simulation Model using Statistical Learning

Guyi Chen, Northwestern University, Evanston, IL, United States, David Morton, Oscar Dowson

We consider a simulation model of a highly detailed concentrating solar power system, which requires a large number of input parameters. Because of the novelty of the system, many of the parameters have a high degree of uncertainty. To be practically useful, we must learn these input parameters from limited data. Bayesian optimization is a promising tool to learn parameter values of a possibly expensive oracle. We couple Bayesian optimization method, a local search algorithm, and a scheme to search the space of parameters with a focus on exploration. We present empirical and computational results to show the effectiveness of the framework.

■ SC42

CC Room 212B

In Person: Artificial Intelligence II

Contributed Session

Chair: Soomin Lee, Yahoo! Research, Sunnyvale, CA, 94087, United States

1 - Image-based Characterization of Laser Scribing Quality using Transfer Learning

Mohammad N. Bisheh, Kansas State University, Manhattan, KS, United States, Shing Chang, Xinya Wang, Shuting Lei, Jianfeng Ma

Due to the processing speed and high-quality requirement in modern industrial applications, it is important to measure and monitor quality characteristics in real time during ultrafast laser scribing process. This research presents a study on image-based characterization of laser scribing quality using a novel transfer deep convolutional neural network (TDCNN) model for several quality characteristics such as debris, scribe width, and straightness of a scribe line using only a few images. Appropriate image processing techniques are provided to measure scribe width and line straightness as well as total scribe and debris area using classified images with 96 percent accuracy.

2 - Welfare-based Fairness Through Optimization in Artificial Intelligence Applications
Violet Xinying Chen, Carnegie Mellon University, Pittsburgh, PA, United States, John Hooker

We propose optimization as a general paradigm for formalizing welfare-based fairness in AI systems. Optimization models allow formulation of a wide range of fairness criteria as social welfare functions, while enabling AI to take advantage of highly advanced solution technology. We highlight that social welfare optimization supports a broad perspective on fairness motivated by general distributive justice considerations. In addition, we discuss how to integrate optimization with rule-based AI and machine learning, and outline research directions to explore for practical implementation of integrated methods.

3 - A Strongly Polynomial Algorithm for Risk Constrained Problems
Alexander Zadorojniy, IBM Research, Haifa, Israel, Takayuki Osogami

We consider a Markov Decision Process problem with risk related constraint. The constraint is a linearized variance approximation. We find a policy that maximizes a ratio of the reward expectation to its linearized variance. We show that under monotonicity assumption which is natural for risk related problem the Simplex algorithm with Gass-Saaty shadow-vertex pivoting rule is strongly polynomial for both cost models: discounted and expected average for infinite horizon. We show an application of the algorithm to the problem of maximization of the Sharpe ratio.

4 - Deep Learning-based Cutting Force Prediction with Machining Process Monitoring Data
Soomin Lee, Chungnam National University, Daejeon, Korea, Republic of, Wonkeun Jo, Dongil Kim, Hyein Kim, Jeongin Koo

We propose a method to predict cutting force with machining process monitoring data. The data were collected from a computer numerical control module and sensors. The proposed method employs an LSTM-based regression model composed of residual and bidirectional structures. In experiments, we compared the performance of the proposed method and the conventional LSTM as baseline. The experimental results showed that the proposed method not only has greater accuracy but also is more proper for various machining process conditions than the baseline.

■ SC43

CC Room 213A

In Person: Emerging Topics in Information Systems

General Session

Chair: Haozhao Zhang, Richardson, TX, 75080-3021, United States

1 - Spectator or Participator? The Optimal Mechanism for Online Advertising Platforms Facing the Transactions Between Advertisers and Third-party Data Sellers
Wangsheng Zhu, University of Texas at Dallas, Richardson, TX, United States, Shaojie Tang, Vijay S. Mookerjee

Every year, many online advertising slots are sold through auctions which attract a lot of advertisers. Compared with offline advertising, online advertising is more targeted. To better exploit this advantage, advertisers purchase user data and use it to select a better advertisement for each slot. Advertising platforms also realize the importance of user data. They provide technology supports for advertisers to integrate data acquisition into the auction process. Despite this, platforms are spectators of data transactions. In this study, we analyze a context in which the platform actively affects data transactions by either providing a subsidy or charging an extra fee for advertisers purchasing user data. We characterize the optimal subsidy (or fee) that depends on the game between advertisers. We also propose two subsidy mechanisms and compare their performances.

2 - Time and the Value of Data
Ehsan Valavi, PhD Candidate, Harvard Business School, Boston, MA, United States, Joel Hestness, Newsha Ardalani, Marco Iansiti

This research investigates the effectiveness of time-dependent data in improving the quality of AI-based products and services. We, theoretically, prove several counter-intuitive results. Having these results, we answer questions on how data volume creates a competitive advantage. We complement our theoretical results with an experiment.

3 - A Network Embedding Approach to Measure Competition
Jiaying Deng, University of Washington, Seattle, WA, 98105, United States, Yingfei Wang, Zhijie Lin, Yong Tan

Competition is a central concept of economic analysis and understanding the competitive market structure is essential for suppliers to derive a good competitive strategy. Leveraging a longitudinal data from a large peer-to-peer food-sharing platform, we construct a dynamic heterogeneous network among kitchens, dishes and customers. Then, a meta-path based random walker is adopted to learn the latent network representation and capture the competitive market structure among suppliers (kitchens). We integrate both the supply-based (i.e., dishes they provide) and demand-based (i.e., customers they serve) perspectives to identify the competitive market structure, and examine the interplay between competition, reputation and promotion on kitchens' performance.

4 - Matching Versus Wage Differentiation in Sharing Economy
Haozhao Zhang, University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Peng Wang, Zhe Zhang

In this study, we examine a ridesharing context where drivers have heterogenous costs of providing service qualities and the platform designs contracts for drivers to reveal their types. In practice, a ridesharing platform can offer contracts that tie a driver's service quality to either wage, or matching probability (i.e., the probability to match with a rider's request). We find that the ridesharing platform's choice of incentive compatible contracts, different wages or different matching probability, depends on factors like the difference in drivers' cost of providing service quality, the relative size of riders to drivers, and the distribution of driver types.

■ SC44

CC Room 213B

In Person: Supply Chain Management II

Contributed Session

Chair: Wen Zhu, Umass Lowell, Lowell, MA, 01851-5173, United States

1 - Supply Chain Management and COVID-19: Scientometric Analysis
Olga Biedova, Assistant Professor, College of Charleston, Charleston, SC, United States, Maryam Mahdikhani

Supply Chain Management (SCM) has matured in a well-researched and highly esteemed field. The ongoing pandemic intensifies interest in this field from the general public as well as various academic groups. In this study, we address the patterns in the SCM publications prior to and after the COVID-19 pandemic. In addition, we propose a novel method that utilizes supervised machine learning algorithms for predicting publication citation scores based on unsupervised latent topic analysis.

2 - Supply Chain Contracting for Network Goods
Dawei Jian, University of California-Riverside, Riverside, CA, United States

How should manufacturers sell network goods through retail channels? We study this new supply chain contracting problems, where the retailer can privately observe and control the evolving market conditions. The optimal contract resembles the classic second-best in the short run, but converges to the dynamic first-best in the long run.

3 - Order Batching And Driver Routing in an Uber Style Restaurant Delivery Operation
Wen Zhu, New Jersey Institute of Technology, Newark, NJ, United States, Marena Marco, Sanchoy Das

The time variant state of a restaurant delivery model is described by a set of customer orders and a set of available drivers. Order attributes are the associated restaurant, promised delivery time, and delivery location. Driver attributes are the available time and current location. We model a fixed cycle scheduling model with M orders, N drivers, and R restaurants. The batching and routing objectives are to minimize driver travel distance and order delivery tardiness. Drivers are capacitated but can pick orders from multiple restaurants.

■ SC45

CC Room 213C

In Person: Inventory Management I

Contributed Session

Chair: Antonio Arreola-Risa, Texas A&M University, College Station, TX, 77843-4217, United States

1 - Dynamic Stochastic Inventory Management in E-grocery Retailing
David Winkelmann, Universitaet Bielefeld, Bielefeld, Germany, Hermann Jahnke, Roland Langrock, Michael Roemer, Matthias Ulrich

Inventory management optimisation requires the determination of replenishment order quantities in a dynamic stochastic environment. Retailers are faced with stochastic determinants such as demand, supply shortages and spoilage. We develop a general model and investigate the importance of accounting for each source of uncertainty when designing inventory management policies. The modelling framework is illustrated in a business case using real-world data from a European e-grocery retailer.

2 - The Effect of Stockout Based Substitution on Fill Rates
Kevin Sweeney, Sam Houston State University, Huntsville, TX, United States, Heidi P. Celebi, Alan Pritchard, Phil Evers

In this research we construct a series of decision trees and a simulation model to examine the impact of stockout based customer switching on different fill rate metrics in a continuous review inventory system. Using a variety of target service levels and customer substitution probabilities, we find that the decision trees occasionally misestimate expected fill rates when compared to the simulation model, and that this misestimation is more likely and of larger magnitude in scenarios where both substitute item service levels and customer willingness to switch to a substitute item are high. Implications for managing retail inventory are discussed.

3 - Optimizing Inventory Placement in a Two-echelon Distribution System with Fulfillment-time-dependent Demand
Yue Wang, Texas A&M University, College Station, TX, United States, Joseph Geunes, Xiaofeng Nie

We study a two-echelon system where a fulfillment center supplies local distribution centers (LDCs) within committed resupply leadtime, and LDCs serve end customers within a committed delivery time (CDT). Expected system demand depends on price, CDT, and the number of LDCs (N), which are determined by a profit maximizing model. We characterize optimal solution structures and consider models for characterizing demand growth as N increases. The results provide insights on how operational scale and constraints influence strategic stock placement and distribution system structure.

4 - Designing Stockless Production Systems in the Presence of Manufacturing Disruptions
Antonio Arreola-Risa, Texas A&M University, College Station, TX, United States, Jordi Fortuny-Santos, Carla Vintró-Sánchez

In stockless production systems, an item is first demanded and then produced. We study the design of production systems with heterogenous items. Items demand is a Poisson process and unit production times are generally distributed random variables. Production experiences random disruptions of random duration. The objective is minimization of the long-run average holding and back-ordering costs. We establish conditions on the design variables process velocity and variability for which stockless operation is optimal.

■ SC46

CC Room 213D

In Person: Health Care, Strategy and Policy

Contributed Session

Chair: Shubham Akshat, University of Maryland, College Park, MD, 20742-1862, United States

1 - Vancomycin Dosing in Critically Ill Patients: A Machine Learning Approach
Mohammad Samie Tootooni, Assistant Professor, Loyola University Chicago, Maywood, IL, United States, Erin Barreto, Kianoush Kashani, Kalyan Pasupathy

As a nephrotoxic medication, both sub- and supra-therapeutic vancomycin trough concentrations have consequences. We aimed to identify the key predictive factors for the vancomycin steady-state trough level and their relative contribution and estimate the risk of a steady-state trough outside the goal range. Our models were tested via the left-out set in predicting sub-therapeutic (ROC: 0.85, Specificity: 0.53, and Sensitivity: 0.94) and supra-therapeutic (ROC: 0.83, Specificity: 0.47, and Sensitivity: 0.94) categories, respectively. We also developed an on-demand recommendation engine which offers the optimal dosing regimen for each individual.

2 - Developing a Novel Exact Model of Zoning Optimization for Marine Spatial Planning
Mohadese Basirati, IM T. Atlantique, Lab-STICC, UM R. CNR S. 6285, Brest F-29238, France, Brest, France, Patrick Meyer, Romain Billot

Marine spatial planning (MSP) as an efficient planning tool simplifies decisions on the sustainable use of marine resources. Determining an optimal zone for one marine user, considering the other users' activities, represents one challenge in MSP. We propose modeling the problem as an Exact Multi-Objective Integer Linear Program. We developed the raster data model to maximize the interest of the zone dedicated to a single actor and to maximize its spatial compactness. We are studying two approaches for resolution: first, a weighted sum and second, an improved augmented version of the -constraint method, AUGMECON2. We validate the model by performing experiments on artificially generated data.

3 - Does Broader Sharing Improve Patient Outcomes? Analysis of Share 35 Liver Allocation Policy
Shubham Akshat, University of Maryland, College Park, MD, United States, Liye Ma, Subramanian Raghavan

Broader sharing of organs is believed to mitigate geographic disparity in access to liver transplants. We build a structural model to study the impact of Share 35 policy, a variant of broader sharing introduced in 2013, on behavior changes and on patients' welfare. We find that Share 35 policy helped in reducing the geographic disparity. The sicker patients benefited from policy and became selective in accepting organs, however there was heterogeneity in behavior change across geographies in lesser sick patients. Collectively, not all geographies benefited from Share 35 policy. We conclude that the current acuity circles policy would result in lower patient welfare than the previous Share 35 policy.

■ Poster

CC – Exhibit Hall B, Foyer

In Person Poster Session

Poster Session

1 - A Dynamic Programming Model for Joint Optimization of Electric Drayage Trucks Operations and Charging Stations Planning at Ports
Xuanke Wu, University of South Carolina, Columbia, SC, United States, Yunteng Zhang, Yuche Chen

Port electrification is a promising strategy to achieve sustainability at ports, but its success depends on coordination of infrastructure planning and operation. This paper fills the knowledge gap by proposing a jointly optimization framework to co-optimize infrastructure decisions and operational scheduling to achieve the minimum system cost. The scheduling decision is modeled as a dynamic programming problem with sequential decision-making. We incorporate spatial and temporal heterogeneities of charging and driving costs of different truck trips.We implement our model on an empirical study to fulfill 5% of daily Twenty-foot Equivalent Unit containers in Port of LA and Long Beach.

2 - A Robust Optimization Approach for Robust Explicit Model Predictive Control
Iosif Pappas, Texas A&M University, College Station, TX, United States, Nikolaos A. Diangelakis, Richard Oberdieck, Efstratios Pistikopoulos

The adoption of explicit model predictive control (MPC) for a process control application includes uncertainty, which primarily stems from plant-model mismatch. Robust optimization has been utilized to solve such problems. However, an open challenge is their solution for a linear quadratic regulator formulation that avoids dynamic programming. We present an algorithm which reformulates the explicit MPC problem to its robust counterpart. Furthermore, linear transformations are employed to preserve the linearity of the feasible space. Finally, the robust solution of the problem is derived by solving a multiparametric optimization problem and its benefits are exhibited through an example.

3 - Selection, Scheduling of Project Portfolios under Profit Uncertainty and Limited Available Scientists by using Adaptive Robust Optimization
Hedieh Ashrafi, Southern Methodist University, Dallas, TX, United States, Aurelie Thiele

We present a model for the selection and scheduling of R&D projects with several phases. The initial problem concerns single-phase projects containing development costs and uncertain commercialization profits. The goal of this model is to maximize the net present value under limited scientists' availability and uncertain profit. Then, we provided the adaptive robust optimization model tackling multi-phase projects in which the new information regarding the previous phases was revealed during the time horizon. We compared the performance of our proposed approach in terms of running time and optimality gap in experiments with static robust optimization benchmarks.

4 - Mothers' Satisfaction from Childbirth Service in Israel
Iris G. Moryossef, Hadassah Academic College, Jerusalem, Israel Keren Orchen

Mother's satisfaction during childbirth influences well being as a mother and relationship with the baby. The study covers more than 300 Ultra-Orthodox Jewish and Non-Religious Jewish Mothers to be in Israel emphasize the importance of Personal Interaction with the mother as a significant factor for childbirth satisfaction for both segments' satisfaction during childbirth. The more responsiveness, empathy and engaged of the mother during childbirth, her satisfaction and safety increase. The surrounding atmosphere hygiene and aesthetic of the room was significant only for religious mothers. Results justify hospital's efforts in service provider.

5 - Drivers of Continuous Improvement Effectiveness During Covid-19: Evidence from the Nigerian Healthcare System

Bukola Bakare, Western Carolina University, Cullowhee, NC, United States, Marco Lam, Olawale Durosimi-Etti, Fuad Hassan

The global pandemic has taxed our modern-day health system in an unforeseen way. High demand for healthcare on already reduced resources, plus an economic downturn, is a recipe for a healthcare catastrophe in a developing country like Nigeria. As such, the implementation of continuous improvement initiatives is more important than ever. An open question then remains: how are healthcare frontline workers getting continuous improvement projects done in an extremely constrained space? This research addresses this question by investigating whether using a highly effective approach or building good relationships with employees is conducive to the success of total quality management initiatives.

6 - Forecasting the Short-Term Electric Load of Electric Reliability Council of Texas (ERCOT) Zones Using LSTM Based Deep Learning Networks

Yue Wang, Texas A&M University, College Station, TX, United States, Pouya Shojaei, Jayeon Kim

In this work, Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM) deep learning networks are applied to forecast the electricity demand in Electric Reliability Council of Texas (ERCOT) zones for a specific week. The regional electricity consumption trend is captured by RNN and the main predictors are extracted from the given time series historical electric load and weather data, which are then trained sequentially using LSTM networks. The forecasting performance of the proposed approach is evaluated with respect to the real power consumption data in the forecasted week.

7- A Data Science Approach on Covid19 Spread Countermeasures

Hamidreza Ahady Dolatsara, Assistant Professor, Clark University, Worcester, MA, United States, Gelareh Ahadi Dolatsara, Reza Poormajidi, Masoumeh Ghasemi Pirbalouti

This study employs a state-of-the-art data science approach to investigate factors contributing to the spread of COVID19. Then develops an Artificial Intelligence platform to facilitate a complex decision-making process for providing an efficient countermeasure.

8 - Analytical Lessons Learned From Covid19 Data Driven Researches

Hamidreza Ahady Dolatsara, Clark University, Worcester, MA, United States, Maryam Ahmadi

This study reviews recent analytical researches that employed Artificial Intelligence for investigating COVID19 data. These researches are mainly related to identifying factors associated to better health outcomes in both patient and society levels, and predicting a future status based of the recorded data. The outcomes of this study help medical practitioners to employ the right analytical tools and make more efficient decisions. More specifically in the countries like Iran which per capita COVID19 cases are high and the health budget is tight. Therefore, employing the most efficient practices that backed up with Artificial Intelligence could save many lives.

9 - Google Employee

Seyedali Nojabaei, Google Company, Kuala Lumpur, Malaysia

Scheduling aims to enhance the correlation between healthcare resources (doctors, nurses, rooms, equipment, medicines, procedures, and management) with patient recovery and transitions after hospitalization. This processes the availability of resources, forecasting future demands for service and automating the allocation of resources to requirements. The use of artificial intelligence in scheduling makes an efficient application of the capacity. Performance and reliability are becoming major aspects in the healthcare. Scheduling plays a significant role in maintaining it. To evaluate the proposed method, a hospital case study has been conducted to show the improvement of performance.

10 - Optimal Character Selection in DND

Michael A. Perry, Fresno State University, Fresno, CA, United States, Aaron Bradley Hoskins

The research uses a Monte Carlo simulation to determine character survival rate in a typical one day of adventuring in Dungeons and Dragons. The Duelist Algorithm is used as an outer loop to optimize the survival rate of the adventuring party. Comparisons to other metaheuristics are also provided.

11 - Irrational Exuberance on the Crowdfunding Studies the Effect of the Covid-19 Pandemic and Government Intervention on the Project Supply and Backer Demand of Kickstarter.

Dan Liu, Florida State University, Tallahassee, FL, United States Guangzhi Shang, Cynthia fan Yang

For reasons no one can explain, crowdfunding is surging during the pandemic with strong support from backers. We conducted this research to study the effect of covid-19 and government intervention on project supply and backer demand of crowdfunding. By analyzing the data from Kickstarter, we detected that while COVID negatively influences project supply, backers' support increases due to COVID-evoked empathy. Our findings inform entrepreneurs to make optimal fundraising decisions, and advise crowdfunding platforms and policymakers on facilitating small-business financing, especially during economic downturns.

12 - Nonlinear Binary Classification with Imbalanced Dataset Using Active Learning Based on Nonparametric Logistic Regression

Wonjae Lee, University of Missouri, Columbia, MO, United States, Kangwon Seo

The imbalance problem in a dataset is ubiquitous and inherent in data science which causes serious bias in a predictive model. It is also doubtful that the true function of classification is actually linear in covariates. This research proposes a novel data-level technique using an active learning (AL) scheme with nonparametric logistic regression to address the imbalance problem considering the nonlinear decision boundary. The preliminary experiment shows that the downsampling strategy using AL with a nonparametric model provides better performance compared to the random downsampling.

13 - Extracting the Collective Wisdom of Experts in Probabilistic Judgments

Cem Peker, Erasmus University Rotterdam, Rotterdam, Netherlands

How should we combine disagreeing expert judgments on the likelihood of an event? Despite its intuitive appeal, simple averaging produces an inconsistent estimator when experts have shared information. This paper proposes a novel Bayesian aggregation algorithm where experts are asked to report a probabilistic prediction and a meta-prediction. The latter is an estimate on the average of other experts' predictions. Three experimental studies suggest that the Surprising Overshoot algorithm consistently outperforms simple averaging. Furthermore, the algorithm compares favorably to alternative aggregation algorithms in questions where experts disagree greatly.

14 - Predicting Scan Quality: A Comparison of Machine Learning Models

Neda Sayahi, Wayne State University, Detroit, MI, United States, Jeremy Lewis Rickli

As a relatively new technology in manufacturing metrology, X-Ray computed tomography has recently become more established. However, setting scan parameters in a quick and proper manner is challenging due to high operator dependency and lack of traceability. We argue that machine learning (ML) can accelerate parameter setting process by eliminating the need for manual setting. In this work, the accuracy of four ML methods on predicting scan quality (whether the scan will be feasible or infeasible), given a set of parameters, are compared. The results indicated that multi-layer perceptron predicted the quality of scan with high accuracy and outperformed the other methods.

15 - LP-based Characterizations of Solvable Cases of the Quadratic Assignment Problem

Peter Liu, Bucknell University, Lewisburg, PA, United States, Swarup Dhar, Lucas Waddell

The quadratic assignment problem (QAP) is perhaps the most widely studied nonlinear combinatorial optimization program. It boasts many applications in a variety of fields but is notoriously difficult to solve. Due to this difficulty, researchers have sought to identify special objective function structures for which the QAP is in fact readily solvable. We explain several such seemingly unrelated solvable cases in terms of the continuous relaxations of various mixed-integer linear reformulations of the QAP that are derived using the reformulation-linearization technique (RLT).

16- Eigen-entropy: A Metric for Sampling Decision

Jiajing Huang, Arizona State University, Tempe, AZ, United States Hyunsoo Yoon, Ojas Pradhan, Teresa Wu, Jin Wen, Zheng O'Neill

Sampling is to identify a representative data subset capturing characteristics of the whole dataset. Existing sampling algorithms have some limitations including required assumptions on data distributions or models. In this study, a new metric, termed Eigen-Entropy, is proposed, derived based on eigenvalues extracted from correlation coefficient matrix on multivariate data. The performance of the proposed method is evaluated using real building case studies. Evaluation results indicate that the proposed method outperforms the methods from existing literature in terms of accuracy while maintaining smaller number of samples.

17- Or-net: An Efficient Network for Solving Integer Programs with Deep Learning

Ashton C. Kappelman, Kansas State University, Manhattan, KS, United States, Ashesh K. Sinha

A new neural network architecture (OR-Net) is introduced for solving integer linear programs efficiently. This network focuses on building connections that explore the orthogonal relationships between an integer program's coefficients. We outline implementation techniques for this OR-Net and apply it to a common knapsack problem utilizing a deep reinforcement learning framework.

18 - Conjecture on the Design of First Come First Served Skilled Parallel Service Systems
Gideon Weiss, University of Haifa, Haifa, Israel

Customers of several types are served by servers of different skills, subject to a bipartite compatibility graph. Service is first-come-first-served, FCFS, assign-longest-idle-server,.ALIS. With general service distributions this is an intractable system, it is even impossible to determine its stability. We model this as a problem of FCF S. matching of two multi-Bernoulli sequences, for which we can calculate matching rates. Based on these matching rates we obtain designs of work force that achieves quality of service as well as high utilization of resources. This is based on the conjecture that large volume many server systems converge to independent Poisson processes.

19 - Hyperparameter Optimization of Deep Neural Networks with Applications to Medical Device Manufacturing
Gautham Sunder, Carlson School of Management, Minneapolis, MN, United States, Christopher Nachtsheim, Thomas Albrecht

Bayesian Optimization (BO), a class of Response Surface Optimization (RSO) methods for nonlinear functions, is a commonly adopted strategy for Hyperparameter optimization (HO) of Deep Neural Networks (DNNs). Through a case study at a medical device manufacturer, we empirically illustrate that, in some cases, HO problems can be well approximated by a quadratic function, and in such cases BO is less efficient than Classical RSO (C-RSO) methods. When there is uncertainty in the complexity of the response function, we propose a highly efficient three staged batch sequential RSO strategy which estimates the response function complexity and adopts the best suited strategy between BO and C-RSO.

20 - Optimizing Moving Company Routes with COVID Restrictions
Mohamad Afkhami, Blend360, Columbia, MD, United States, Amir Nasrollahzadeh, Pip Courbois, Serhat Kecici

It is essential for an interstate moving company to know the size of the cargo in advance. Traditionally, this information was obtained through an in-person visit. With the in-place COVID restrictions, the companies have switched to relying on customers' estimate, which may cause last minute cancellation, either due to price difference from initial quote or the limited capacity of the truck. As a result, an additional source of uncertainty is introduced in the planning of the moving company. We propose a stochastic optimization framework that incorporates this uncertainty in the routing planning of the moving companies.

21- Optimal Experiment Designs for Marketing Mix Models
Amir Nasrollahzadeh, Blend360, Columbia, MD, United States, Mohamad Afkhami, Serhat Kecici, Pip Courbois

Marketing mix models optimize advertising spend across different offline media (e.g., TV) by simulating the return of spend at geographical levels using regression. Recently, these models have incorporated online attributions which measure the effect of online channels (e.g., web) on customer conversion as another input to the media mix model. However, this approach fails to capture marketing lag effects, diminishing returns, and channel interactions. We propose a reinforcement learning approach to marketing experiment designs which learns the underlying relationship between spend and customer behavior while optimizing the return on investment.

22 - Solving the Canadian Prize Collection Problem with Application to Assess The Impact of an Ongoing Humanitarian Disaster
John Becker, University at Buffalo, Buffalo, NY, United States Rajan Batta

We introduce the Canadian Prize Collection Problem (CPCP): a pathing problem from s to t on a graph G where the unknown ground truth is a subgraph of G. Next, we provide two approaches, prize collection and shortest path to prize collection, as heuristic methods. Then, we apply this research in the area of disaster relief and conduct computational testing.

23 - Using Simulation to Advance Branch and Bound Search: Example for TSP
Rajan Batta, University at Buffalo (SUNY), Buffalo, NY, United States, John Becker, Moises Sudit

First, we introduce a sampling procedure for evaluating the value of branch-and-bound nodes. We then describe several branching procedures which guide our branch-and-bound search. Finally, we test our heuristic on a myriad of problem classes and compare it with other heuristics incorporated in branch-and-bound such as Fischetti-Lodi local branching and A* algorithms.

24 - Predicting the Outcome and Overuse Of Invasive Mechanical Ventilation in the Intensive Care Unit
Maryam Alimohammadi, University of Arkansas, Fayetteville, AR, United States, Shengfan Zhang, Heather Nachtmann

Mechanical ventilation is one of the main interventions in intensive care units (ICUs) for patients with various diagnoses and conditions. Predicting the outcome of mechanical ventilation in patients admitted to ICU can help clinicians manage ventilation resources better and improve the patients'. In this research, we train multiple machine learning conditions models to predict the outcomes of invasive mechanical ventilation in ICU. This helps identify the critical observation windows for close monitoring of patients. Additionally, we develop a framework based on the random forest model, which outperforms other models in most cases, to decide when to stop ventilation.

25 - Improved Competitive Ratios for the Secretary Problem with Biased Evaluations
Kathryn Dullerud, University of Southern California, Los Angeles, CA, United States, R. Srikant

We consider a variant of an algorithm introduced by Salam and Gupta for the secretary problem where the candidates' evaluations are biased depending on the demographic group to which they belong. We present new competitive ratio results which improve existing bounds by a factor of e.

■ Poster Competition

CC – Exhibit Hall B, Foyer

In Person Poster Competition

Competition Poster Session

1 - Eigen-entropy: A Metric For Sampling Design
Jiajing Huang, Arizona State University, Tempe, AZ, United States Hyunsoo Yoon, Ojas Pradhan, Teresa Wu, Jin Wen, Zheng O'Neill

Sampling is to identify a representative data subset capturing characteristics of the whole dataset. Existing sampling algorithms have some limitations including required assumptions on data distributions or models. In this study, a new metric, termed Eigen-Entropy, is proposed, derived based on eigenvalues extracted from correlation coefficient matrix on multivariate data. The performance of the proposed method is evaluated using real building case studies. Evaluation results indicate that the proposed method outperforms the methods from existing literature in terms of accuracy while maintaining smaller number of samples.

2 - Predicting the Outcome and Overuse of Invasive Mechanical Ventilation in the Intensive Care Unit
Maryam Alimohammadi, University of Arkansas, Fayetteville, AR, United States, Shengfan Zhang, Heather Nachtmann

Mechanical ventilation is one of the main interventions in ICU. Predicting the outcome of mechanical ventilation in patients admitted to ICU can help clinicians manage ventilation resources better and improve the patients' conditions. In this study, we use multiple machine learning models to predict the outcome of invasive mechanical ventilation in ICU. The descriptive statistics of time-dependent variables are calculated based on multiple time windows during a patient's stay in the ICU. We develop a framework based on the best model, which outperforms other models in most cases, to decide when to stop ventilation.

3 - Costly Active Sensing of Structured Partially Observable Markov Processes
Xiaoqi Bi, University of Illinois, Urbana-Champaign, Champaign, IL, United States, Erik Miehling, Carolyn Beck, Tamer Basar

Gathering information to learn a hidden state process is often costly in practice. To model such scenarios, we propose an active sensing model for partially observable Markov decision processes (POMDPs), with a belief-based reward that quantifies uncertainty of the latent state, and a cost for sensing actions. A core element of our model is the structured distributions dictating the uncertainties in the POMDP. We assume the prior state distribution is conjugate to the observation likelihood. Such structure ensures beliefs are of the same family of distributions as the prior. The proposed model has various real-world applications, including allocation of diagnostic tests in uncertain epidemics.

4 - A Python API for Accessing Forest Inventory and Analysis Database in Parallel
Ashkan Mirzaee, University of Missouri, Columbia, MO, United States

Forest Inventory and Analysis (FIA) Program of the U S. Forest Service provides the information needed to assess America's forests. Many researchers rely on forest attribute estimations from the FIA program to evaluate forest conditions. The Python API is developed to collect large data from FIADB in parallel. In this project we used Python and Slurm workload manager to generate numerous parallel workers and distribute them across the cluster. The API is designed to scale up the query process such that by increasing processing elements the process expected to speedup linearly and can be set up and configured to be run on a single core computer or in a cluster for any given specifications.

5 - Identifying the Optimal Chronic Kidney Disease Screening Frequency Among Diabetics
Chou-Chun Wu, University of Southern California, Los Angeles, CA, United States, Sze-chuan Suen

Diabetes is a leading cause of chronic kidney disease (CKD), as 40% of diabetics will develop CKD in a lifetime. However, the rate of undiagnosed CKD among diabetics can be as high as 50%. We develop screening guidelines stratified by age, proteinuria status, and prior test history for diabetics by race and gender. We adopt a Partially Observed Markov Decision Process (POMDP) framework to identify the optimal action (screen or wait) every three months from ages 30-85 that maximizes a patient's discounted lifetime net monetary benefit (NMB). The optimal policy suggests more frequent screening in all race and gender groups compared with the annual screening policy recommended in the status quo.

6 - Effectiveness of an Mhealth Intervention on Glucose Monitoring for Older Adults with Diabetes in Taiwan: A Clinical Trial
Chou-Chun Wu, University of Southern California, Los Angeles, CA, United States, Shinyi Wu

Mobile health applications (apps) can support diabetes self-management activities but less than 10% of older adults with diabetes adopted an app. We analyze a clinical trial (N = 305) of an intergenerational mHealth program by comparing 4-month effectiveness on glucose monitoring between the intervention and the control group. We used propensity score matching method on the baseline demographics, diabetic symptoms, and complications to ensure group comparability. We found that patients in the intervention group significantly improved glucose monitoring and A1c control. This innovative program has the potential to be an effective diabetes improvement model for the post-COVID pandemic world.

7 - Designing Subscription Contracts for Two Sided Markets
Neha Sharma, Northwestern University, Evanston, IN, United States

a shared economy platform, users rent their assets in exchange for extra earnings. Most platforms offer asset financing options wherein, individuals can own the asset by incurring a recurring fee and can earn rental income to offset this fee by listing the asset on the platform.We study a car rental platform that lets users subscribe to a car by paying a monthly fee. We observe from data that with such contracts, 15-20 percent of users never list their cars. We study how the subscriber's listing behavior changes with contracts. Further, we find how these contracts change with the platform's budget and asset market price. We also study when is it optimal for a platform to have subscribers who do not list.

8 - Quantifying the Impact of Ecosystem Services for Landscape Management under Wildfire Hazard
Marie Pelagie Elimbi Moudio, University of California, Berkeley, Berkeley, CA, United Statesm Cristobal Pais

Effective planning for mitigating future expected losses under wildfire risk is a complex challenge. Previous works simplify the analysis by valuing the landscape using a unique objective(e.g., minimize the average expected area burned). We expand previous works by weighting multiple objectives and analyzing the trade-off between present objectives and future protection against wildfire risk. We study three regions based on their fire history, landscape, and demographic variety and obtain treatment plans reflecting how different priorities of the decision-makers could affect treatment policies.

9 - Political Polarization and Platform Migration: A Study of Parler and Twitter Usage by United States of America Congress Members
Jacqueline Otala, Clarkson University, Potsdam, NY, United States, Gillian Kurtic, Isabella Grasso, Yu Liu, Jeanna Matthews, Golshan Madraki

Growing dissatisfaction with platform governance decisions at social media platforms has led to efforts to shift to new platforms. We examine the effort on the political right to shift from Twitter to Parler in response to Twitter's increased efforts to flag 2020 US election misinformation. We analyze the usage of Parler by US Congress members and compare that to their usage of Twitter. Parler usage was small in comparison to Twitter, but was still impactful. It was linked to the planning of the January 6 2021 US Capitol building attack. This offers lessons about the relationship between platform migration, the impacts of platform governance decisions, and the splintering of our media landscape.

Sunday, 1:30PM 2:30PM

■ Sunday Keynote 01

CC Ballroom A /Virtual Theater 1

Keynote: Challenges in the Application of Mathematical Programming Approaches to Enterprise-wide Optimization of Process Industries

Keynote Session

1 - Challenges in the Application of Mathematical Programming Approaches to Enterprise-wide Optimization of Process Industries
Ignacio E. Grossmann, Carnegie Mellon University, Department of Chemical Engineering, Pittsburgh, PA, 15213, United States

Enterprise-wide optimization (EWO) is an area that lies at the interface of chemical engineering and operations research, and has become a major goal in the process industries due to the increasing pressures for remaining competitive in the global marketplace. EWO involves optimizing the operations of supply, production and distribution activities of a company to reduce costs and inventories. A major focus in EWO is the optimization of manufacturing plants as part of the overall optimization of supply chains. Major operational items include production planning, scheduling, and control. This talk provides an overview of major modeling and computational challenges in the development of deterministic and stochastic linear/nonlinear mixed-integer optimization models for planning and scheduling for the optimization of plants and entire supply chains that are involved in EWO problems. We address the following major challenges in this area: a) multi-scale optimization, b) linear vs. nonlinear models, c) handling of uncertainty and disruptions, d) multiobjective and multilevel optimization. We illustrate these challenges in areas such as planning and scheduling of batch plants, simultaneous optimization of supply chain planning with inventory policies, optimization of business transactional processes in digital supply chains, demand side management in power intensive processes, development of infrastructure for shale gas production, and design of resilient and responsive supply chains for chemical products. These problems, which have been addressed in collaboration with industry through a consortium, have led to substantial economic savings.

■ Sunday Keynote 02

CC Ballroom B /Virtual Theater 2

Keynote: Research, Data, and Policy at the Department of Transportation: An Overview

Keynote Session

1 - Research, Data, and Policy at the Department of Transportation: An Overview
Robert C. Hampshire, University of Michigan, Ann Arbor, MI, 48109-2150, United States

In this talk I will discuss elements of the Infrastructure Bill and the priorities of the Department of Transportation. Specially, I will discuss how the safety, equity, economic strength, and climate goals of the Department of Transportation can benefit from the active engagement of operations research and data science communities.

■ Sunday Keynote 03

CC Ballroom C /Virtual Theater 3

Keynote: Challenges and Opportunities for OR in Electricity Markets

Keynote Session

1 - Challenges and Opportunities for Operations Research in Electricity Markets
Shmuel S. Oren, University of California-Berkeley, Berkeley, CA, 95708, United States

Socio economic forces, development in generation technologies and environmental considerations have led to restructuring of the electric power systems in part of the USA and in many systems worldwide, transforming them from vertically integrated regulated monopolies to competitive market based systems. From a supply chain perspective competitive electricity markets represent, perhaps, the most challenging supply chain. The commodity is non-storable; demand is uncertain and highly correlated with weather, all the demand must be satisfied instantaneously with a high level of reliability (one day in ten years criteria for involuntary load curtailment). In addition service is provided over a network that is prone to congestion, flows over transmission lines cannot be directly controlled as in a transportation system (flows follow Kirchhoff's laws) and the market is encumbered by numerous externalities and market power. In spite of such obstacles there has been fascinating developments in the design and operations of competitive electricity markets over the last two decades through the use of state of the art optimization tools and economic principles. This talk will describe some of the key challenges in designing and operating competitive electricity markets. I will review the basic elements and alternative approaches adopted in different systems and discuss what we have learned so far in this area. I will also discuss new challenges and opportunities due to massive integration of renewable resources, proliferation of smart grid technologies and electrification of the transportation sector.

Sunday, 2:45PM 4:15PM

■ SD01

CC Ballroom A / Virtual Theater 1

Hybrid AAS Award Session

Sponsored: Aviation Applications

Sponsored Session

Chair: Alessandro Bombelli, Delft University of Technology, Delft, 2612 GR, Netherlands

Co-Chair: Alexandre Jacquillat, MIT Sloan School of Management, Cambridge, MA, 2142, United States

1 - Modeling of Supply-Demand Interactions in the Optimization of Air Transport Networks
Sebastian Birolini, University of Bergamo, Dalmine (BG), 24044, Italy

2 - Modeling and Control of Queuing Networks: Applications to Airport Surface Operations
Sandeep Badrinath, Massachusetts Institute of Technology, London, United States

3 - A Stochastic Integer Programming Approach to Air Traffic Scheduling and Operations
Alexandre Jacquillat, MI T. Sloan School of Management, Cambridge, MA, 2142, United States

■ SD02

CC Ballroom B / Virtual Theater 2

Hybrid HAS Graduating PhD Job Flash Session

Sponsored: Health Applications Society

Sponsored Session

Chair: Sait Tunc, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Pengyi Shi, Purdue University, West Lafayette, 47907, United States

■ SD03

CC Ballroom C / Virtual Theater 3

Hybrid APS Panel Discussion

Sponsored: Applied Probability Society

Sponsored Session

Chair: Shane Henderson, Cornell University, Ithaca, NY, 14853, United States

1 - Panelist
Jose Blanchet, Columbia University, Dallas, United States

2 - Panelist
Shane Henderson, Cornell University, School of ORIE, Rhodes Hall, Cornell University, Ithaca, NY, 14853, United States

3 - Panelist
Jim Dai, Cornell University & CUHK-Shenzhen, Ithaca, NY, 14853, United States

4 - Panelist
Amy R. Ward, The University of Chicago Booth School of Business, Chicago, IL, 60637-1610, United States

5 - Panelist
Devavrat Shah, Massachusetts Institute of Technology,, Cambridge, MA, 02139-4301, United States

■ SD04

CC Ballroom D / Virtual Theater 4

Hybrid MSOM Student Paper Competition II

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Vishal Agrawal, Georgetown University, Washington, 20057, United States

Co-Chair: Dragos Florin Ciocan, INSEAD, Fontainebleau, France

Co-Chair: Yanchong (Karen) Zheng, Massachusetts Institute of Technology, Cambridge, MA, 02142-1508, United States

1 - Online Policies for Efficient Volunteer Crowdsourcing
Scott Rodilitz, Yae University, New Haven, CT, 90278, United States, Vahideh Manshadi

Nonprofit crowdsourcing platforms encourage volunteers to complete tasks by using nudging mechanisms to notify a subset of volunteers with the hope that at least one of them responds positively. However, since excessive notifications may reduce volunteer engagement, the platform faces a trade-off between notifying more volunteers for the current task and saving them for future ones. Motivated by these applications, we introduce the online volunteer notification problem and develop an online randomized policy that achieves constant-factor guarantees. Further we demonstrate the effectiveness of our policy by testing it on data from a volunteer-based food recovery platform.

2 - Contextual Learning with Online Convex Optimization: Theory and Application to Chronic Diseases
Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, MI, 77807, United States, Mohammad Zhalechian, Cong Shi, Mark P. VanOyen, Pooyan Kazemian

We formulate a new contextual multi-armed bandit model under a two-dimensional control with a nested structure, where each arm (treatment) has a control (dosage) that affects the arm's performance. Reward (disease progression) is binary and is modeled as the outcome of a logistic random variable that depends on the chosen arm and a convex function of the corresponding control. We develop a joint contextual bandit learning and stochastic gradient descent algorithm, that integrates the strength of contextual bandit learning with online convex optimization. We prove a sub-linear regret, which is provably tight up to a logarithmic factor. We illustrate the effectiveness of our methodology by using case data on patients with type 2 diabetes.

3 - Distributionally Robust Batch Contextual Bandits
Nian Si, Stanford University, Stanford, CA, 94305, United States, Fan Zhang, Zhengyuan Zhou, Jose Blanchet

Policy learning using historical observational data is an important problem that has found widespread applications. However, existing literature rests on the crucial assumption that the future environment where the learned policy will be deployed is the same as the past environment that has generated the data—an assumption that is often false or too coarse an approximation.In this paper, we lift this assumption and aim to learn a distributionally robust policy with incomplete (bandit) observational data. We propose a novel learning algorithm that is able to learn a robust policy to adversarial perturbations and unknown covariate shifts. We first present a policy evaluation procedure in the ambiguous environment and then give a performance guarantee based on the theory of uniform convergence.

■ SD06

CC Room 303A

In Person: Causality, Machine Learning, and Optimization

General Session

Chair: Nur Kaynar, University of California-Los Angeles, Los Angeles, CA, 90049-5554, United States

1 - Exact Logit-Based Product Design
Irem Akcakus, Anderson School of Management, University of California-Los Angeles, Los Angeles, CA, United States, Velibor Misic

The share-of-choice product design problem is to find the product that maximizes market share arising from a collection of customer segments. When customers follow a logit model of choice, the market share is given by a weighted sum of logistic probabilities, leading to a challenging problem to solve: one must optimize an objective function that is neither convex nor concave, over an exponentially-sized set of attribute combinations. We develop an exact methodology for solving this problem based on modern integer, convex and conic optimization by showing that the resulting problem can be reformulated as a mixed-integer convex program, which can be further reformulated using conic constraints. Using synthetic problem instances and instances derived from real conjoint data sets, we show that our approach can solve large instances in operationally feasible time frames.

2 - Evidence-Based Policy Learning
Jann Spiess, Stanford Graduate School of Business, Stanford, CA, 94305-8526, United States, Vasilis Syrgkanis

The past years have seen the development of machine-learning algorithms to estimate personalized treatment-assignment policies from randomized controlled trials. Yet such algorithms often do not take into account that treatment assignments are frequently subject to hypothesis testing. In this project, we explicitly take significance testing of the effect of treatment-assignment policies into account, and consider assignments that optimize the probability of finding subsets with a statistically significant positive treatment effect. We provide an efficient implementation using decision trees, and demonstrate its gain over selecting subsets based on positive (estimated) treatment effects. Compared to standard tree-based regression and classification tools, this approach tends to yield substantially higher power in detecting positive treatment effects.

3 - Discovering Causal Models with Optimization: Confounders, Cycles, and Feature Selection
Nur Kaynar, University of California-Los Angeles, Los Angeles, CA, 90049-5554, United States, Auyon Siddiq, Frederick Eberhardt

The recent advancements in graphical approaches to causality have opened new opportunities to learn the underlying causal relations systematically from observational data. In this work, we propose a new method for causal structure discovery that allows for both unmeasured confounders and feedback cycles. Our new representation of the inference as an integer optimization enables us to solve instances in minutes that are intractable for current state-of-the-art methods. We then demonstrate how our method can be used to shed light on the validity of a proposed instrument in a simple and intuitive manner.

■ SD08

CC Room 303C

In Person: Social Media and Platform Economy

General Session

Chair: Luna Zhang, University of Washington-Tacoma, Tacoma, WA, 98402-3100, United States

1 - Analysis of Orange County 311 Non-emergency Call System During the Covid-19 Pandemic
Duygu Pamukcu, Virginia Tech, Blacksburg, VA, United States, Christopher W. Zobel

Local governments are responsible for maintaining necessary services and quickly and timely informing citizens before, during, and after an emergency. To do this, governments implement smart information and communication technologies in public services. This study examines the 311 non-emergency call system reactions in the U.S. metropolitan areas to reflect the COVID-19 pandemic. We investigate if the 311 system can capture citizen needs and complaints about the pandemic. 311 system collects and reports a highly structured and location-based dataset similar to social media data in some ways. We provide a comparative analysis with geolocated tweets from the same region to examine if the 311 system is a valuable source of information and if there are additional advantages of using the 311 system over social media data to identify service needs during a crisis.

2 - Digital Platforms and Race-Related Classroom Curriculum: Evidence from Black Lives Matter
Ananya Sen, Carnegie Mellon University, Pittsburgh, PA, United States

We study whether digital platforms can be a force for equality in the context of systemic racism. We use requests made by teachers on DonorsChoose.org as a measure of demand for race-related conversations in the classroom. We use the precise timing of high-profile police brutality events to identify the effect on race-related requests. We find a significant increase in race-related requests with the effect being driven by the killing of George Floyd in 2020. These requests are related to books written by Black authors and those that have Black protagonists. There are significant spillovers related to other minority communities such as Asians and Hispanics. The impact is higher for schools that witnessed a protest in the city. We find no polarization on the platform with requests coming from both Republican and Democratic zip-codes.

3 - Revenue-sharing Designs for Platforms
Luna Zhang, University of Washington-Tacoma, Tacoma, WA, 98402-3100, United States, Hemant K. Bhargava, Kitty Wang

Platforms motivate value creators by sharing platform revenue with them. Major platforms today use a linear revenue-sharing scheme. We explore alternative designs for revenue-sharing between the platform and creators, and apply our insights to the tensions that have arisen between platforms and creator-partners.

■ SD09

CC Room 303D

In Person: Design and Control of Queues and Applications in Healthcare Systems

General Session

Chair: Jing Dong, Columbia University, New York, NY, 10027-6945, United States

1 - A New Approach to Global Stability of Multiclass Queueing Networks
Feiyang Zhao, The University of Texas at Austin, Austin, TX, 78731-2434, United States, John Hasenbein, Itai Gurvich

The focus of this research is on the global stability of stochastic processing networks, under a wide class of control policies. A framework for global stability is developed, in which the resources are given freedom to decide their own priority policy, under some general constraints. We offer a new approach for determining sufficient conditions for global Skorohod Problem (SP) stability, which builds on, and makes connections to, suitable robust optimization problems, with the collection of priority policies as the uncertainty set. We also show how global SP stability of a family of policies is inherited from the stability of static-priority policies.

2 - Skills-based Routing under Demand Surges
Jinsheng Chen, Columbia University, New York, NY, 10027-6714, United States, Jing Dong, Pengyi Shi

Many service systems employ dedicated staffing with cross-training to provide partial flexibility. Servers primarily serve specific classes of customers, but may serve other classes if necessary, at the cost of inefficiency. For example, during a pandemic, nurses trained in other specializations may be reassigned to take care of patients who have contracted the infectious disease.We consider a multi-class multi-pool parallel server system with partial flexibility, under general time-varying arrival rates. We derive near-optimal scheduling policies that minimize the sum of holding and "overflow" costs. Our policy is simple, intuitive, and makes use of future arrival rate information.

■ SD10

CC Room 304B

In Person: Cutting-Edge Methods for Data-Driven Decision-Making

General Session

Chair: Fei Fang, Duke University, Durham, NC, 27705-4547, United States

1 - Online Learning via Offline Greedy Algorithms: Applications in Market Design and Optimization
Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, 94305-5008, United States, Negin Golrezaei, Fransisca Susan, Joshua Wang, Ashwinkumar Badanidiyuru

Motivated by online decision-making in time-varying combinatorial environments, we study the problem of transforming offline algorithms to their online counterparts. We focus on offline combinatorial problems that are amenable to a constant factor approximation using a greedy algorithm that is robust to local errors. For such problems, we provide a general framework that efficiently transforms offline robust greedy algorithms to online ones using Blackwell approachability. Demonstrating the flexibility of our framework, we apply our offline-to-online transformation to several problems at the intersection of revenue management, market design, and online optimization.

2 - Decision Forest: A Nonparametric Approach to Modeling Irrational Choice
Yi-Chun Chen, UCLA Anderson School of Management, Los Angeles, CA, United States, Velibor Misic

We propose a new nonparametric choice model that can represent any customer choice model, including those that are inconsistent with weak rationality. In the proposed model, each customer type is associated with a binary decision tree, which represents a decision process for making a purchase based on checking for the existence of specific products in the assortment. We theoretically characterize the model complexity and propose two practical estimation methods. Using real-world transaction data, we show that the proposed model outperforms benchmark models in out-of-sample predictive ability. We also demonstrate how the proposed model can extract insights about substitution and complementarity effects and identify interesting customer behaviors within a specific product category.

3 - Estimating Direct Causal Effect under Hierarchical Interference On Networks In Observational Studies

Fei Fang, Duke University, Chapel Towers Durham, NC, 27705-4547, United States, Alexandre Belloni, Alexander Volfovsky

We study causal estimators for direct treatment effect under interference given network and treatment assignment. Our estimators are constructed by hierarchical trees whose nodes represent distinguished pattern graphs, under interference associated with treated neighborhood graphs. Applying our pruning procedure to these trees, oracle inequalities and corresponding adaptive rates are established to the estimators. Our results are generic to different hierarchical structures of interference and data generating processes. A theoretical example whose explicit rate of convergence is investigated when the graph is generated by stochastic block model. Finally, we examine the empirical performance of our estimators by simulations and real datasets.

■ SD13

CC Room 201A

In Person: Network Optimization and its Applications

General Session

Chair: Illya V Hicks, Rice University, Houston, TX, 77005-1827, United States

Co-Chair: Samuel Kroger, Rice University

1 - MIP Formulations for Solving the Maximum Anchored K-core Problem

Samuel Kroger, Rice University, Houston, TX, United States, Hamidreza Validi, Illya V. Hicks

In this talk, we investigate two mixed integer programming (MIP) formulations for the maximum anchored k-core problem. We compare the MIP formulations analytically and computationally. Furthermore, we propose valid inequalities and fixing procedures to improve their computational performance. Finally, we conduct an extensive set of experiments to evaluate the performance of the MIP formulations. Joint Work with Hamidreza Validi and Illya V. Hicks

2 - An Improved Approximation for Maximum K-dependent Set on Bipartite Graphs

Sergiy Butenko, Texas A&M University, College Station, TX, 77841-3131, United States, S. Mohammad Hosseinian

We present a (1+k/(k+2))-approximation algorithm for the Maximum k-Dependent Set problem on bipartite graphs for any positive integer constant k. The algorithm runs in $O(k m \sqrt{n})$ time and improves upon the previously best-known approximation ratio of 1+k/(k+1) established by Kumar et al. [Theoretical Computer Science, 526: 90-96 (2014)].

■ SD15

CC Room 201C

In Person: Empirical Research in Health Care Operations

General Session

Chair: Jong Myeong Lim, The Wharton School, Philadelphia, PA, 19104, United States

1 - Nonprofit vs. For-profit: Allocation of Beds And Access to Care in U.S. Nursing Homes

Yangzi Jiang, Northwestern University, Evanston, IL, 60201, United States, Lauren Xiaoyuan Lu, Jan A. Van Mieghem

Motivated by empirical observations of U.S. nursing homes, we formulate a queueing network model to study nursing homes' bed allocation decisions and the resulting access to care for economically disadvantaged populations. To distinguish nonprofit from for-profit nursing homes, we incorporate altruism into a nonprofit nursing home's objective function to capture resident welfare including the blocking cost of high-margin Medicare residents and the waiting cost of low-margin Medicaid residents. Our theoretical and empirical findings inform the public that the growth of the for-profit nursing home segment does not necessarily hurt the access to care for the Medicaid population, and surprisingly, under high Medicaid demand, for-profit nursing homes might provide higher access to care than their nonprofit counterparts.

2 - Liver Cancer Screening after Hepatitis C Cure: Updating the Outdated Risk Threshold for Screening

Ali Hjaar, Harvard Medical School, Mass General Hospital, Boston, MA, United States, Jagpreet Chhatwal, Peter Mueller, Gizem Nemutlu, Mary L. Peters, Leigh Anne Dageforde, Fasiha Kanwal

The number of hepatitis C-cured patients is rapidly rising but these patients remain at risk of liver cancer (LC). The current screening guidelines recommend semi-annual screening if the patient's annual risk of LC >1.5%. However, this threshold is considered outdated as LC treatments have improved substantially since these guidelines were published. In this analysis, we investigated the cost-effectiveness of LC by developing a microsimulation model of the natural history of hepatitis C-cured patients and using the latest published data on LC progression, treatments, and surveillance adherence. We found that semi-annual screening is cost-effective in patients with cirrhosis if LC risk>0.4%.

■ SD16

CC Room 201D

In Person: Mining Digital Trace Data of Online Communities

General Session

Chair: Tianjie Deng, University of Denver, United States

1 - Are Critics Really Unbiased? The Impact of Social Ties on Critics' Rating Behavior

Tianxi Dong, Assistant Professor, Trinity University, San Antonio, TX, United States, Tianjie Deng, Thomás Peña

Grounded in the differentiation theory, this study aims to empirically investigate the relationship between social ties and the rating similarities between critics. We collected an extensive data set from Rotten Tomatoes exploring the critics' social relations in conjunction with their movie-rating behavior. We find that loners (critics who have no connections) give higher ratings than non-loners (critics with at least one connection). What is more, critics tend to give lower ratings when they have more connections. In terms of social tie strengths, critics with strong ties appear to provide similar ratings. These findings raise questions about the reliability of critic ratings as unbiased indicators of quality. Platform stakeholders can adjust their strategies to account for possible review biases resulting from the social interactions among critics.

2 - Preserving History: Archiving Search Query Results for Future Research

Joshua Madden

Efforts to preserve web pages have been dramatically increased in the past decade. Cheaper data storage and faster processing have allowed for an increase in the number websites archived and the frequency with which they are archived. However, archiving the results of search queries presents unique challenges not easily addressed by traditional web crawling methods. This research outlines some of the potential challenges and presents some possible solutions for archiving these types of pages.

3 - A Reinforcement Learning Algorithm for Online Personalized Tutor Recommendation

Mohamad Kazem Shirani Faradonbeh, University of Georgia, Athens, GA, United States

Intelligent computerized education reduces costs of tutoring by learning from the trajectories of the students. We present a data-driven algorithm implemented on an online platform for recommending personalized tutoring to students. To do so, multiple important challenges are addressed. First, the experiments for collecting data need to be diverse for exploring student responses, while at the same time they must focus on the immediate weakness of each student. Moreover, there are many tutoring items, but each student provides an extremely small data. Further challenges as well as employed methods that utilize student backgrounds for combining the data will be discussed.

■ SD18

CC Room 202B

In Person: Macro Energy Systems: Energy and Climate

General Session

Chair: Tyler Ruggles, Research Scientist, Carnegie Science, Stanford, CA, United States

1 - Operational Flexibility of Natural Gas Combined Cycle Power Plant Coupled with Flexible Carbon Capture and Storage

Fangwei Cheng, Princeton University

Achieving net-zero economy requires affordable low carbon or carbon neutral power systems. Natural gas combined cycle (NGCC) coupled with carbon capture and sequestration (CCS) enables continuous consumption of fossil fuels for power generation with minimal CO2 emissions. In this study, we apply integer clustering and linear relaxation unit commitment (UC) to the subcomponents (e.g., gas turbine, steam turbine, absorber, and regenerator) of NGCC coupled with flexible CCS and compare the results against the conventional binary UC. Our results show integer clustering/linear relaxation UC of NGCC-CCS subcomponents leads to substantial run time reduction with marginal errors. We also study how flexible NGCC-CCS affects the economic, environmental, and generation dispatch profiles under a wide range of carbon price (0-120 $/t) and variable renewable capacity.

2 - Incorporating Learning-by-Doing Into Mixed Complementarity Equilibrium Models

Benjamin D. Leibowicz, Assistant Professor, University of Texas-Austin, Austin, TX, 78712-1591, United States, Baturay Calci, Jonathan F. Bard, Gopika Jayadev

Energy market equilibrium models are often specified and solved as mixed complementarity problems (MCPs). A limitation of existing MCPs is that they treat costs as exogenous input parameters. Therefore, MCPs have not been able to capture learning-by-doing (LBD), the empirically observed phenomenon whereby production costs tend to decline as a function of cumulative production experience. In this paper, we demonstrate the incorporation of LBD into a mixed complementarity equilibrium model. Through theoretical analysis and numerical exploration, we establish the conditions under which LBD formulations lead to convex optimization problems, which is important for inclusion in an MCP. Then, we demonstrate the practical application of a mixed complementarity equilibrium model with LBD using the North American natural gas market as an example.

3 - How Many Years of Data is Enough?: Using Multiple Years of Data to Increase Performance of Electricity System Models

Tyler H. Ruggles, Research Scientist, Carnegie Science, Stanford, CA, United States, David J. Farnham, Nathan S. Lewis, Ken Caldeira

Wind and solar generation are both subject to geophysical variability in their power output from hour to hour and on longer time scales. Recent studies looked at the frequency and duration of resource droughts that could have detrimental impacts of wind- and solar-powered energy systems. In this study, we use multi-decadal historical electricity demand and wind and solar data to study reliable least-cost electricity systems optimized over multiple years of input data. We show how asset capacities and system cost increase as a function of the number of years of input data (Nyrs). The performance of systems improves as a function of Nyrs when tested on out-of-sample years of data, which may help guide long-term system planning decisions.

■ SD19

CC Room 203A

In Person: Predictive Analytics Towards Improved Health Outcomes

General Session

Chair: Maryam Kheirandish, University Arkansas, AR, United States

Co-Chair: Sasa Zorc, University of Virginia, Darden School of Business, Charlottesville, VA, 22903, United States

1 - Using Simple Optimization Methods to Enhance the Development of Stratified Models for Infectious Disease

Anthony C. Nguyen, PhD Student, University of Southern California, Los Angeles, CA, 92886-9014, United States, Sze-chuan Suen

Infectious disease models are powerful tools for assessing health policy benefits. It is critical to stratify these models by demographic characteristics, such as race/ethnicity and age, if prevalence, incidence, transmission, or treatment vary across these factors. However, this may be challenging as limited subpopulation-specific data may be available. We use simple optimization techniques to parameterize a race- and age-stratified model of HIV in Los Angeles given limited data from publicly available surveillance reports. Given these straightforward formulations, we hope these formulations can be widely adopted among modelers in public health and epidemiological disciplines.

2 - Feature Engineering for Opioid Overdose Prediction

Shengfan Zhang, University of Arkansas, Fayetteville, AR, 72701, United States, Ryan Sanders, Maryam Alimohammadi

We develop an efficient methodology for extracting features from time-dependent variables in transaction data. Transaction data is collected at varying time intervals making feature extraction more difficult. Unsupervised representational learning techniques are investigated, and the results compared with those from other feature engineering techniques. This methodology is then applied to insurance claims data in order to find features to predict whether a patient is at risk of opioid overdose. Features created are input to recurrent neural networks with long short-term memory cells. Hyperparameters are found through Bayesian optimization. Validation data features are reduced using weights from the best model and compared against those found using unsupervised learning techniques in other classifiers.

3 - Pricing the Covid-19 Vaccine: A Mathematical Approach

Banafsheh Behzad, California State University-Long Beach, Long Beach, CA, 90808-0506, United States, Susan E. Martonosi, Kayla Spring Cummings

We use optimization and game theoretic approaches to model the COVID-19 U.S. vaccine market as a duopoly with two manufacturers Pfizer-BioNTech and Moderna. The results suggest that even in the context of very high production and distribution costs, the government can negotiate prices with the manufacturers to keep public sector prices as low as possible while meeting demand and ensuring each manufacturer earns a target profit. Furthermore, these prices are consistent with those currently predicted in the media.

■ SD20

CC Room 203B

In Person: But, what if we were Wrong: Modeling and Analysis of Policy-related Strategies Against the COVID-19 Pandemic

General Session

Co-Chair: Dan Yamin, Tel Aviv University Iby and Aladar Fleischman Faculty of Engineering, Rehovot, Israel

1 - Early Detection of COVID-19 Outbreaks Using Human Mobility Data

Grace Guan, Stanford University, Stanford, CA, United States, Yotam Dery, Matan Yechezkel, Irad Ben-Gal, Dan Yamin, Margaret Brandeau

To appropriately target the timing, location, and severity of measures intended to reduce COVID-19 spread, it is essential to predict when and where outbreaks will occur, and how widespread they will be. We analyze aggregated, anonymized health and cell phone mobility data from Israel. We develop predictive models for daily new cases and the test positivity rate to predict the severity of COVID-19 in districts of Israel over the following week. Models using mobility data outperformed models that did not use mobility data. Our models accurately predict outbreak severity as defined by the tiers. Our method provides a useful tool for government decision makers.

2 - Human Mobility and Poverty as Key Drivers of COVID-19 Transmission and Control

Matan Yechezkel, Tel Aviv University, Tel Aviv, Israel

Applying heavy nationwide restrictions is a powerful method to curtail COVID-19 transmission but poses a significant humanitarian and economic crisis. We analyzed aggregated and anonymized mobility data from the cell phone devices of >3 million users in Israel. We integrated these mobility patterns into age-, risk- and region-structured transmission model. We found that localized and temporal interventions during regional outbreaks, that focus on individuals at risk, can substantially reduce mortality. Utilizing cellphone data despite being anonymized and aggregated can help policymakers worldwide identify hotspots and apply designated strategies against future COVID-19 outbreaks.

3 - A Multilayer Model for Early Detection of COVID-19

Dan Yamin, Tel Aviv University, Tel Aviv, Israel, Erez Shmeuli, Ronen Mansuri, Matan Porcilan, Tamar Amir, Lior Yosha, Matan Yechezkel, Tal Patalon, Sharon Handelman-Gotlib, Sivan Gazit

We developed a machine-learning model, for COVID-19 detection that utilizes four layers of information: 1) sociodemographic characteristics of the tested individual, 2) spatiotemporal patterns of the disease observed near the testing episode, 3) medical condition and general health consumption of the tested individual over the past five years, and 4) information reported by the tested individual during the testing episode. Analyzing data of 140,682 individuals, our model obtained an area under the curve of 81.6%. Our ability to predict early the outcomes of COVID-19 tests is pivotal for breaking transmission chains, and can be utilized for a more efficient testing policy.

■ SD21

CC Room 204A

In Person: Empirical Studies in Healthcare Operations

General Session

Chair: Hyun Seok (Huck) Lee, Korea University Business School

1 - Machine Learning Methods to Predict Operational Surges in the Emergency Department During Covid-19

Ari J. Smith, University of Wisconsin Madison, Madison, WI, United States, Justin J. Boutilier, Manish Shah, Brian Patterson, Michael Pulia, Frank Liao

The context of the Covid-19 pandemic has led to new perceptions of the factors that contribute to emergency department arrival and admission rates. We create machine learning models using recent department and patient-level data collected in an ED in conjunction with community Covid-19 metrics to predict the volume of arriving and admitted patients in short time frames. Predictions will motivate training activities and operational decisions in preparation of surges.

2 - Negative Spillover on Service Level Across Priority Classes: Evidence From a Radiology Workflow Platform

Bernardo (Bernie) F. Quiroga, Pontificia Universidad Catolica de Chile, School of Management, Macul, Santiago RM, Chile, Timothy Chan, Nicholas Howard, Saman Lagzi, Gonzalo Romero

We study a radiology workflow platform connecting off-site radiologists with hospitals: Tasks are selected from a common pool, and the service level is characterized by meeting priority-specific turnaround time targets. Imbalances between pay and workload of different tasks could result in higher priority tasks with low pay relative to workload receiving poorer service than low priority tasks. We analyze, using IV regressions, if low priority tasks with a high pay-to-workload ratio have shorter turnaround times, and if low priority tasks with high pay-to-workload increase turnaround times and probability of delay of higher priority tasks (negative spillover). We find evidence that turnaround time decreases in pay-to-workload for lower priority tasks, increases in workload for high priority tasks, and also presence of a negative spillover effect.

3 - The Success of Women Leadership in Fighting Covid-19: Evidence from U.S. Nursing Homes

Poyraz Bozkurt, Purdue University, West Lafayette, IN, United States, Susan F. Lu, Lauren Xiaoyuan Lu

Using the U.S. nursing home data, we investigate the impact of women leadership on Covid-19 infection and death rates in nursing homes. We observe that a higher number of women directors in management teams results in fewer Covid-19 infections. We further investigate the mechanisms by analyzing staff planning, PPE shortages and weekly visitors. Our findings suggest that women leadership leads to higher staffing and quality ratings. Moreover, nursing homes led by female directors are more likely to have weekly availability of PPE supply. While these results are significant for all nursing homes, our analysis reveals that the impact of female managers is weaker in for-profit nursing homes.

4 - Learning in Drug Shortages

Hyun Seok (Huck) Lee, Korea University Business School, Seoul, 97333-3235, Korea, Republic of, Junghee Lee, In Joon Noh

In this study, we investigate whether pharmaceutical manufacturing plants learn from their own drug shortage instances. Specifically, we examine if more drug shortages recovery at a plant lead to quicker recovery from its subsequent shortages. We also investigate factors that might affect this learning. Our findings will have policy implications for the FDA and will also contribute to the academic literature on learning.

■ SD22

CC Room 204B

In Person: OR Methods for Health Policy Design

General Session

Chair: Saumya Sinha, Rice University, Houston, TX, 77005-1827, United States

1 - Multi-year Optimization of Malaria Intervention: A Mathematical Model

Susan E. Martonosi, Professor, Harvey Mudd College, Claremont, CA, 91711-5901, United States, Harry Dudley, Abhishek Goenka, Cesar Orellana

Malaria is a mosquito-borne, lethal disease that affects millions and kills hundreds of thousands of people each year, mostly children. In this paper, we couple a susceptible-infected-recovered compartment model for the disease dynamics with an integer linear program to allocate malaria interventions across geographic regions and time, subject to budget constraints, with the aim of minimizing the number of person-days of malaria infection. The model provides a qualitative decision-making tool to weigh alternatives and guide malaria eradication efforts. A one-size-fits-all campaign is found not to be cost-effective; it is better to consider geographic variations and changes in malaria transmission over time when determining intervention strategies.

2 - Combination Chemotherapy Optimization

Temitayo Ajayi, Nature Source Improved Plants, Ithaca, NY, 77004, United States, Dave Fuller, Andrew J. Schaefer, Mohammad Hosseinian

Chemotherapy is one of the primary modalities of cancer treatment. Chemotherapy drug administration is a complex problem that often requires expensive clinical trials to evaluate potential regimens. One way to better inform future trials is to build reliable models that illustrate how a patient may react to specified drugs and doses. Previous chemotherapy optimization models have relied on optimal control, which does not lend itself to discrete considerations such as doses via pills and rest periods. In this paper, we develop mixed-integer linear programming models for combination chemotherapy that incorporate various important operational constraints. We also address uncertainty in the tumor heterogeneity with a chance constraint.

3 - Incentives in Outcome-based Regulation for Organ Transplantation

Saumya Sinha, Rice University, Houston, TX, 77005-1827, United States, David Mildebrath, Taewoo Lee, Andrew J. Schaefer

Federal agencies use outcome-based regulatory criteria for oversight of transplant programs, aiming to incentivize programs to improve their post-transplant outcomes. However, clinical evidence indicates that the regulations may induce programs to reject medically suitable patients to avoid penalization. We present a game-theoretic model of transplant programs to analyze the incentives created by these regulations. We demonstrate that excessively harsh penalization, more so than other factors, incentivizes programs to engage in adverse patient selection. We propose an alternative pay-for-performance reimbursement scheme which penalizes underperforming programs and pays a bonus to programs with above-average outcomes. The proposed scheme can incentivize programs to improve post-transplant outcomes without inducing adverse patient selection.

■ SD23

CC Room 204C

In Person: Service Workforces

General Session

Chair: Vincent Slaugh, Cornell University, Genoa, NY, 13071, United States

1 - Staffing for Housekeeping Operations

Buyun Li, Indiana University, Bloomington, IN, United States, Vincent Slaugh

We develop an analytical model of hotel housekeeping to minimize staffing costs and guest wait times for room readiness. We show structural properties, including discrete convexity, of the single-day rostering problem for room attendant shift start times. Using data from a hotel, heuristics enabled by these save up to 17% of total costs compared to a common industry staffing heuristic. We also describe strategies for hotels facing a staffing shortage, including the use of part-time workers.

2 - Optimal Return Time Window with Consumer Learning

Punya Chatterjee, Pennsylvania State University, State College, PA, United States, Aydin Alptekinoglu, Nicholas C. Petruzzi

In this paper, we analytically study a retailer's decision of the length of return time window when consumers update their product valuation over time as they consume a product. We develop a model consisting of a profit-maximizing retailer who sets the length of its return time window, a product which has a finite life-time, and a forward looking consumer who needs to consume the product to understand how much they value the product (e.g., electronics). Our results can guide retailers to select return time windows for various product categories and different consumer types in the case that the consumers learn over time.

3 - On Designing a Socially-optimal Expedited Service and its Impact on Individual Welfare

Ricky Roet-Green, Simon Business School, University of Rochester, Rochester, NY, 14534-2883, United States, Aditya Shetty

Our research is motivated by the expedited security check at US airports (TSA PreCheck). We consider the problem faced by a welfare-maximizing service provider who must make a decision on how to split a fixed capacity between a standard service and an expedited service. The service is mandatory. Choosing the expedited variant requires enrollment at a fixed cost per period. Customers are strategic and have the same cost of waiting, but are heterogeneous in the rate at which they use the service. We show customers' strategic behavior in equilibrium is uniquely determined by the provider's allocation decision. We use this result to solve for the socially optimal allocation. We show that even when customers behave strategically, an expedited service offered in parallel to a standard service can not only increase overall welfare, but also do so for each customer individually.

4 - Congestion, Conflict, and Coordination: Contracting with a Food Delivery Platform

Andrew E. Frazelle, The University of Texas at Dallas, Dallas, TX, 75205-3685, United States, Pnina Feldman, Robert Swinney

In a stylized model of a restaurant as a congested service system, we explore various contractual arrangements between the parties. We find that the commonly-used, traditional revenue sharing contract, in which the platform takes a percentage cut of each delivery order, fails to coordinate the system because the platform does not internalize the effect of its pricing on dine-in revenues. By contrast, a no-contract arrangement, in which the platform pays menu price on each unit, protects the restaurant's revenue from being cannibalized by lower-margin delivery orders. Unfortunately, it too leaves potential revenue on the table. We propose an alternative, practical coordinating contract. As well as coordinating the system, our contract protects restaurant margins by ensuring that the restaurant receives no less per order on delivery than dine-in.

■ SD24

CC Room 205A

In Person: Data-Driven Healthcare Operations Management

Flash Session

Chair: Jing Dong, Columbia University, New York, NY, 10027-6945, United States

1 - Adaptive Clinical Trial Designs with Surrogates: When Should We Bother?

Arielle Elissa Anderer, The Wharton School, PA, 19096-2455, United States, Hamsa Sridhar Bastani, John Silberholz

Surrogate outcomes have long been used in clinical trials when the true outcome of interest is expensive, time consuming, or otherwise difficult to measure. In this work we propose optimal adaptive clinical trial designs that integrate surrogate and true outcomes, and we analytically and empirically characterize regimes where our designs are especially beneficial.

2 - Prediction-driven Surge Planning with Application in the Emergency Department

Yue Hu, Columbia University, New York, NY, 10027-3203, United States, Carri Chan, Jing Dong

Optimizing emergency department (ED) nurse staffing decisions to balance the quality of service and staffing cost can be extremely challenging, especially when there is a high level of uncertainty in patient-demand. Increasing data availability and continuing advancements in predictive analytics provide an opportunity to mitigate demand-rate uncertainty by utilizing demand forecasts. In this work, we study a two-stage prediction framework that is synchronized with the base (made months in advance) and surge (made nearly real-time) staffing decisions in the ED. We quantify the benefit of the more expensive surge staffing. We also propose a near-optimal two-stage staffing policy that is straightforward to interpret and implement. Lastly, we develop a unified framework that combines parameter estimation, real-time demand forecasts, and staffing in the ED.

■ SD25

CC Room 205B

In Person: Idea to Product to Business

General Session

Chair: Hallie Sue Cho, PhD, Vanderbilt University, Nashville, TN, 37203, United States

1 - The Role of Learning Mechanisms on Pivoting Success in Start-ups

Stylianos Kavadias, Margaret Thatcher Professor of Innovation & Growth, University of Cambridge, Judge Business School, Cambrige, CB2 1AG, United Kingdom, Konstantinos Ladas

Entrepreneurial pivots have become almost necessities for start-up companies to survive and succeed. However, it remains unclear how should entrepreneurs learn which options to pursue during these pivots. We build an evolutionary model based on the cultural evolution tradition and we identify circumstances where imitation (social learning) benefits more than the often advocated learning based on experiments (so called "scientific entrepreneurialism"). We identify how different learning mechanisms aid or hinder entrepreneurs during their pivoting efforts.

2 - Best in Class: The Effect of Relative Perceived Quality on Demand in the U.S. Automobile Industry

Hallie Cho, Vanderbilt University, Nashville, TN, United States

This paper explores which factors drive consumers to consider certain products together and which factors set apart the ultimate choice from the rest. Based on co-occurring product mentions in online customer reviews, we find which products are often considered together. Using aggregated customer review measures as a proxy for product quality, we investigate how relative quality amongst similar products influences market shares in a competitive market. Our findings help to understand what drives optimal distinctiveness from the consumer's perspective and have important implications for an automobile manufacturer's product strategy.

3 - Ai-assisted Multimodal Evaluation System for Design Assessment

Chenxi Yuan, Northeastern University, Boston, MA, United States

Design concept evaluation is a key process in new product development with a significant impact on the product's success. In view of limited and biased concept evaluation caused by subjective judgment of designers, we propose a deep multimodal regression model as a potentially disruptive way to bridge this gap. Specifically, we develop a deep neural network enabling accurate and scalable prediction of overall and the attribute-level performance ratings of design concepts from product images and descriptions. We test and validate the model through experiments on a large footwear dataset with low MSE loss and high accuracy.

■ SD26

CC Room 206A

In Person: Global Optimization and Computing Applications

General Session

Chair: Anna Svirsko, United States Naval Academy, Annapolis, MD, 21401, United States

1 - Minimization of a Particular Singular Value

Michael C. Rotkowitz, Amazon, Palo Alto, CA, United States

We consider the problem of minimizing a particular singular value of a matrix variable, neither the largest nor the smallest, with the matrix subject to various constraints. This simply stated but unstudied problem arises in control theory, where it serves as the main obstacle to computing metrics for stabilizability, controllability, and robustness. Prior work found fast methods for obtaining upper bounds, but scalable lower bounds remained elusive. We show how to achieve convex upper and lower bounds for this problem, beginning with using a Difference of Convex (DC) formulation.

2 - Risk Based Allocation of COVID-19 PPEs under Supply Shortages

Gohram Baloch, University of Waterloo, Waterloo, ON, Canada, Fatma Gzara, Samir Elhedhli

We consider a resource allocation problem for personal protective equipment (PPEs) by integrating government supply and procurement decisions with healthcare facilities' PPE usage policy. We present a modelling framework to make these decisions simultaneously to minimize both infection risk and monetary cost to the government. We derive closed-form expressions under different objective criteria to present easy-to-use policies to decision-makers. A mixed-integer quadratically constrained program (MIQCP) is also proposed to handle real-life PPE distribution planning problems. An Ontario-based case is built to derive managerial insights.

3 - Two-stage Distributionally Robust Optimization in Natural Disaster Management

Mohamed El Tonbari, ISyE Georgia Tech, Atlanta, GA, United States, Alejandro Toriello, George L. Nemhauser

We are motivated by natural disaster applications where data is limited. We solve a two-stage distributionally robust optimization model with a Wasserstein ambiguity set, where the first stage is a facility location problem and the second stage is a fixed-charge transportation problem. We develop a column and constraint generation algorithm and handle the presence of binary variables in the second stage by leveraging the structure of our support set and of the second stage value function.

4 - Convexification of Disjoint Bilinear Programs

Hyun-Ju Oh, Graduate Student, Purdue University, West Lafayette, IN, United States, Mohit Tawarmalani

In this paper, we construct a hierarchy of relaxations for disjoint bilinear programs using double description (DD) method. We show that, at each level, our relaxations are at least as tight as the corresponding lift-and-project (L&P) relaxation. In contrast to L&P relaxations, our relaxations converge to the convex hull of the bilinear set in a finite number of iterations. We discuss various ways to tighten relaxations using vertex decompositions and discuss applications of our results to max-min problems.

5 - Creating Equitable Communities Through Natural Disaster Recovery

Anna C. Svirsko, Assistant Professor, United States Naval Academy, Annapolis, MD, United States, Daphne Skipper, Tom Logan, Tommy Reeder, Christina Domanowski

When a natural disaster strikes, a resident's ability to access services such as food and gas, are crucial to rebuilding the community. Instead of simply rebuilding, a natural disaster can be used as a catalyst to create equitable communities where residents have increased access to these services. We develop an integer programming model that determines a recovery plan after a natural disaster which looks to provide access as quickly as possible while also considering equitable access in the long-term. We solve both the deterministic and robust model with data from Hurricane Florence to demonstrate the advantages of including uncertainty in the recovery process.

■ SD27

CC Room 206B

In Person: Network Optimization: Theory and Applications

General Session

Chair: Demetrios Vasilios Papazaharias, Buffalo, NY, 14214-2399, United States

Co- Chair: Akhil Singla, Northwestern University, Evanston, IL, 60201, United States

1 - Conditional Value-at-Risk Shortest-Path Interdiction
Di Nguyen, Clemson University, Clemson, SC, United States, Cole Smith

We investigate an interdictor-evader shortest-path problem in which the interdictor attacks the network in advance and therefore only knows that the arc costs are uniformly distributed in given finite non-negative intervals. The impact of interdiction, i.e., the exact increase in an arc cost if interdicted, is known to both players. The evader, however, observes the arc costs in real time and chooses a shortest path when traversing the network. The interdictor seeks a solution that protects against the worst cases by maximizing the Conditional Value-at-Risk of the evader's shortest-path cost.

2 - Resilient Network Flow Models
Masoud Eshghali, University of Arizona, Tucson, AZ, United States, Pavlo Krokhmal

In this talk we propose metrics of network resilience with respect to exogenous stochastic disruptions in the context of network flow models, such as the classical maximum network flow and minimum-cost network flow models. The proposed approach is based on stochastic programming and is inspired by concepts of modern risk theory. The properties of the resulting problems are discussed, and numerical studies are presented, including Benders decomposition based solution algorithms.

3 - A Fork-Join Decision Flow Network for Fact Checking in Social Media
Akhil Singla, Northwestern University, Evanston, IL, United States, Seyed Iravani

Social media works with a network of fact-checkers to identify misinformation on their platforms. They face the trade-off between "speed" and "accuracy" of detecting misinformation. We propose an POMDP to strike a balance between speed and accuracy in a fork-join fact checking network.

4 - Optimal Task Planning of Adversarial Games: An Integer Programming Approach
Demetrios Vasilios Papazaharias, Buffalo, NY, 14214-2399, United States, Jose L. Walteros, Moises Sudit

In this study we will focus on determining an optimal schedule of tasks in an adversarial setting. We model this problem within the guise of network interdiction, where the defender seeks to complete a schedule of tasks in the minimum amount of time. The attacker can expend some resources in order to delay the processing time of the defender's tasks. The attacker seeks a minimum cost interdiction plan to ensure that the minimum completion time of the defender's schedule is bounded by a given parameter. We first model this problem as a bilevel mixed integer program. We then propose a reformulation with respect to the extreme points of the defender's polyhedron. Finally, we develop a decomposition algorithm to handle its exponential size.

■ SD28

CC Room 207B

In Person: Recent Advances in Data-Driven Nonconvex Optimization

General Session

Chair: Salar Fattahi, Berkeley, CA, 94702-2147, United States

Chair: Jianhao Ma, University of Michigan

1 - Can Temporal-difference and Q-learning Learn Representation? A Mean-field Theory
Yufeng Zhang, Northwestern University, Evanston, IL, United States

Temporal-difference and Q-learning play a key role in deep reinforcement learning, where they are empowered by expressive nonlinear function approximators such as neural networks. At the core of their empirical successes is the learned feature representation. We aim to answer the following questions: When the function approximator is a neural network, how does the associated feature representation evolve? We prove that utilizing an overparameterized two-layer neural network, temporal-di erence and Q-learning globally minimize the mean-squared projected Bellman error at a sublinear rate. The associated feature representation converges to the optimal one. The key to our analysis is to connect the evolution of a parameter to its limiting counterpart over Wasserstein space. Our analysis generalizes to soft Q-learning, which is further connected to policy gradient.

2 - Implicit Regularization of Sub-gradient Method in Robust Matrix Recovery: Don't Be Afraid of Outliers
Jianhao Ma, University of Michigan, Ann Arbor, MI, United States

It is well-known that simple short-sighted algorithms, such as gradient descent, generalize well in the over-parameterized learning tasks, due to their implicit regularization. However, it is unknown whether the implicit regularization of these algorithms can be extended to robust learning tasks. In this work, we provide a positive answer to this question in the context of robust matrix recovery problem. We show that a simple sub-gradient method with a novel spectral initialization converges to the true low-rank solution efficiently, when it is applied to the over-parameterized l1-loss function without any explicit regularization or rank constraint. Moreover, by building upon a new notion of restricted isometry property, called sign-RIP, we prove the robustness of the sub-gradient method against outliers in the over-parameterized regime.

■ SD29

CC Room 207C

Undergraduate Operations Research Prize 1

Award Session

Chair: Trilce Encarnacion, University of Missouri- St. Louis, Saint Louis, MO, 63121, United States

■ SD30

CC Room 207D

In Person: Multimodal Data Fusion for Healthcare Applications

General Session

Chair: Nathan B. Gaw, Georgia Institute of Technology, Scottsdale, AZ, 85258-2222, United States

1 - Statistical Inference for High-dimensional and Large-scale Data with Noisy Labels
Hyebin Song, Pennsylvania State University, University Park, PA, United States

In many classification applications, we are presented with data with partially observed or contaminated labels. One example of such an application is in the analysis of datasets from deep mutational scanning (DMS) experiments in proteomics, which typically do not contain non-functional sequences. In this talk, I will present statistical approaches and algorithms for analyzing noisy, high-dimensional binary data, demonstrating the optimality and scalability of our proposed methods. Finally, I will present an application of our methodology to inferring sequence-function relationships and designing highly stabilized enzymes based on large-scale DMS data.

2 - Cross Recurrence Analysis for Pattern Matching of Multidimensional Physiological Signals
Adam Meyers, Doctoral Candidate, The Pennsylvania State University, University Park, PA, United States, Hui Yang, Mohammed Buqammaz

Cross recurrence quantification analysis (CRQA), based on cross recurrence plot (CRP), is an effective method to characterize and quantify nonlinear interrelationships between pairs of time series. Despite its many advantages, CRQA has largely been unutilized for pattern mining of multidimensional, especially spatiotemporal, physiological signals. We present new methodology to visualize a patient-to-patient network where distance corresponds to pairwise patient dissimilarity based on CRQA statistics. This methodology is evaluated on real data consisting of 3D spatiotemporal vectorcardiogram signals from healthy and diseased patients. Experimental results show that certain diagonal line measures in the CRP, including our proposed measure characterizing maximum pairwise similarity between signals, are effective in distinguishing between patients.

■ SD32

CC Room 208B

In Person: Platform Operations

General Session

Chair: Pnina Feldman, Boston University, Boston, MA, 2215, United States

1 - Entropy as a Driver of Engagement in Online Discussion Platforms
Joseph Carlstein, University of Pennsylvania, Philadelphia, PA, 19104, United States, Gad Allon, Yonatan Gur

With the rise of remote work and remote learning, it has become increasingly imperative for firms and educators to facilitate discussions in a clear and organized fashion. There are many possible objectives of these discussions, depending on the situation, from identifying a correct answer to a question, to building consensus, to sparking debate. However, in this presentation, we will focus on determining the key drivers of engagement in a group discussion on a closed online platform, and how the platform can leverage comment-level and discussion-level engagement drivers to design effective practical recommendation algorithms for directing traffic to different parts of the discussion, in order to maximize user engagement.

2 - Managing Customer Search: Assortment Planning for a Subscription Box Service
Fernando Bernstein, Duke University, Durham, NC, 27708-9972, United States, Yuan Guo

We consider subscription box services where the provider selects assortments of products to match customers' needs and preferences. Customers choose between actively searching stores and subscribing to the box service. We use a cross-nested logit framework to model the impact of the overlap of products between the two channels on customer choice. We find that the box should include a collection of popular subsets of store products for customers experiencing either low or high search costs. We further explore box service strategies regarding exclusive brands and multiple product categories.

3 - Strategic Choices and Routing within Service Networks: Modeling and Estimation Using Machine Learning
Kenneth Moon, University of Pennsylvania, Philadelphia, PA, 19104-6340, United States

Service networks with open routing by self-interested customers have drawn attention in the theoretical literature. However, these networks, which range from shopping centers to amusement parks, remain challenging to explore empirically. Large-scale trajectory datasets offer new opportunities to understand customer motivations and behaviors but are complex to analyze. We develop structural empirical methods to recover customer demand preferences and congestion sensitivities from diverse trajectory patterns using machine learning. We employ adversarial neural networks to handle the high-dimensional space of (combinatorially many) trajectory types, collapse the dynamics of customer trajectory choices into static trajectory market shares, and derive theoretically efficient incentive-compatibility bounds on customers' preferences.

4 - Contextual Pareto Bandit under Covariate Shift
Apurv Shukla, Columbia University, New York, NY, 10025-1868, United States

We consider the contextual bandit problem under covariate shift and vectorial rewards. We propose a tree-based policy that maintains separately discretizes action and covariate spaces. For vectorial feedback, we use Contextual Pareto regret as the performance metric of the proposed policy. We establish an upper bound on the performance of the proposed policy for multiple-models of covariate shift including single, multiple and smoothly varying context distributions. Finally, the efficacy of the proposed policy is described on a suite of numerical experiments.

■ SD33

CC Room 209A

In Person: Fairness in Data-Driven Operations

General Session

Chair: Vivek Farias, MIT, Cambridge, MA, 02142-1508, United States

1 - Stateful Offline Contextual Policy Evaluation and Learning
Angela Zhou, Cornell University ORIE, 206 Rhodes Hall, Ithaca, NY, 14853-3801, United States

We study off-policy evaluation and learning from sequential data that arise from repeated interactions with an exogenous context arrivals with unknown individual-level responses to agent actions that induce known transitions. This model is an offline generalization of contextual bandits with resource constraints. We adapt single-timestep doubly-robust estimation to this setting so that a state-dependent policy can be learned even from a single timestep's worth of data. We study uniform convergence for off-policy learning, which can be viewed as a model-based approach in the marginal MDP.

2 - Fair Exploration via Axiomatic Bargaining
Jackie W Baek, MIT, Cambridge, MA, 02139-4301, United States, Vivek Farias

Exploration is often necessary to maximize long-term reward in online learning, but it comes at the cost of reducing immediate reward. We develop the Nash bargaining solution in the context of `grouped` bandits, which associates each time step with a group from some finite set of groups. The utility gained by a group under some policy is naturally viewed as the reduction in that group's regret relative to the regret that group would have incurred 'on its own'. We derive policies that yield the Nash bargaining solution, and we show that the 'price of fairness' under such policies is limited, while regret optimal policies are arbitrarily unfair under generic conditions. Our theoretical development is complemented by a case study on contextual bandits for warfarin dosing where we are concerned with the cost of exploration across multiple races and age groups.

3 - Fair Intervention Bundle Design
Elisabeth Paulson, Stanford University, Stanford, CA, 02141-1437, United States

This work introduces the Fair Product Line Design Problem (FPLDP) in which a service provider must determine the optimal number and set of product/service bundles to offer its users in order to minimize cost while meeting an individual-level fairness constraint. The fairness constraint ensures that each users' resulting utility from their chosen (or assigned) bundle is above a prespecified threshold. This problem arises in settings such as healthcare and public policy (where services can be thought of as interventions or treatments), as well as retail settings in which fair outcome guarantees are desirable. We formulate FPLDP as a mixed-integer non-linear program, and develop a class of approximation algorithms for this problem whose solutions correspond to different trade-offs between robustness and cost.

4 - Taming Wild Price Fluctuations: Monotone Stochastic Convex Optimization with Bandit Feedback
Jad Salem, Georgia Institute of Technology, Atlanta, GA, 30318-5608, United States, Swati Gupta, Vijay Kamble

Prices generated by automated price experimentation often display erratic fluctuations which can be perceived as unfair and may erode a customer's trust. To address this concern, we propose demand learning under a monotonicity constraint on the sequence of prices. We give the first known sublinear-regret algorithms for monotonic price experimentation for smooth and strongly concave revenue functions under bandit and first-order feedback. Our key innovation is to utilize conservative gradient estimates to adaptively tailor the degree of caution to local gradient information. Importantly, we show that our algorithms achieve best-possible regret bounds up to logarithmic factors.This is joint work with Swati Gupta and Vijay Kamble.

■ SD34

CC Room 209B

In Person: Simulation and Reinforcement Learning

General Session

Chair: Ankit Shah

1 - Boosted Nonparametric Hazards with Time-dependent Covariates
Donald Lee, Associate Professor, Emory University, Atlanta, GA, United States, Ningyuan Chen, Hemant Ishwaran

Survival analysis permeates all fields of science, and in operations it manifests itself in the context of reliability analysis and queuing transition rates. This talk introduces a rigorous solution to a central problem in survival analysis: Estimating hazard functions nonparametrically in the presence of high-dimensional, time-dependent covariates. This is particularly relevant to healthcare analytics, given the availability of high-frequency data capture systems embedded within EHRs and wearables. We illustrate the performance of this technique using an open-source implementation called BoXHED.

2 - Dynamic Vulnerability Prioritization Using Deep Reinforcement Learning
Soumyadeep Hore, University of South Florida, Tampa, FL, 33613-4728, United States, Ankit Shah

There has been a steep increase in the number of cyber vulnerabilities reported in the national vulnerability database. In response, the vulnerability mitigation strategies employed by the cybersecurity operations centers (CSOCs) have been static and rule based. In addition, due to the uncertainty in the arrivals of new vulnerabilities and their respective mitigation time, the CSOC is unable to optimally identify and prioritize critical vulnerabilities. There also exist a potential temporal threat associated with a vulnerability instance, which the current methods fail to capture. In this talk, we describe a deep reinforcement learning (DRL) approach to triage cyber vulnerabilities, individualized for a CSOC. Results show that the DRL agent can make accurate decisions by training in a simulated environment, which is powered by real-world vulnerability datasets.

■ SD35

CC Room 210A

In Person: Pricing in Shared Mobility Markets

General Session

Chair: Eduardo Marino, University of California, CA, United States

1 - Dynamic Simulation Model for Planning and Real-time Management of System of EV Fast-Charging Stations

Dingtong Yang, University of California-Irvine, Irvine, CA, 92697, United States

Motivated by the environmental benefits of and associated government regulations promoting electric vehicles (EVs), as well as the limited charging infrastructure to support EV travel in place, this study presents an agent-based stochastic dynamic modeling framework of a regional system of EV fast-charging stations to support the planning and real-time management of EV fast-charging stations. To model EV user fast-charging station choices, the framework incorporates a multinomial logit station choice model that considers station charging prices, expected wait times, and detour distances. Moreover, Each EV charging station is modeled as a multi-server queueing model. To manage the system of stations, this study proposes dynamic demand-responsive price adjustment (DDRPA) schemes based on station queue lengths. The computational results, based on a real-world system of EV charging stations in California, indicate that the best DDRPA scheme reduces average wait time by 26%, increases revenue by 5.8%, and increases social welfare by 2.7%. Moreover, the results illustrate how the modeling framework can identify stations that require additional chargers and areas that would benefit from additional fast-charging stations.

2 - Dynamic Parking Management for Automated Vehicles in Downtown Areas

Tara Radvand, Graduate Student Research Assistant, University of Michigan, Ann Arbor, MI, United States, Sina Bahrami, Yafeng Yin

This study proposes a dynamic model for the parking choice in a downtown area in the era of automated vehicles (AVs). Given the distribution of users' activity time in the downtown, we propose a system of ordinary differential equations to model their AVs' choice between an outskirt parking lot and cruising as a substitution for parking. Cruising may cause traffic congestion, which is captured by a network macroscopic fundamental diagram. With the proposed model, we further investigate dynamic time-based tolling strategies to optimize the system performance.

3 - Modeling Framework for Pricing-consistent Subscription Services in Shared Mobility Systems

Eduardo Marino, University of California, Irvine, CA, United States, R. Jayakrishnan

As shared mobility systems and various new paradigms of associated ownership and subscription systems are taking hold now, costs and prices in such systems need to be analyzed in depth. The current cost models are based on average values and long life-cycles, which are insufficient as daily travel miles of vehicles may significantly change. We present the conceptual aspects of the interactions of new cost structures and system performance in these new mobility systems. We present the properly designed cost function, a framework to analyze the interactions and optimize the new systems and provide results from an agent-based simulation of candidate contexts.

■ SD36

CC Room 210B

In Person: Emerging Topics in Food and Grocery Delivery Services

General Session

Chair: Qi Luo, Clemson University, Clemson, SC, 29634, United States

Chair: Zhengtian Xu, The George Washington University, Ann Arbor, MI, 48105-2540, United States

1 - The Vertical Spillover Effect of Online Ratings on Platform Competition: An Empirical Investigation

Yulia Vorotyntseva, Saint Louis University, Saint Louis, MO, 19102-4325, United States, Aleksi Aaltonen, Subodha Kumar, Paul Pavlou

The familiar 'five-star' ratings system makes it easy for consumers to use product evaluations across competing platforms to choose a product or service. The average rating for the same product can vary across platforms for reasons unrelated to quality, including pure randomness. We argue that such diverging evaluations can give rise to a vertical spillover effect, that is, the evaluations of a product represented on a platform may affect the consumer's choice between the platforms. To study this, we conduct a series of experiments in a restaurant food delivery setting. Our results show that consumers indeed tend to choose the platform where their chosen restaurant is rated higher, even when they know they will receive exactly the same service. This may imply that in face of competition a platform may find it disadvantageous to counter vendors' rating inflation.

2 - Dine in or Take Out? Trends on Restaurant Service Demand Amid the Covid-19 Pandemic

Linxuan Shi, The George Washington University, Washington, DC, United States, Zhengtian Xu

The outbreak of COVID-19 pandemic has caused unprecedented damage to restaurant dine-in services, given the concerns of exposure to coronavirus. In contrast, online food ordering and delivery services, represented by DoorDash, Grubhub, and Uber Eats, filled in the vacancy and achieved explosive growth. The restaurant industry is experiencing a drastic change under the crossfire of these two driving forces. However, due to the lack of first-hand data, we are not fully exposed to the underlying changes, let alone understand the potential impacts and launch targeted policies. To address such a pressing need, this study proposes to leverage the foot-traffic data to effectively keep track of the rapidly evolving demand for restaurant businesses. Data based on 0.8 million cellphone users and 10 thousand restaurants in the DC area is applied for demonstration and analysis.

3 - Drone Dispatch Policy to Fulfill Uncertain Customer Demands in a Delivery Network

Zhenyu Zhou, Wayne State University, Detroit, MI, 48201-1111, United States

We present a dynamic vehicle routing problem encountered in the design of an on-demand meal delivery network. Through subscription contracts each customer has the right to order a meal a day which will be delivered in, e.g., 20 minutes, by a drone. Customer locations are aggregated and represented by demand nodes in the network. In a delivery trip, a drone will start from a depot node, visit the demand node and return to (the same or a different) depot node. Not every demand node is reachable all depots. The drone dispatch is performed periodically, e.g., once every 10 minutes. The time slot in which a customer makes the order is uncertain. We present a stochastic dynamic programming model to maximize the total expected number of demands fulfilled by the end of the day. Reasonable state space reduction schemes will be presented to address the representation and computation challenges.

■ SD37

CC Room 210C

In Person: Vehicle Routing

Contributed Session

Chair: Xufei Liu, University of South Florida, Tampa, FL, 33613, United States

1 - Solution Approaches for the Rendezvous Vehicle Routing Problem

Eric Oden, University of Maryland-College Park, College Park, MD, United States, Bruce L. Golden, S. Raghu Raghavan

We consider a novel scheme for same-day delivery, in which a set of vehicles (shuttles) may intercept trucks moving along their fixed routes to transfer packages ordered at the last minute. This scheme can lead to significant transportation savings, as shuttles need not travel as far to accommodate the last-minute requests. We present a column generation algorithm which can quickly generate optimal solutions for reasonably-sized instances. We also develop and demonstrate the effectiveness of a specialized heuristic for use in larger instances. We then present results demonstrating the efficiency of truck-shuttle synchronization in various settings.

2 - A Column Generation Approach for a Stochastic Vehicle Routing Problem

Eric Oden, University of Maryland-College Park, College Park, MD, United States, Bruce L. Golden, Subramanian Raghavan

We consider a vehicle routing problem with stochastic travel times and service times. Furthermore, the customers are stochastic (i.e., each customer may cancel with some probability). We consider the problem of hiring trucks, assigning trucks to customers, routing trucks through their customers, and establishing appointment times, subject to fixed, travel, earliness/tardiness, and overtime costs. We present our column generation heuristic, as well as results concerning the subproblem of determining expected arrival times given the sources of stochasticity in the problem.

3 - An Exact Algorithm for the Parallel Drone Scheduling Traveling Salesman Problem Using Benders-decomposition
Jerimi Lee, Hankuk University of Foreign Studies, Yongin-si, Korea, Republic of, Jaegwan Joo, Youngjoo Roh, Chungmok Lee

The parallel drone scheduling TSP (PDSTSP) combines the drone deliveries at the depot and the traditional vehicle routing to serve a given set of customers. Due to the limited operating range of the drones, only customers close to the depot can be served by the drones, while the remaining customers should be visited by the vehicle. We present an exact algorithm based on the logic-based Benders decomposition incorporated into a branch-and-cut framework. The computational experiments on the well-known benchmark show that the proposed algorithm outperforms the previous heuristic approaches, including the state-of-the-art MIP solvers.

4 - An Adaptive Large Neighborhood Search Method for Drone Truck Arc Routing Problem
Xufei Liu, University of South Florida, Tampa, FL, United States, Sung Hoon Chung, Changhyun Kwon

Arc Routing Problems (ARP) are widely used in many fields, including traffic monitoring, infrastructure inspection, and security. This talk considers ARP by a mixed fleet of drones and trucks. While trucks follow road networks, drones can fly directly between any two points on the network. With a limited flying range and battery capacity, drones need to fly from and to trucks to recharge. A metaheuristic method based on Adaptive Large Neighborhood Search (ALNS) is proposed to solve the Drone-Truck ARP. The performance of ALNS is evaluated using randomly generated ARP instances.

■ SD38

CC Room 210D

In Person: Commodity and Energy Market Operations

General Session

Chair: Bo Yang, Carnegie Mellon University, Pittsburgh, PA, 15213-4226, United States

1 - The Term Structure of Optimal Integrated Hedges
Danko Turcic, University of California, Riverside, Graduate School of Business, CA, 92521-9800, United States

We show how a commodity processor facing stochastic demand and stochastic selling price has a capacity and lead-time preference and how that preference can be advantageously manipulated with hedging. The results apply in industries in which firms' revenues are significantly affected by movements in commodity prices.

2 - Pathwise Reinforcement Learning for Informationally Rich Models: Coordinated Decomposition and Regression
Bo Yang, Carnegie Mellon University, Pittsburgh, PA, 15213-4226, United States, Selvaprabu Nadarajah, Nicola Secomandi

Pathwise reinforcement learning (PRL) has been used to obtain high quality bounds and control policies for Markov decision processes with rich information structures. Beyond optimal stopping, the state of the art for solving underlying linear program is a block coordinate descent (BCD) procedure that exhibits high per iteration computational complexity. We propose a coordinated decomposition methodology with improved complexity that (i) finds a solution to the dual of the sampled LP and (ii) recovers a primal solution by approximately enforcing complementary slackness via regression. We conduct a numerical study in the context of merchant energy production. Compared to BCD, our technique can solve both existing instances more efficiently and with similar accuracy and new larger size ones that are out of reach for this alternative, achieving near optimal performance.

■ SD39

CC Room 211A

In Person: Healthcare Operations and Technology Management

General Session

Chair: Minje Park, Boston University, Boston, MA, 02215-1704, United States

1 - Multi-channel Referrals and Patient Outcomes
Sokol Tushe, Emory University, Atlanta, GA, 30322-1059, United States, Diwas S. Kc

A physician consultation has traditionally required the collocation of the physician and the patient. However, the wide adoption of telemedicine creates multiple channels for delivering healthcare, including core processes such as patient diagnosis. We investigate how primary care physicians adjust their referral behavior when they can choose to refer patients to specialists through an in-person channel or an online channel. Specifically, we look at how patient classes are separated into different referral channels based on their complexity level. We also study the implications for patient outcomes.

2 - Impact of Pharmaceutical Supply Chain Disruptions on Medication Safety: Synthetic Control Method Approach
Minje Park, Boston University, Boston, MA, 02215-1704, United States, Anita L. Tucker, Rena Conti

We investigate the impact of pharmaceutical supply chain disruptions on medication safety by studying a drug shortage case caused by Hurricane Maria in 2017. By applying the synthetic control method (Abadie et al. 2003, 2010), we measure the increase in medication errors and adverse drug events after the supply disruption. With our results, we provide implications for safe substitution between drugs during the supply disruption period.

■ SD40

CC Room 211B

In Person: Issues in Energy Market Design, Regulation, and Evolution

General Session

Chair: Ramteen Sioshansi, The Ohio State University, The Ohio State University, OH, United States

1 - Can an Energy-only Market Design Yield Electricity Decarbonisation? Insights from a System Dynamics Approach
Olivier Massol, IFP School, Paris, France, Alexis Lebeau, Marcelo Saguan, Yannick Perez

In contemporary power systems, an important policy issue is whether an energy-only type of market design (EOM) is capable to yield a transition towards net carbon neutrality. In this research, we adopt a simulation framework and propose a system dynamics representation to investigate the two follwoing questions: (1) what assumptions about investor behavior and available information are needed to ensure that an EOM achieves the desired decarbonization trajectory and the desired target mix?; (2) How robust is an EOM (as measured by deviations between realized vs. optimal mix trajectories) when different assumptions are considered? Our results extend the standard analyses by stressing the crucial importance of a series of conventionally admitted assumptions (e.g., the role of perfect foresight, that of full information and the agents' type of rationality).

2 - Multi-period Pricing under Price History Dependent Investments in Consumption Infrastructure: An Application in Natural Gas Sector
Baturay Calci, The University of Texas at Austin, Austin, TX, 78751-5031, United States, Benjamin D. Leibowicz, Jonathan F. Bard, Gopika Jayadev

We build a bilevel model of the interaction between two agents where the leader sets prices over the planning horizon, and then the follower determines the investments at each period that set the future demand based on the price history until that period. This framework is applied to a natural gas producer (leader) and an electric utility company (follower) which decides investments in natural gas-fired power generation infrastructure based on past average gas prices. There is a trade-off in the leader's problem between high prices (high current revenue) and low prices (high future revenue due to investments). Preliminary results are presented as well as the formulation and solution approach.

3 - Data-driven Piecewise Linearization for Distribution Three-phase Stochastic Power Flow
Jiaqi Chen, University of Wisconsin–Madison, Madison, WI, United States, Wenchuan Wu, Line A Roald

As the penetration of distributed renewable energy increases, stochastic power flow (SPF) becomes an essential tool to analyze the uncertainties in active distribution networks. The Monte Carlo (MC) method is the most straightforward and accurate technique to calculate the three-phase SPF. However, the computation burden of the MC method is significant since it involves numerous calculations of three-phase nonlinear AC power flow. This talk will introduce a piecewise linear, data-driven power flow approach for the MC-based three-phase SPF calculation. An improved K-plane regression algorithm is proposed while considering the collinearity of the training data. We demonstrate that the proposed SPF approach can handle complex operational conditions such as the correction of random variables and three-phase unbalance with high accuracy and efficiency.

■ SD41

CC Room 212A

In Person: Modeling Deep Decarbonization in the Electricity Sector

General Session

Chair: Qingyu Xu, Princeton University, Princeton, NJ, 21218-2625, United States

1 - Rapid Deep Decarbonization of the PJM System

Qingyu Xu, Princeton University, Princeton, NJ, 21218-2625, United States, Jesse D. Jenkins, Neha Patankar, Chuan Zhang

In this work, we investigate how fast the PJM, a subnational power system of the U.S., can move toward deep decarbonization in the next decade. The work focuses on exploring the policy alternatives and their efficiency and robustness against the uncertainty of load, technology advancement, and natural gas prices. With the capacity expansion tool called GenX, we gauge the policy efficiency and the distributional effect by measuring system cost, load-serving payment, and the generator profit under different policy scenarios. The policy alternatives explored include rate-/mass-based carbon pricing and clean energy standards.

■ SD43

CC Room 213A

In Person: Information Systems

Contributed Session

Chair: Salih Tutun, Washington University in St. Louis, Chesterfield, MO, 63017, United States

1 - Improving Machine Learning Algorithms by Collecting Diverse and Granular Data in Crowdsourcing Platforms

Aida Khosh Raftar Nouri, Memorial University of Newfoundland, St John's, NL, Canada, Jeffrey Parsons

Citizen science volunteers have played an essential role in creating training data for the machine learning algorithm. Furthermore, using crowdsourcing maximizes the undiscovered value of the data. This research aims to develop, implement, and evaluate design principles for data collection in crowdsourcing platforms with the ability to collect granular and diverse data. This study also conducts experiments to show that information diversity and granularity as the pertinent dimension of information quality in crowdsourced data improve machine learning algorithms.

2 - Increasing Healthcare Organizations Agility via Cloud Analytics Platforms

Hossein Kalantar, University of Colorado-Denver, Denver, CO, United States

Healthcare organizations should constantly and swiftly detect and respond to environmental opportunities and threats. The COVID-19 outbreak demands fast and precise actions from healthcare organizations across the globe more than ever before. These organizations can utilize various analytics tools on the cloud-based platform to increase their agility in the operational domain and clinical areas. In this study, we investigate the impact of cloud analytics platform adoption on healthcare organizations' agility.

3 - Understanding Differential Effects of Social Network Capital on the Crowdsourced Answering Process in Stack Overflow

Orcun Temizkan, Ozyegin University, Istanbul, Turkey, Ram Kumar

Virtual Question and Answer (VQ&A) communities are becoming increasingly important in today's knowledge intensive environment. They represent a crowdsourced knowledge creation process that involves volunteer participants, and thus they are large repositories of online knowledge. A knowledge creation process may require different types and degree of social network capital of participants based on the complexity of the VQ&A process. We develop and empirically test models of the differential effects of social network capital on the VQ&A process. Empirical results based on data from Stack Overflow will be presented. Research and managerial implications will also be discussed.

4 - Investigating Factors Affecting the Retention of Firms' IT Capability

Jinho Kiim, Lewis University, Romeoville, IL, United States, Timothy Komarek, Kayoung Park, Li Xu

Scholars have discussed firms' IT capability and its impact on their business performance. However, there has been little discussion of the factors in firms' long-retention of IT capability. To explain this phenomenon, this study describes a new construct, continuous IT capability, which can be used to measure the accumulation of IT capability over time and employs survival analysis to show how these factors are related to firms' risk of losing IT capability. The results show that turnover in IT managers, which can bring in outside knowledge and experience, allows firms to retain IT capability, whereas IT managers' structural power doesn't contribute to firms' sustaining their IT capability.

5 - Digital Piracy and Platform Competition: Which Platforms are Targeted by Pirates, and Why?

Wendy Bradley, Assistant Professor of Strategy, Southern Methodist University, Dallas, TX, United States, Joost Rietveld

Two-sided platforms (video game consoles, mobile operating systems) depend on a large installed base of both complements (games, apps) and end-users to succeed. Many users of digital products—via illegal online sharing—participate in platform markets without paying for complements or contributing to sales. This affects the potential performance and innovation incentives of platform owners and complements. Which platforms are most affected by digital piracy, and why? Using a dataset of pirated console video games in the U.S. (2000-2011), we find that complement diversity and concentration, platform architecture, and platform adoption are significant factors in predicting digital piracy.

6 - Intelligent System for Wind Farm Maintenance Planning

Salih Tutun, Washington University in Saint Louis, St Louis, MO, United States, Ilker Yesilkaya, Sedat Irgil, Ada Deniz Keskin

Understanding the faults and relations of wind turbines in the farm could help to manage the planning of maintenance. When the fault happened, we lost energy and costing a lot of money. For example, in the US, the cost of maintenance on wind farms in 2016 ranged between $42000 and $48000 per MW. The decision-makers need an intelligent recommendation system that will analyze resources and understand all interactions among turbines. In this research, we proposed a new network-based intelligent recommendation system to identify the faults and the reasons behind them. To show how our intelligent system works, we worked with one wind farm. We proved how we reduced the cost and improved the system's quality.

■ SD44

CC Room 213B

In Person: Supply Chain Competition/Operations Management

Contributed Session

Chair: Beverly Osborn, The Ohio State University, Columbus, OH, 43201, United States

1 - Effects of Firm's Structural Position in its Value Network on Competitive Intensity and Complexity

Yang Yang, Assistant Professor, University of Texas at El Paso, El Paso, TX, United States

Competition is fluid and dynamic, so firms must constantly create temporary advantages by frequently launching various competitive actions to sustain their competitive advantage. While research has shown that firms become increasingly dependent on their suppliers and customers to gain competitive advantage and has examined the impact of value network on firm performance (i.e., a result of a firm's competitive actions), no study has investigated how value networks could directly affect a firm's strategic competitive behavior. This study examines how firms' structural characteristics in value networks influence their competitive behavior in respect of competitive aggressiveness.

2 - The Role of Peer Experience and Learning in Operational Decisions

Neslihan Ozlu, Stockholm University-Företagsekonomi, Stockholm, Sweden

Drawing on purchasing data from a European manufacturer, we investigate the purchasers-ordering behaviour under variable lead times. In particular, we examine the learning of the purchasers through their experiences with the suppliers from their peers. We also incorporate the specific versus all other purchasers as well as suppliers into the analysis. We mainly observe varying behaviours of purchasers depending on the relationships with the suppliers. Our results have both managerial and practical implications.

3 - Organizational Challenges and Root Cause Interpretations: Evidence From a Longitudinal Study of Business Executives

Robert N. Eberhart, Associate Director of Entrepreneurship and Society, Stanford University, Palo Alto, CA, United States, George Foster, Jim Andrew Best-Devereux

How managers respond to their challenges is central to studies of both strategy and organizational theory, but how challenges are interpreted is much less studied. Strategic literature examines managerial responses from a performance-oriented perspective, organizational scholars theorize that actions are selected to maintain legitimacy. We employ LDA topic modeling to analyze 1,648 written challenges and cause interpretations from CEOs and executive officers who attended executive education programs over a twenty-three-year period at Stanford University. We test how the type of challenge matches the type of interpretation and observe changes in these responses.

4 - The Effect of The U.S.-China Trade War and the Covid-19 Pandemic on the Effectiveness of the Promotion of U.S. Agricultural Exports

Misty Blessley, Associate Professor, Temple University, Philadelphia, PA, United States

U.S. agricultural exports have long been vulnerable to changes in weather, politics and the global economy. Recently, agricultural exports have been hurt by the U.S.-China trade war and the COVID-19 pandemic. The objective of our project is to improve understanding of the factors that lead to U.S. government's export promotion of specific agricultural product categories, and the effectiveness of the export promotions. Insights are developed through the analysis of multiple years of agricultural export promotions. The findings are expected to provide important contributions to theory, policy and practice.

5 - Proposal Evaluation Approaches and Supplier Performance

Beverly Osborn, PhD Candidate, The Ohio State University, Columbus, OH, United States, John V. Gray

We use a matching design to study the effects of proposal evaluation procedures, criteria, and their relative weighting on supplier performance by combining U.S. government data on contract awards with data extracted from the corresponding RFP documents. Our performance measure, recontracting, captures subjective and difficult to measure aspects of supplier performance. Our results are relevant for policymakers, buyers, and potential suppliers.

■ SD45

CC Room 213C

In Person: Scheduling

Contributed Session

Chair: Hua Wang, Carnegie Mellon University, Pittsburgh, PA, 15217-2094, United States

1 - A Two-step Approach to Recover Aircraft Schedule under Uncertainty

Ai Zhao, The University of Texas at Austin, Austin, TX, United States

Airlines are not able to fly the published schedule due to certain disruptions sometimes. Moreover, the duration and intensity of the disruption is often uncertain. Therefore, decision makers are seeking robust solutions that limit the modifications to the operational schedule and provide some amount of contingency in case the operations encounter longer disruptions. A two-step approach minimizing the impact of the disruption on the schedule and passengers is used here for aircraft recovery.

2 - Machine Learning for Parallel Machine Scheduling in Semiconductor Manufacturing

Jelle Adan, Eindhoven University of Technology, Eindhoven, Netherlands

This research focuses on the unrelated parallel machine scheduling with sequence and machine dependent setup times in the context of semiconductor manufacturing. Currently, a scheduling tool is used that bases its setup and process time predictions on preset deterministic parameters. When predictions off, it is necessary to deviate from the proposed schedule, counteracting efficiency. This study investigates the use of machine learning on actual production data to increase the accuracy of these predictions with the ultimate goal to increase production efficiency.

3 - Flight and Maintenance Planning for Aircraft Fleet: A Data-driven Approach

Zhengyang Fan, George Mason University, Fairfax, VA, United States, Ran Ji, KC Chang, Genshe Chen

Maintaining and deploying an aircraft fleet under limited resources can be challenging. Traditional preventive maintenance methods are inflexible to subtle changes of aircraft and may lead to low level of fleet availability and high maintenance cost. We propose a learning-then-optimization condition based predictive maintenance paradigm, which determines daily flight and maintenance planning directly from readings of multiple onboard sensors. The paradigm first predicts remaining useful life for components of aircraft by using deep learning, then models the fleet level optimization as a mixed integer program which captures different failure modes of aircraft and available resources.

4 - Pharmaceutical R&D Resource Planning and Activity Scheduling Based on a Superstructure of Drug Development Pathways

Hua Wang, Carnegie Mellon University, Pittsburgh, PA, United States, Shekhar Viswanath, Steve Guntz, Jon Dieringer, Shankar Vaidyaraman, Salvador Garcia-Munoz, Chrysanthos Gounaris

We address the portfolio-wide activity planning and resource allocation problem for pharmaceutical R&D. For this, we formulate a new MILP model based on a superstructure of possible pathways for the drug development process, and we test the model on datasets inspired from real-life operations at a major pharmaceutical company. We also show how to improve our model's tractability by applying a number of reformulations and practical heuristic techniques. Finally, we discuss our experience with deploying a decision support tool based on our optimization approach for the systematic and largely automated derivation of development pathways and activity schedules in the real-life setting.

■ SD46

CC Room 213D

In Person: Health Care, Public Health I

Contributed Session

Chair: Emine Yaylali, Istanbul Technical University, Decatur, GA, 30033-3822, United States

1 - Impact of Digital Health Interventions on the Quality of Care for Children with an Autism Spectrum Disorder

Hannah Mulroe, University of Southern California, Los Angeles, CA, United States

Due to the COVID-19 pandemic, there has been a sharp increase in the number of virtual visits. As this becomes the new normal for non-emergent behavioral healthcare appointments, there currently lacks defined strategies to monitor the quality of these visits. This study focuses on virtual visits for pediatric patients with an Autism Spectrum Disorder (ASD). The study identifies variables present in a virtual visit as they relate to the six areas of quality of care. Borrowing from research in Environmental, Health, & Safety management systems, the study identifies a set of leading indicators to evaluate the impact the transition to virtual visits has had on the quality of care for pediatric ASD patients.

2 - Deadline Effect in Door-to-needle Time of Ischemic Stroke Patients

Brandon Lee, Assistant Professor, University of Dayton, Dayton, OH, United States, Seokjun Youn, Lawrence Fredendall

TPA (Tissue Plasminogen Activator) for stroke patients should be administered within 4.5 hours of symptom onset. The clinicians' time for the administration of TPA depends on how much time is remaining before the 4.5 hours are fully spent (i.e., deadline effect). We examine the circumstances that mitigate such deadline effect.

3 - Injuries in Israeli Schools: An Advanced Retrospective Nationwide Six-year Analysis for Policymakers

Michael Khalemsky, Head of Management Information Studies, Hadassah Academic College, Jerusalem, Israel, Eli Jaffe, Anna Khalemsky

Child injury is a global public health problem. A nationwide dataset of 36,002 school injury events in Israel between 2013 and 2019 was analyzed. Exploratory research based on cluster analysis combined with advanced statistical tools revealed injury patterns. Games were identified as the prevailing cause of school injuries in Israel. Gender and age differences, and seasonal and circadian trends were observed. Comparison to international data is provided. Understanding the patterns and the trends of school injuries can enable the development of effective prevention policies on the national, municipal, and local levels, focusing the efforts on the key factors affecting injury incidence.

4 - Mathematical Models for Estimating HIV Incidence in Turkey

Emine Yaylali, Assistant Professor, Istanbul Technical University, Istanbul, Turkey, Zikriye M. Erdogan

The number of HIV patients has been decreasing in the world, however HIV incidence has been significantly increasing in Turkey in the last decade. We developed mathematical models to analyze the spread of HIV in Turkey. First, we utilized a Bernoulli model and estimated annual incidence for high risk groups. Then, we developed a dynamic compartmental model of HIV transmission and progression in Turkey to estimate HIV incidence from 2019 to 2030 and to determine continuum of care levels which represent diagnosed and treated persons. Our results suggested that both incidence and HIV-related deaths could continue to rise in the next decade, placing a significant burden on the Turkish healthcare system.

Monday, 7:45AM-9:15AM

■ MB01

CC Ballroom A / Virtual Theater 1

Hybrid AAS Special Speaker Talk

Sponsored: Aviation Applications

Sponsored Session

Chair: Alexandre Jacquillat, MIT Sloan School of Management, Cambridge, MA, 2142, United States

1 - Introduction of AI/ML Capabilities into Airline Industry

Sergey Shebalov, Sabre Holdings, Southlake, TX, 76092, United States

AI/ML capabilities are being widely adopted across many industries. We will share practical experience of introducing these capabilities into airline industry. There are several key properties of AI/ML that generate incremental value compare to decision support approaches used in the past. We describe specific use cases to illustrate these properties and discuss typical challenges and roadblocks for successful implementation of AI/ML capabilities. We will also look beyond creating ML models to into data management and MLOps areas that are crucial for AI/ML adoption. Finally, we'll make a few suggestions on the role of academic community in this process and describe a path toward closer collaboration between academia and industry.

■ MB02

CC Ballroom B / Virtual Theater 2

Hybrid Inverse Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States

1 - Learning Personalized Diabetic Retinopathy Screening Preferences

Fariha Kabir Torsha, University of Houston, Houston, TX, United States, Taewoo Lee

Diabetic retinopathy (DR) is the leading cause of vision loss in working-age Americans. Due to the asymptomatic early stages of DR, the American Diabetes Association recommends annual eye screening exams for all diabetic patients. However, not all patients are screened annually; compliance rate varies significantly across different types of patients, typically within the range of 20-60%. In this study, we model the patient's screening decision-making process as a Markov decision process (MDP) and use inverse optimization to infer the patient's reward function from his/her past screening decisions. We then use the inferred reward function to generate personalized screening decisions.

2 - A Penalty Block Coordinate Descent Algorithm for Data-driven Inverse Convex Optimization

Rishabh Gupta, University of Minnesota, Minneapolis, MN, United States, Qi Zhang

We consider inverse convex optimization where the goal is to jointly infer the unknown objective and constraint parameters of a convex NLP from noisy observations. We formulate the problem as a bilevel program and apply a KKT-based approach to obtain a single-level reformulation. The resulting nonconvex nonlinear problem is solved with an approximate block coordinate descent method. We show that the proposed algorithm is guaranteed to converge to a stationary point for several important classes of forward problems such as convex QCQPs and geometric programs. Numerical experiments on synthetic datasets demonstrate the computational advantage of our method against standard commercial solvers.

3 - Optimality-Based Clustering

Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States, Zahed Shahmoradi

Clustering is a well-known technique to group a set of data points into smaller clusters such that the data points in the same cluster are closer to each other than to those in other clusters based on some similarity function. We propose a new clustering approach, called optimality-based clustering, that clusters data points based on their encoded decision preferences. We model the problem as a mixed-integer program and propose efficient heuristics.

■ MB03

CC Ballroom C / Virtual Theater 3

Hybrid Markov Lecture

Sponsored: Applied Probability Society

Sponsored Session

Chair: Rhonda L. Righter, University of California-Berkeley, Berkeley, CA, 94720-1777, United States

1 - Fragmenting Financial Markets

Darrell Duffie, Stanford University, Graduate School of Business, 518 Memorial Way, Stanford, CA, 94305-5015, United States

This talk on financial market design addresses the costs (and sometimes the benefits) of fragmenting trade across multiple venues.Size discovery trading crosses buy and sell orders, with no bid-ask spread and no price impact, by exploiting the price determined on a separate exchange market.Although popular in practice, size discovery reduces the depth of exchange markets and, as modeled, worsens overall allocative efficiency.On the other hand, fragmenting trade in the same asset across multiple exchanges can improve allocative efficiency.This talk draws from research with Samuel Antill, Daniel Chen, and Haoxiang Zhu.

2 - Discussant

Mathieu Rosenbaum, Ecole Polytechnique, France

■ MB04

CC Ballroom D /Virtual Theater 4

Hybrid Predictive Analytics Applications

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Yixin Lu, The George Washington University, Washington, DC, 20052, United States

Chair: Francesco Balocco, Rotterdam School of Management Erasmus University, Rotterdam, 3011 ZX, Netherlands

1 - Tech Tax: Ad Exchanges' Fees in Display Advertising

Francesco Balocco, Rotterdam School of Management Erasmus University, Rotterdam, Netherlands, Yixin Lu, Ting Li

We study the Ad Exchanges' (ADX) fee optimization problem under the two dominant mechanisms in the display advertising market: the waterfall and the header bidding mechanism. We address two research questions: (1) What are the welfare implications of ADXs' fee structures? (2) How do ADXs' optimal fee structures evolve under different market configurations? Our study contributes to both theory and practice of digital advertising. First, to the best of our knowledge, this study is among the first to examine the welfare implications of ADXs' fee structures under different market mechanisms. Second, our findings shed light on the underlying drivers for the publisher's move from the waterfall mechanism to the header bidding mechanism. Finally, our model allows ADXs to perform policy counterfactuals, providing useful implications for their decisions on fee structures.

2 - Investigating the Willingness to Pay For Enhanced Mobile Internet Services: Evidence From a Mobile Network Upgrade

Yi Zhu, University of Minnesota at Twin Cities, Minneapolis, MN, United States, Jason Chan, Xuan Bi

We investigate consumers' willingness to pay (WTP) for two mobile internet pricing models, the speed-based model and the data-consumption-based model. We examine consumer sentiment toward unexpected slow network speed and data overuse problems, which provides valuable information for understanding customers' WTP for increasing network speed or data allowance. Our empirical strategy leverages the staggered introduction of 4G network across various districts in a metropolitan Asian city and a quasi-experimental setup. We find that consumers are more willing to pay for increasing network speed than data allowance in the new mobile internet era. We also show that substantial heterogeneity in consumer sentiment is explained by consumers' income and age. These insights can inform relevant stakeholders of optimal responses around future mobile network pricing models.

3 - How Local Competition Reshapes Consumers' Review Behavior: An Empirical Investigation

Xinyu Zang, University of Florida Warrington College of Business, Gainesville, FL, United States, Xiang (Shawn) Wan, Naveen Kumar, Liangfei Qiu

We examine how local competition of a restaurant might affect its consumers' propensity to write two types of influential reviews: informative reviews and negative reviews. Building on the antecedents of review contributions and expectation-confirmation theory, we hypothesize as the local competition level increases, the number of informative reviews and the number of negative reviews received by a restaurant will first increase up to a point and then decrease (i.e., inverted U-shaped relationships). We also hypothesize the restaurant's popularity could moderate such relationships. Leveraging a Yelp dataset, we empirically confirm the existence of inverted U-shaped relationships and the moderating role of the restaurant's popularity. Taken together, we find the geographic location of a business plays a prominent role in reshaping consumers' review behavior.

4 - Life-event Targeting and Customer Uncertainty Evidence From Field and Online Experiments

Zherui Yang, Erasmus University, Rotterdam, 3062PA, Netherlands, Ting Li

Life-event targeting has gained increasing attention that companies target customers for marketing activities based on life-event prediction. However, seldom has study explored its underlying mechanism. We conduct experiments to examine life-event targeting, and dive into literature on information seeking, behavioral targeting and customer uncertainty theory to explore its underlying mechanism. Our findings suggest that customers' information-seeking need mediates the effect of life-event targeting on customers' response, which is contingent on different customer uncertainty. Specifically, customers with higher choice uncertainty and those with lower knowledge uncertainty are more likely to respond to life-event targeting. This paper contributes to IS research by adding an information perspective to the growing practice of life-event targeting.

■ MB05

CC Ballroom E / Virtual Theater 5

Hybrid TSL Award Session I

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States

■ MB06

CC Room 303A

In Person: Humanitarian Operations and Disaster Management

General Session

Chair: Ashkan Mirzaee, University of Missouri, Columbia, MO, 65201, United States

Co-Chair: Osman Alp, University of Calgary, Calgary, AB, T2N 1N4, Canada

Co-Chair: Christopher W. Zobel, Virginia Tech, Blacksburg, VA, 24061-0235, United States

1 - Towards a Greener Society: Exploring the Adoption Level of Solar Technologies in the State Of Sonora, Mexico

Jose Luis Ruiz Duarte, San Jose State University, San Jose, CA, United States

In this project, the solar potential of a delimited geographical region is explored. The analysis includes the evaluation of local energy generation and energy trades with neighboring regions. Optimization under uncertainty is proposed to evaluate the size and location of solar energy sources. The project analyzes the performance of the region with different adoption levels of roof solar panels, as well as the possibility of large-scale solar generation considering concentrated thermal and photovoltaic technologies. A case study for the state of Sonora, Mexico is performed to show the effectiveness of the proposed model and algorithms.

2 - A Framework for Planning Access Corridors to Northern Territories of Canada

Osman Alp, University of Calgary, Calgary, AB, T2N 1N4, Canada, Meraj Ajam

Geographical conditions provide challenges accessing to northern territories of Canada. This creates friction in trade flows between territories and provinces, which limits the economic activity and prosperity. We embed a Trade Cost model borrowed from the economics literature into a network flow optimization model. This model can help the federal government in planning infrastructural investments to lower the trade costs by creating access corridors from south and east to north. We analyze how such corridors can reduce the cost of transporting energy-related commodities.

3 - Impact of Increased Biopower Generation on US Forests

Ashkan Mirzaee, University of Missouri, Columbia, MO, 65201, United States, Ronald McGarvey

Biopower, electricity generated from biomass, is a major source of renewable energy in the US. Over 20% of US renewable electricity in 2019 was generated from woody biomass. Despite significant growth in woody biomass use for electricity, a systematic assessment of associated impacts on forest resources is lacking. This study assessed associations between biopower generation on timberland structure and carbon stocks across 450 landscapes in the eastern US including 210 procurement zones that were harvested from 2005 to 2017 to supply biomass to power plants. In this study, we used data analysis and statistical learning techniques to collect and analysis forest conditions in a large scaled areas.

■ MB07

CC Room 303B

In Person: Yards and Terminals

General Session

Chair: Roger William Baugher, TrAnalytics, LLC, Johns Creek, GA, 30097-8510, United States

1 - Flat Yard Simulation using AnyLogic

Roger William Baugher, MBA, Northwestern; MSCE, University of Illinois, TrAnalytics, LLC, Duluth, GA, 30097, United States

Choosing the correct sequence for switching cars in a flat yard can be a complex challenge. Such yards may not have dedicated tracks for arriving or building trains, may be switched from both ends, may have multiple switch jobs with conflicting movements, may have the mainline running through the middle and other complicating factors. A simulation of the switching process can provide insight for training, analysis and process improvement. The presentation will demonstrate the simulation of flat switching operations at a terminal railroad using AnyLogic, a software package capable of depicting railroad movements.

2 - Hump Yard Simulation using AnyLogic

Jiaxi Zhao, University of Illinois at Urbana-Champaign, Newmark Civil Eng. 205 N. Mathews Ave # 1245, Urbana, IL, 61801-2350, United States

On North American freight railways, railcars spent majority of their transit time in classification (marshalling) yards waiting for being sorted and classified to their destination. The congestion of one yard could promote mainline train delay and further affect down stream yards and then decrease the railway level of service. However, few research has focused on the interaction of yards and mainline with the impact of vast volume and schedule variability. This study conducted a series of simulation experiments to quantify the interaction of inbound and outbound traffic and schedule variability among yards with a novel AnyLogic hump yard model. A few yard performance metrics are collected to reveal the propagation and transformation of the variability from upstream yards to downstream yards.

■ MB08

CC Room 303C

In Person: spORts I

General Session

Chair: Eli Olinick, Southern Methodist University, Dallas, TX, 75275-0123, United States

1 - The International Timetabling Competition on Sports: Results And Lessons Learned

Dries Goossens, Ghent University, 9000, Belgium, David Van Bulck, Jeroen Belien, Morteza Davari

From mid October 2020 till April 2021, the International Timetabling Competition (ITC2021) challenged over a dozen teams to find the best solution on various sports timetabling problem instances. Our competition involved a rich and diverse set of artificial instances, involving up to 9 different constraints that are common in real-life. In this talk, we explain how the instances were designed and how feasibility and diversity was ensured. Moreover, we discuss the results obtained by the participants, and provide insights on what solution approach works best for what types of instances.

2 - Adapting First-break-then-schedule to Time-relaxed Sports Timetabling
David Van Bulck, Ghent University, Belgium, Dries Goossens

A popular technique to construct sports timetables is the first-break-then-schedule approach which first determines for each time slot whether a team plays at home or away, after which its opponent is determined. This approach, however, is only applicable to time-constrained schedules where each team approximately plays one game per time slot. In this talk, we adapt the first-break-then-schedule approach to time-relaxed competitions, like the NBA or NHL. In particular, we propose to first determine the so-called game-off-day patterns (GOPs) after which we construct a compatible timetable. We settle the computational complexity of this approach and show that it outperforms existing approaches to optimize rest times and differences in games played when the total number of off days is no more than twice the number of games per team.

3 - In Game Win Probability Models for Canadian Football
Stephen Hill, University of North Carolina-Wilmington, Congdon Hall, Wilmington, NC, 28403-5611, United States

In game win probability models are used to estimate the probability that each team in a game, at any point in a game, will ultimately win. Such models have been built for a variety of sports, however, no such models have been proposed for Canadian football. In this work in game win probability models for Canadian football are described along with several extensions.

4 - Geographic Design of Sports Leagues to Optimize Driving Time and Competitiveness
Zhuo Chen, Southern Methodist Univesity, Dallas, TX, United States

Club sports in metro areas are popular nowadays, however there are key concerns for organizers, which are reducing driving time due to teams commuting to facilities in different regions while keeping league divisions competitive. A three-step approach is adopted to solve this problem. Driving time data between each location is analyzed initially, and clubs are split into several groups accordingly. Teams are assigned to groups based on their location and ranking. And these two processes are merged in the end to find the best solution. Applying this process to the Tennis Competitors of Dallas, a large and well-established sports league in the Dallas area, we demonstrate that this process can rearrange existing groups in a way that not only shortens the travel time for players, but also maintains an acceptable level of competition.

5 - Demystifying the Crystal Ball in Professional Sports
Eli Olinick, Southern Methodist University, Dallas, TX, 75275-0123, United States, Mark Husted, Alexandra M. Newman

Mixed integer programming (MIP) models for determining magic numbers (first place and playoff clinch and elimination) for a variety of professional sports have been proposed in the literature and implemented in practice. Often the proof that a magic number is correct relies on showing that a MIP model is infeasible. So, although fans enjoy tracking these numbers, most must take them on faith. We discuss strategies for and challenges of automating the process of justifying magic numbers to sports fans in plain English.

■ MB09

CC Room 303D

In Person: Large-Scale Analysis of Stochastic Systems

General Session

Chair: Debankur Mukherjee, Georgia Institute of Technology, Georgia Institute of Technology

1 - Large-scale Parallel Server Systems with Multi-component Jobs
Alexander Stolyar, University of Illinois at Urbana-Champaign, Urbana, IL, 61801-2925, United States, Vsevolod Shneer

A broad class of parallel server systems is considered, for whichwe prove the steady-state asymptotic independence of server workloads, as the number of servers goes to infinity, while the system load remains sub-critical. Arriving jobs consist of multiple components. There are multiple job classes, and each class may be of one of two types, which determines the rule according to which the job components add workloads to the servers. The model is broad enough to include as special cases some popular queueing models with redundancy, such as cancel-on-start and cancel-on-completion redundancy. Our analysis uses mean-field process representation and limits. It relies almost exclusively on three fundamental properties of the model: monotonicity; work conservation; the property that, on average, "new arriving workload prefers to go to servers with lower workloads.

2 - Ergodicity of High Dimensional Reflected Diffusions
Sayan Banerjee, University of North Carolina-Chapel Hill, Chapel Hill, NC, 27517-4073, United States, Amarjit Budhiraja, Brendan Brown

We will discuss ergodicity properties of high dimensional reflected diffusions that arise as scaling limits of queueing networks in heavy traffic and interacting particle systems. As the system dimension increases, it (naturally) takes longer for the entire diffusion to approach equilibrium. However, we will present several scenarios where local statistics exhibit dimension-free convergence rates. We will explore connections of such phenomena with a discrete time Markov chain arising out of the reflection structure of these diffusions. The Atlas model, which is a `critical case' in a certain sense, will also be discussed. The infinite Atlas model has uncountably many stationary measures, and we will obtain sufficient conditions for the initial conditions to lie in the domain of attraction of each of these measures.

■ MB10

CC Room 304B

In Person: New Applications of Queueing Theory

General Session

Chair: Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

1 - Stochastic Models for Community Bail Funds
Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

Bail funds have a long history of helping those who cannot afford bail in order to wait for trial at home. Not only have bail funds help release those who cannot afford their bail, but it also has had an immeasurable impact on the decision of the defendant. In this paper, we consider the first stochastic model for a community bail fund. To build our stochastic model, we uniquely combine insurance models and infinite server queues to model the bail fund. As a result, we are able to not only model the bail fund, but also assess the impact that a bail fund will have on a community. In this regard, we determine the amount of money a county might save by implementing a bail fund. Although, we cannot measure the impact on the human spirit, we can start to understand in a rigorous way, the impact of the bail fund on the community.

2 - Queues with Updating Information
Philip Doldo, Cornell University, Ithaca, NY, 14853, United States

Many service systems provide customers with information about the system so that customers can make an informed decision about whether to join or not. Many of these systems provide information in the form of an update. Thus, the information about the system is updated periodically in increments of size . It is known that these updates can cause oscillations in the resulting dynamics. However, it is an open problem to explicitly characterize the size of these oscillations when they occur. In this paper, we solve this open problem and show how to exactly compute the amplitude of these oscillations via a fixed point equation. We also compute closed form approximations via Taylor expansions and show that these approximations are very accurate, especially when is large. Our analysis provides new insight for systems that use updates as a way of disseminating information to customers.

■ MB11

CC Room 304C

In Person: Emerging Research in Behavioral Operations Management

General Session

Chair: Samer Charbaji, University of Michigan, Ann Arbor, MI, 48105, United States

Co-Chair: Blair Flicker, University of South Carolina, Columbia, SC, 29208-4011, United States

1 - Team Composition and Cooperation in Queueing Systems
Mouli Modak, Purdue University, West Lafayette, IN, United States, Yaroslav Rosokha, Masha Shunko

We study a single-queue system in which heterogeneous tasks arrive stochastically and are processed by a team of either heterogeneous or homogenous servers. Particularly, servers specialize in one type of task, which, in our model, implies a lower cost of effort while processing that type of task. The effort chosen by servers determines the processing time of a task. We show that, theoretically, in the implied stochastic dynamic game, the choice of high effort can be sustained in the subgame-perfect equilibrium if the arrival rate is high enough regardless of team composition. Further, for intermediate arrival rates, homogeneous teams perform better than heterogeneous teams when the types of arriving tasks are independent or are serially positively correlated, and heterogeneous teams perform better in the presence of negative serial correlation in the types of tasks.

2 - Creative Task Constraints and Knowledge Worker Productivity
Samer Charbaji, University of Michigan, Ann Arbor, MI, 48105, United States, Roman Kapuscinski, Stephen Leider

Knowledge workers often work on creative tasks that involve originality and recognizability aspects. It is unclear how varying recognizability constraints affects a knowledge worker's productivity in an originality-focused creative task. We conduct a lab experiment that studies the effect of varying the threshold of recognizability constraints on the average originality and recognizability of creative tasks. In the experiment, participants are asked to draw images using a set of drawing materials to depict an object and a set of emoji to depict an action on that object. Their payment depends on the originality of their submitted image on condition that it meets a certain recognizability threshold. The originality and recognizability of each image are determined by external raters. Our treatments examine how different constraints impact participant performance.

3 - On People's Utility Over Wait Fundamentals and Information
Blair Flicker, University of South Carolina, Columbia, SC, 29208-4011, United States, Russell Charles Hannigan

This paper explores the link between people's utility and fundamental wait features, such as duration, reward, and context via a conjoint analysis study. We find evidence of the intuitive: that people dislike long and variable waits. We run eight experimental treatments which manipulate how waits are presented and find that information about a wait significantly influences people's utility, independent of the underlying wait. We distill these behavioral effects into a general model of people's utility over wait fundamentals and information which may be of use to modelers and practitioners alike.

■ MB12

CC Room 304D

In Person: Behavioral Operations Job Market Candidate Showcase

Panel Session

Chair: Rihuan Huang, Cornell University, Ithaca, NY, 14853-6900, United States

1 - Human Decision-making in Dynamic Resource Allocation
Jiawei Li, University of Michigan, Ann Arbor, MI, United States

Abstract not available at this time

2 - Mitigating the Negative Effects of Customer Anxiety Through Access to Human Contact
Michelle A. Shell, Boston University, 2 Crest Dr, Dover, MA, 02030-1820, United States

Abstract not available at this time

3 - Designing Procurement Auction with Loss-averse Workers in Online Labor Markets
Xianghua (Jason) Wu, College of business, University of Texas At Arlington, Arlington, TX, 76013, United States

Abstract not available at this time

4 - Retailer Inventory Sharing in Two-tier Supply Chains: An Experimental Investigation
Rihuan Huang, Cornell University, Sage Hall 114 East Ave # 301a, Ithaca, NY, 14853-6900, United States

Abstract not available at this time

■ MB13

CC Room 201A

In Person: Advances in Power Systems Planning

General Session

Chair: Kyle Skolfield, Arizona State University, Tempe, AZ, United States

1 - On the Theory of Stability and Hyperbolicity in Electric Power Systems
Amin Gholami, Georgia Tech, Atlanta, GA, 30080-8407, United States, Andy Sun

Mitigating power system instability is a continuing challenge for system operators. In this talk, we present a new theoretical result on the stability and hyperbolicity of electric power systems. We derive new sufficient conditions to guarantee small-signal stability of equilibrium points in both lossless and lossy power networks. Our results reveal an analog of Braess's Paradox in power system stability, showing that adding power lines to the system may decrease the stability margin. We also provide new insights into the effects of damping on the stability and hyperbolicity of equilibrium points. The proposed stability certificates are suitable for real-time monitoring and fast stability assessment in power systems.

2 - Robust Power Systems Planning Against Rising Temperatures with Discrete Transmission Considerations
Kyle Skolfield, Arizona State University, ASU, Tempe, AZ, United States

As average temperatures continue to rise, the ability of the transmission network to meet demand is diminished. Higher temperatures lead to congestion by reducing thermal transmission limits while simultaneously reducing generation potential. Due to prohibitive costs and limited real estate for new lines, it is necessary to consider topology control to improve the efficiency of the grid. Optimal control, however, requires many discrete choices, rendering fully accurate models intractable. It is necessary to model temperature changes and transmission flows with high spatial resolution. This work proposes a case study of the transmission grid centered in Arizona, using an adaptive robust DCOPF mathematical formulation and corresponding valid inequalities to plan for future transmission expansion, switching, and capacity expansion to efficiently meet demand.

■ MB14

CC Room 201B

In Person: Data Analytics in Developing Quality Management Theory

General Session

Chair: Xianghui (Richard) Peng, Penn State-Erie
The Behrend College, Fairview, PA, 16415-3317, United States

1 - Investigation of Patient Satisfaction in High-quality Health Care
Xinyu Wei, California State University, Chico, Chico, CA, 76201, United States, Xianghui (Richard) Peng, Victor R. Prybutok

Evaluation and improvement of patient-reported experiences and outcomes are drawing increasing attention from health care leaders. This study explores and discusses a variety of health care operations measurements that relate to patient satisfaction and health care delivery performance. The conceptual model examines the structural relationship among these measurements and tests both direct and indirect effects. The findings contribute to the health care operations literature and reveal the need for comprehensive quality guidance and oversight.

2 - The Impact of Big Data on Quality Management in Traditional Industries
Yuchen Wang, University of North Texas, Denton, TX, 76203-5017, United States, Yuchen Wang, Kean University, Union, NJ, United States

In the big data era, every company has a vast amount of data to process. The data that people needed to invest massive resources and time are piled up and hard to manipulate, especially in traditional industries (TI), such as mining, machinery manufacturing, and oil. This research utilizes a series of text mining techniques to study the annual report of Nasdaq listed companies in the TI and investigates the role of data in quality management with the emerged operations methods to capture how profits and products are influenced. The chronological analysis is conducted to analyze the trend of competition advantage earned by data management and information technology.

3 - Internal Control and Cybersecurity Breaches: The Moderating Effect of Operational Efficiency
Anh Ta, University of North Texas, TX, United States, Linh Le

This study investigates the interrelationship among firm operational efficiency, internal control, and cybersecurity breaches. Using data from Audit Analytics cybersecurity, DataLossDB, and Privacy Rights Clearinghouse, the findings provide insights to the literature by empirically showing the moderating effect of operational efficiency on mitigating the strength of the relationship between material weaknesses in internal control and the frequencies of cybersecurity breaches.

■ MB15

CC Room 201C

In Person: Advances in Data Analytics and Applications

General Session

Chair: Tianyi Lin, University of California, Berkeley, Berkeley, CA, 94720-2502, United States

1 - Computing Wasserstein Barycenters: Easy or Hard?
Jason Altschuler, Massachusetts Institute of Technology, Cambridge, MA, United States

Averaging data distributions is a core subroutine throughout data science. Wasserstein barycenters (a.k.a. Optimal Transport barycenters) provide a natural approach for this problem that captures the geometry of the data, and are central to diverse applications in machine learning, statistics, and computer graphics. Despite considerable attention, it remained unknown whether Wasserstein barycenters can be computed in polynomial time. Our recent work provides a complete answer to this question and reveals a surprising "curse of dimensionality".Joint work with Enric Boix

2 - Optimal Transport for Text Mining
Zhiyue Hu, University of California-Berkeley, Berkeley, CA, United States

Topic sparsity refers to the observation that individual documents usually focus on several salient topics instead of covering a wide variety of topics, and a real topic adopts a narrow range of terms instead of a wide coverage of the vocabulary. Understanding this topic sparsity is especially important for analyzing user-generated web content and social media, which are featured in the form of extremely short posts and discussions. As topic sparsity of individual documents in online social media increases, so does the difficulty of analyzing the online text sources using traditional methods. In this paper, we propose two novel neural models by providing sparse posterior distributions over topics based on the Gaussian sparsemax construction, enabling efficient training by stochastic back-propagation.

3 - An Empirical Investigation of Factors Influencing Performance of Decentralized Applications
Luv Sharma, University of South Carolina, Columbia, SC, 29206, United States, Moonwon Chung, Jie Lian

We investigate factors impacting the performance of decentralized application (DApp) that are built on the Ethereum blockchain.

4 - Characterizing and Comparing Covid-19 Misinformation Across Languages, Countries and Platforms
Jacqueline Otala, Clarkson University, Potsdam, NY, United States, Golshan Madraki, Isabella Grasso, Yu Liu, Jeanna Matthews

We investigate COVID-19 misinformation in multiple languages/countries: Chinese/China, English/USA, and Farsi/Iran; on multiple platforms: Twitter, Facebook, Instagram, WhatsApp, Weibo, WeChat and TikTok. Utilizing opportunistic sampling, we compiled 200 items of viral and debunked misinformation across these languages, countries and platforms from January 1-August 31 2020. While it was observed that COVID-19 misinformation on social media varied across different languages, politics was observed as the root of most collected misinformation across all three languages. We further observe the impact of government platform restrictions on content in China, Iran, and USA.

■ MB18

CC Room 202B

In Person: Macro Energy Systems: Energy Infrastructure Resilience

General Session

Chair: Benjamin D Leibowicz, University of Texas-Austin, Austin, TX, 78712-1591, United States

1 - Disaster Resilience Planning under Uncertainty: A Nexus Approach
Rachel Moglen, University of Texas at Austin, Austin, TX, United States, Benjamin D. Leibowicz

Natural disasters pose a serious threat to our infrastructure systems, inflicting significant losses of property and life annually. Decision-makers aim to prevent these negative consequences by hardening infrastructure, a process complicated by the inter-dependencies between critical infrastructure systems. We develop and implement a two-stage stochastic program to capture the uncertainty in disaster realization, minimizing expected unmet water and power demand across disasters. Our results show that our proposed nexus optimization approach performs significantly better than if the water and power network were optimized independently. The results also show an emphasis on power system hardening, even when water service is strictly prioritized, due to the dependency of the water system on power for drinking water treatment.

2 - Racial Equity in Energy and Sustainability: A Case Study in Mexico
Rodrigo Mercado Fernandez, Appalachian State University, Richmond, VA, 23220, United States, Erin Baker

Using Mexico as a case study, we employ a bottom-up model of the electrical system to identify critical geographic areas of investment for installed capacity and transmission that are robust across a set of climate mitigation pathways derived from multiple Integrated Assessment Models. We find that more diverse energy portfolios are associated with relatively less transmission investment; and that despite a lack of robustness in the location of installed capacity investments, investment in transmission expansion is fairly robust across pathways.

3 - Exploring the Role of Electric Vehicles in Africa's Energy Transition
Michael Dioha, Carnegie Institution for Science, Stanford, CA, United States, Lei Duan, Tyler Ruggles, Sara Bellocchi, Ken Caldeira

We employ a bottom-up modelling framework to examine the interplay of electric vehicles (EVs) and variable renewables (VRE) in Africa using Nigeria as a case study. Our results indicate that despite having a natural gas-dominated electricity system, the deployment of EVs can support the decarbonization of the Nigerian transport sector but at a relatively high cost. The cost of EVs would need to drop by ~40% to become cost-competitive. However, if VRE delivers the EVs power requirement with a bidirectional smart charging strategy, then the cost of EVs would need to decline by only ~30% to be a cost-effective option. Not all EVs need to participate in a bidirectional charging strategy in order to realize its full benefits; there is substantial benefit from flexibility in charging loads. Robust policies are needed to support EVs.

■ MB19

CC Room 203A

In Person: Data Mining

Contributed Session

Chair: Anna Khalemsky, Maale Adumim, 9856227, Israel

1 - Random Forest Incorporated Multi-fidelity Cokriging to Handle the Nonstationarity in the Data
Mithun Ghosh, University of Arizona, Tucson, AZ, United States, Qiang Zhou

We propose an ensemble framework to model the multi-fidelity data with heterogeneity across the input space. Computationally, modeling a p-level recursive multi-fidelity-based cokriging is equivalent to build p individual krigings. We use the recursive cokriging model in the random forest framework, where the high-fidelity data with the bootstrapped samples are split into homogenous sections. We propose an efficient recursive partitioning of the tree that enables the model to handle the nonstationarity by using a stationary covariance function. The dependency between trees in the random forest makes the prediction distribution of our model using the Gaussian Mixture model.

2 - Efficient and Trusted Resource Allocation by Enhancing Theory Driven Models with Causal Machine Learning
Ozden Gur Ali, Koc University, Istanbul, Turkey

Novel methodology for capturing causal impact heterogeneity for highly efficient targeting using large scale observational data. Supports justifiable resource allocation with interpretable models that enable theory-driven qualitative constraints and incorporate important findings of causal machine learning. Quantifies the interpretability performance tradeoff with untapped targeting efficiency.Applied on targeting resources to increase physical activity levels in the Turkish adult population, we find that imposing literature driven qualitative constraints, and model modification based on causal machine learning with XAI both increase the expected public health benefits.

3 - A Decision Support Tool to Estimate Rank in Plant Breeding Experiments
Reyhaneh Bijari, PhD Student, Iowa State University, Ames, IA, United States, Hanisha Vemireddy, Sigurdur Olafsson

Plant breeders aim to select the genotypes with the best genetic properties. This decision may fall in ranking these genotypes based on some phenotypic traits. However, the uncertainty of the ranking makes this decision hard as it is only possible to observe each genotype in a few environments. Each genotype has significant genetics-by-environment effects, resulting in one genotype appearing better than its genetic potential or the other way around. We propose a bootstrapping approach to construct confidence intervals around rank, capturing its inherent uncertainty. We show that the tool is effective as the empirical coverage of the confidence interval closely matches the theoretical coverage.

4 - Online Segmentation of Dynamic Data Stream Using Dynamic Classification Unit Model and Expandrogram Visualization
Anna Khalemsky, Lecturer, Hadassah Academic College, Jerusalem, Israel, Roy Gelbard

The incremental dynamic classifier DCU supports real-time segmentation processes in big and dynamic data environments. The model suggests using small data buffers, as an alternative to the reexamination of all past data for the updating of existing segments. To support the calibration of diverse domains, the model accommodates different forms of processing by using a wide range of parameters. The decision-making process strictly depends on the user's preferences or implementation requirements. Comprehensive visualization, named ExpanDrogram, can potentially improve the interpretation of sophisticated segmentation processes and allow the user to participate in decision-making.

■ MB20

CC Room 203B

In Person: Healthcare Delivery

General Session

Chair: Sandeep Rath, University of North Carolina at Chapel Hill, Kenan Flagler, Chapel Hill, NC, 27599, United States

1 - Equity and Efficiency in Hospital Physicians' Work Structure
Masoud Kamalahmadi, University of Miami, Coral Gables, FL, United States, Kurt M. Bretthauer, Jonathan Eugene Helm, Alex Mills

We study the fair and efficient assignment of patients to hospitalists (inpatient physicians) when hospitalists are partially localized to specific hospital units: each unit has a local hospitalist; however, hospitalists may be assigned to attend patients in the other units. We formulate a stochastic model of hospitalist-patient assignments and characterize the structure of the optimal policy that balances equity and efficiency in hospitalists' work structure. We discuss how some of the policies that are commonly used in practice can be adjusted to achieve a better balance between equity and efficiency.

2 - Scheduling in Primary Care to Balance Patient Appointments and EHR Work
Sandeep Rath, UNC Kenan Flagler Business School, Chapel Hill, NC, United States, Saravanan Kesavan, Bradley R. Staats

Primary Care Physicians (PCPs) spend several hours a day working on Electronic Health Record Systems. EHR workload has been identified as a major source of PCP burnout. Broadly the PCPs have discretion on how to divide the daily EHR work. Currently, the appointment scheduling practices do not incorporate EHR workload when determining the daily appointment schedule for a PCP. Thus, PCPs have to manage the EHR work around the appointment schedule. We develop an optimization model which creates appointment schedules which explicitly incorporates EHR workload, as well as determines the best way to allocate EHR workload during the day.

■ MB21

CC Room 204A

In Person: Optimization Models in Healthcare

General Session

Chair: Oguzhan Alagoz, University of Wisconsin-Madison, Madison, WI, 53706-1539, United States

Co-Chair: Elizabeth Scaria, University of Wisconsin-Madison, Madison, WI, United States

1 - Optimal Infection Control Interventions for Hospital Associated Clostridioides Difficile Infection: An Optimal Control Approach
Elizabeth Scaria, University of Wisconsin-Madison, University of Wisconsin, Madison, WI, United States, Oguzhan Alagoz, Achal Bassamboo, Nasia Safdar

Clostridioides difficile infection (CDI) is a common healthcare-associated infection. Hospitals use several controls simultaneously to mitigate CDI spread, including environmental cleaning and enhanced hand hygiene practices, but it is unclear how to select the best controls for a unique hospital. We formulate and solve an optimal control model using data from our agent-based model of CDI to characterize optimal infection control bundles in hospitals. We examine the optimal policy under varying budgets, disease distributions, and cost estimation methods.

2 - Novel Pooling Strategies for Genetic Testing, with Application to Newborn Screening
Hussein El Hajj, Virginia Tech, Blacksburg, VA, United States, Ebru Korular Bish, Douglas R. Bish

Cystic fibrosis is among the most prevalent life-threatening genetic disorders. For cost-effectiveness, most cystic fibrosis screening processes start with a biomarker test, followed by a more expensive and accurate genetic test (DNA) for those newborns with elevated biomarker levels. To overcome the cost barriers of expanding genetic testing, we explore a pooled approach for DNA testing. This leads to a novel pooling problem that involves selection of variants for screening, potential partition of the selected variants into multiple panels, and selection of pool size for each panel. We establish key structural properties of optimal pooled DNA designs; develop an exact algorithm that generates a family of optimal pooled DNA designs, along with their corresponding budgets; and characterize the conditions under which a one-panel versus a multi-panel design is optimal.

■ MB22

CC Room 204B

In Person: Analytics for COVID and Pandemic Response

General Session

Chair: Dan Andrei Iancu, Stanford University, Stanford, CA, 94305-7216, United States

Co-Chair: Dragos Florin Ciocan, INSEAD, Fontainebleau, France

1 - Forecasting Covid-19 with Application to Vaccine Trial Design
Michael Lingzhi Li, Massachusetts Institute of Technology, Cambridge, MA, 02111, United States, Hamza Tazi Bouardi, Omar Skali Lami, Thomas Trikalinos, Nikolaos Trichakis, Dimitris Bertsimas

To help combat the COVID-19 pandemic and understand the impact of government interventions, we develop DELPHI, a novel epidemiological model. We applied DELPHI across >200 regions since early April 2020 with consistent high predictive power. DELPHI compares favorably with other models and predicted large-scale epidemics in areas such as South Africa and Russia weeks before realization. Furthermore, using DELPHI, we can quantify the impact of interventions and provide insights on future virus incidence under different policies. We illustrate how Janssen effectively accelerated the Phase III trial of the first single-dose vaccine Ad26.Cov2.S by selecting optimal locations using such analysis.

2 - Deploying a Data-driven Covid-19 Screening System at the Greek Border
Vishal Gupta, University of Southern California, Marshall School of Business, Los Angeles, CA, 90026, United States, Hamsa Sridhar Bastani, Kimon Drakopoulos

In the summers of 2020/2021 in the wake of the COVID-19 pandemic, many European countries sought to ease restrictions on non-essential travel to bolster its tourist economy, while still safeguarding public health. In collaboration with Greece, we deployed a data-driven COVID-19 testing system, which used real-time, bandit feedback to allocate scarce testing resources to I) identify asymptomatic, infected travelers ii) monitor different populations for potential spikes that merited adjusting border policies. We describe the system and document its effectiveness over summer of 2020; our data-driven system is able to prevent twice as many asymptomatic infections from entering the border than random, surveillance testing. We discuss some implications for the use of AI in managing the pandemic.

3 - COVID-19 Vaccine Allocation Optimization by Age and Risk Groups
Nazlican Arslan, Northwestern University, Evanston, IL, United States, Ozge Surer, David Morton, Lauren Meyers

Vaccines are the primary means for mitigating a pandemic, but mass vaccination does not typically begin until a pandemic is well underway. As various types of COVID-19 vaccines become available in the US, it is crucial to decide on a vaccine prioritization strategy. We present an age and risk structured epidemiological model that incorporates vaccine allocation. We apply a derivative-free optimization algorithm as well as a greedy heuristic into our SEIR-type simulation model to determine an optimal vaccine rollout to minimize an objective, which can incorporate expected mortality, infections, and hospitalizations, accounting for both general ward and ICU beds.

4 - Quantifying the Benefits of Targeting for Pandemic Response
Dan Andrei Iancu, Stanford University, Stanford, CA, 94305-7216, United States, Sergio Camelo-Gomez, Florin Ciocan, Xavier Warnes, Spyros Zoumpoulis

The social-distancing measures implemented in response to COVID-19 have involved targeting specific groups or activities for confinement. Such targeting can be contentious, so rigorously quantifying its health and economic benefits is critical for designing effective and equitable policies. We propose a framework for computing interventions targeted by population group characteristics as well as the activities that individuals engage in, and showcase a full implementation using publicly available data. We find that optimized dual-targeted policies have a simple and explainable structure, and lead to substantial complementarities and Pareto improvements, reducing the overall number of deaths and the economic losses, and also reducing the time in confinement for each population group.

■ MB23

CC Room 204C

In Person: Empirical Work in Service Operations

General Session

Chair: Carlos Bonet, Columbia University, New York, NY, 10025, United States

1 - Strategic Choices and Routing Within Service Networks: Modeling and Estimation Using Machine Learning
Kenneth Moon, University of Pennsylvania, Philadelphia, PA, 19104-6340, United States

Service networks with open routing by self-interested customers have drawn attention in the theoretical literature. However, these networks, including shopping centers and amusement parks, remain challenging to explore empirically. Large-scale trajectory datasets offer tremendous opportunities to understand customer motivations and behaviors but are complex to analyze. We develop structural empirical methods to recover customer demand preferences and congestion sensitivities from diverse trajectory patterns using machine learning. Specifically, we employ adversarial neural networks to handle the high-dimensional space of trajectory types. Key innovations collapse the dynamics of customer trajectory choices into static trajectory market shares and derive theoretically efficient incentive-compatibility bounds on customers' preferences.

2 - Private vs. Pooled Transportation: Customer Preference and Congestion Management
Kashish Arora, Cornell University, Ithaca, NY, 77300, United States, Fanyin Zheng, Karan Girotra

In this work, we build a structural model to study customers' preferences on prices and service features when choosing between private taxis and a scheduled shuttle service. Using the estimated model, we evaluate the efficacy of congestion surcharge policies in reducing congestion on the road. We also compare the efficacy of these policies with policies that reduce inconveniences associated with the shuttle service. We find that a 20% decrease in the walking inconvenience can achieve 35% of the total number of customers substituting from cabs to shuttles achieved as compared to the congestion surcharges. Our findings suggest that, by changing operations levers such as pooled service features, cities can achieve a substantial amount of the benefit from reducing congestion, without sacrificing customer welfare, compared with congestion surcharge policies.

3 - Lotteries for Shared Experiences
Carlos Bonet, Columbia University, New York, NY, 10025, United States, Nick Arnosti

We consider a setting where tickets for an experience are allocated by lottery. Each agent belongs to a group, and a group is successful if and only if its members receive enough tickets for everyone to participate. A lottery is efficient if it maximizes the number of agents in successful groups, and fair if it gives every group the same chance of success.The most widespread mechanism, the Individual Lottery, gives large groups a significant advantage and may award groups more tickets than they need. We show that these issues can lead to arbitrarily unfair and inefficient outcomes. We propose two alternatives — the Group Lottery and the Weighted Individual Lottery — and show that they are approximately fair and approximately efficient.

■ MB24

CC Room 205A

In Person: Innovative Incentives in Sustainable Operations and Supply Chain Management

General Session

Chair: Shouqiang Wang, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - Avoiding Fields on Fire: Information Dissemination Policies for Environmentally Safe Crop-residue Management
Mehdi Farahani, MIT, Cambridge, MA, 75082, United States, Milind Dawande, Ganesh Janakiraman, Shouqiang Wang

Agricultural open burning, i.e., the practice of burning crop residue to prepare land for sowing a new crop, is a major contributor to climate change. An agricultural machine, called Happy Seeder, which can sow the new seed without removing the residue, has emerged as the most effective alternative. We study how the government can use effective information-disclosure policies to minimize open burning. A Happy Seeder is assigned to process a group of farms in an arbitrary order. Farmers decide whether to burn their farms or to wait for the Happy Seeder, given the information provided by the government about the Happy Seeder's schedule. We propose the class of dilatory policies that provide no information until a pre-specified period and then reveal the entire schedule. We show that the use of an optimal dilatory policy can significantly reduce CO2 and black carbon emissions.

2 - Impact of Return Logistics on Future Repurchase: A Service Co-production Perspective
Guangzhi Shang, Associate Professor, Florida State University, Tallahassee, FL, United States, Michael Galbreth, Li Wang

The impact of forward logistics has been studied extensively in the recent retail operations literature. We look into the understudied return logistics. A prominent feature of this reverse process is that the service is completed by a co-production process between the customer and the firm.

3 - Slow and Steady, or Fast and Furious? An Empirical Study About Omnichannel Demand Sensitivity to Fulfillment Lead Time
Fangyun Tan, Southern Methodist University, Dallas, TX, 75275, United States, Stanley Lim, Fei Gao

We examine a large data set of an Italian omnichannel furniture retailer to study channel-specific effects of fulfillment lead time on demand. This omnichannel retailer sells the same products and has the same product fulfillment across three channels showroom, online and catalog. We find that the showroom channel makes consumers less sensitive to fulfillment lead time than both online and catalog channels. This finding contradicts the common practical and theoretical assumption about homogeneous lead time sensitivity across channels. We also find that niche products and experience goods accentuate the difference of lead time sensitivity between showroom and non-physical channels. Our study highlights the previously-ignored fulfillment time sensitivity aspect of the physical store's value.

■ MB25

CC Room 205B

In Person: Social Responsibility and Sustainability in Supply Chains: Incentives, Monitoring, and Strategies

General Session

Chair: Huan Cao, Greenbelt, MD, 20770-4193, United States

1 - Deadstock Fabric: The Role of Upcycling and Postponement Strategies
Xiaoyang Long, University of Wisconsin-Madison, Wisconsin School Of Bus. Madison, WI, 53706-1324, United States, Luyi Gui

Over-production has long been a pain point for the fashion industry, as it leads to the accumulation of deadstock, i.e., inventories that do not sell. Deadstock not only hurts the profitability of fashion brands but also leads to severe waste if not treated properly. Motivated by this problem, our work investigates how adopting postponement strategies affects fashion brands' fabric acquisition practices and the subsequent implications for the amount of deadstock (including both fabric and finished goods) in the system. We also analyze the interaction between brands' postponement and upcycling strategies, as well as the impact of such interactions on deadstock reduction. Finally, motivated by the growing policy attention to the deadstock problem, we turn to the governmental perspective and analyze potential policy interventions to promote deadstock reduction.

2 - Rider Behavior and Efficiency of Bike Sharing Systems
Huan Cao, Robert H. Smith School of Business, College Park, MD, United States, Tunay Tunca, Weiming Zhu, Lin Jianfeng

We empirically explore rider incentives and e ciency of dockless bike sharing systems. We develop a novel framework to model the customer decision process by explicitly accounting the customer arrival and the commuter-to-bike distance. Using transactional data from a major Chinese bike sharing company, we estimate the usage drivers for the system. Based on the estimation results, we then run counterfactual analysis to demonstrate how the number of deployed bikes a ect the performance of the system. We also study measures to improve e ciency, and compare the e ectiveness of dockless versus dock-based systems.

■ MB27

CC Room 206B

In Person: Network Optimization: Network Influence

General Session

Chair: Majid Akhgar, Oklahoma State University, Stillwater, OK, United States

1 - A Randomized Solution Approach for Finding Groups with Maximum Betweenness Centrality
Tomas Lagos, PhD Student, Swanson School of Engineering, University of Pittsburgh, Pittsburgh, PA, United States

Group betweenness centrality (GBC) indices are widely used to quantify the importance of nodes relatively to the structure of a network. For a given group of nodes, it is defined as the proportion of pairwise shortest paths in a network that each contains at least one node from the group. The problem of finding the group (of some given cardinality) that maximizes GBC is known to be NP-hard. In this talk we discuss a randomized solution approach for solving this problem with some theoretical performance guarantees. The performance of our approach is demonstrated in a numerical study with real-life and randomly generated test instances.

2 - Ecole: A Library for Learning Inside MILP Solvers
Antoine Prouvost, Polytechnique Montréal, Montreal, QC, H3C 3A7, Canada, Justin Dumouchelle, Maxime Gasse, Didier Chételat, Andrea Lodi

We describe Ecole (Extensible Combinatorial Optimization Learning Environments), a library to facilitate integration of machine learning in combinatorial optimization solvers. It exposes sequential decision making that must be performed in the process of solving as Markov decision processes. This means that, rather than trying to predict solutions to combinatorial optimization problems directly, Ecole allows machine learning to work in cooperation with a state-of-the-art a mixed-integer linear programming solver that acts as a controllable algorithm. Ecole provides a collection of computationally efficient, ready to use learning environments, which are also easy to extend to define novel training tasks.

3 - Mixed Integer Linear Optimization Formulations for Learning Optimal Binary Classification Trees
Brandon Alston, Rice University, Houston, TX, United States, Hamidreza Validi, Illya V. Hicks

Decision trees are powerful tools for classification and regression that attract many researchers working in the burgeoning area of machine learning. A binary classification tree is a special type of classification trees in which each branching node has exactly two children. An optimal binary classification tree can be obtained by solving a biobjective optimization problem that seeks minimizing (i) number of misclassified datapoints and (ii) number of branching nodes. In this paper, we propose three MILO formulations for designing optimal binary classification trees: two flow-based formulations and a cut-based formulation. In this talk, we propose three mixed integer linear optimization (MILO) formulations for designing optimal binary classification trees: two flow-based formulations and a cut-based formulation.

4 - Influence-Coverage Optimization Problem
Majid Akhgar Farsani, Oklahoma State University, Stillwater, OK, United States, Juan Sebastian Borrero

We introduce the problem of influence-coverage optimization, where the Influence Optimization and the Maximum Coverage problems are merged into one network optimization problem. In this problem, we have a social network where nodes get activated either by their active in-neighbors or by getting at least a point of their piecewise linear paths covered by external factors. Depending on the application, external factors could be facilities, flyers, billboards, Geo-fences, street art paintings, campaigns, social movements and so on. The aim is to minimize the time until all nodes are active, which depends on the locations of external factors and the value of in-neighbors influence rates. In this regard, we apply an exact approach as well as heuristic approaches providing both decent lower and upper bounds for the proposed MIP problem.

■ MB28

CC Room 207B

In Person: Office of Naval Research Sponsored Talks/Recent Advances in High-Order Methods

General Session

Chair: David Phillips, U.S. Naval Academy, Annapolis, MD, 21401, United States

Co-Chair: Soomin Lee, Yahoo! Research, Sunnyvale, CA, 94087, United States

1 - A Stochastic Newton Algorithm for Distributed Convex Optimization
Brian Bullins, Toyota Technological Institute-Chicago, Chicago, IL, United States, Kumar K. Patel, Ohad Shamir, Nathan Srebro, Blake Woodworth

We propose and analyze a stochastic Newton algorithm for distributed convex optimization. At the heart of our approach is recent work showing that quadratic objectives can be optimized to high accuracy using a parallel algorithm with only a single round of communication. Our algorithm expresses the Newton update as the solution to a quadratic problem which we optimize using stochastic gradients and stochastic Hessian-vector products for the objective, both of which can typically be computed efficiently. We analyze our method for quasi-self-concordant objectives (e.g., logistic regression), and demonstrate that it can in some instances achieve faster convergence rates than comparable first-order methods while requiring less communication and a similar amount of computation.

2 - The Optimization Portfolio Supported by the Office of Naval Research: Current and Future Initiatives
David Phillips, U.S. Naval Academy, Math Department, Annapolis, MD, 21401, United States

In this talk, we will discuss different research directions in optimization and analytics the Office of Naval Research supports and encourages. We discuss examples of ongoing projects that illustrate the breadth of the basic research we support as well as the types of applied projects the Navy is interested in.

■ MB29

CC Room 207C

In Person: Transportation Science and Technology

General Session

Chair: Nilay Noyan, Amazon, Seattle, WA, 98109-5314, United States

Co-Chair: Mauricio C. Resende, Amazon.com, Inc., Seattle, WA, 98109-5314, United States

1 - Mitigating Spot Market Premiums
Idil Arsik, Amazon, Seattle, WA, 98109, United States, Philip Kaminsky, Tara Mardan

Amazon uses both committed capacity acquired weeks ahead of use, and a spot market to procure truckload capacity. The committed capacity is secured in the form of blocks of driver shifts with pre-specified start times and starting/ending location, and several hours to a day ahead of time, specific routes are assigned to these shifts. The delay in this assignment allows Amazon to effectively adapt to changing demand, but it also delays sending loads that are not planned into routes to the spot market, leading to higher premiums. We present a novel approach that is designed to mitigate this risk by offering the loads in the spot market at a reduced price while simultaneously considering them for routing.

2 - Block Time Planning with Atmospheric Wind Information
Xiaofeng Wei, Amazon / Air Science and Technology, Bellevue, WA, United States, Rui Sun, Na An

In today's Cargo airline operations, block times are playing a critical role in the entire network, from planning fleet schedules, fuel cost and CO2 emissions to optimizing package shipment flows. Block time is composed of three components: taxi out time, flight time and taxi in time. In this paper, we develop forecast models using machine learning tools to predict each component of block time separately. Our model can apply the flight and taxi time patterns we learn from the existing OD pairs to forecast the flight and taxi times for new OD pairs and takes into account seasonal atmospheric wind patter for flight time. We test our forecast model using historical on-time performance data, and show that our model results outperform the benchmark forecast results compare to the other block time forecast methods.

■ MB30

CC Room 207D

In Person: Closing the Analytics Talent Gap

General Session

Chair: Jennifer Priestley, Kennesaw State University, Kennesaw, GA United States

1 - Closing the Analytical Talent Gap: What Analytics Professionals Should Know About Working With Universities (But Don't)
Jennifer Priestley, Kennesaw State University, Kennesaw, GA, 30144, United States, Robert Joseph McGrath

Managers of Analytical Teams deal every day with the shortage of people with deep computational skills who are also capable of communicating results to non-technical audiences. As professors, we are asked almost daily from practitioners in the private sector - We have a project how do we reach out to your students? If we do research together who owns it? How much does all of this cost? At the same time, we hear from our academic colleagues - How can I bring a "real" analytical project in the classroom? Is what I am teaching aligned with the demands of the market? How do I start a conversation with a company? This session seeks to answer these questions and provide a tangible set of tools to establish industry-university collaborations. Case studies on working with universities from Equifax, The Home Depot, The Southern Company, and Shaw Industries will be integrated into the session.

■ MB31

CC Room 208A

In Person: Machine Learning and Discrete Optimization

General Session

Chair: Bistra Dilkina, University of Southern California, Los Angeles, CA, 90089, United States

1 - Learning to Generate Graphs End-to-end with Combinatorial Objectives

Haoming Li, University of Southern California, Los Angeles, CA, United States, Aaron Ferber, Bistra Dilkina

With applications in drug discovery, social network modeling and algorithm benchmarking, graph generation considers learning and generating synthetic graphs that effectively mirror those of the real-world graphs in terms of graph statistics. In this work, we focus on graph generation models optimized to match specific combinatorial graph properties, e.g. to minimize the distance between the maximum modularity solutions in the given graphs and those in the generated graphs. We propose to train a graph generator that explicitly integrates the specific combinatorial metrics in a differentiable manner. Our end-to-end learning approach, combining convolutional neural network and differentiable optimization, demonstrates promising performance on generating graphs according to various combinatorial properties.

2 - Toward a Unified Framework for Branch and Bound and Reinforcement Learning

Mohammad Hesam Shaelaie, Lehigh University, Bethlehem, PA, United States, Ted K. Ralphs, Lawrence V. Snyder

In this research, we are aiming to develop a framework unifying Branch and Bound (BB) and Reinforcement Learning (RL). Each of these algorithmic approaches has its own strengths and weakness. Our effort is to design a unified framework to benefit from the strengths while addressing the weakness of each algorithm. BB searches the feasible region systematically and employs powerful pruning methods, but this comes at a high cost per iteration. In contrast, RL has a relatively low iteration cost but is also quite myopic. We explore the tradeoffs inherent in these two approaches and the possibilities for developing a unified framework.

3 - Efficient Active Search for Combinatorial Optimization Problems

Kevin Tierney, Bielefeld University, Bielefeld, 33615, Germany, André Hottung, Yeong-Dae Kwon

Deep learning-based machine learning approaches have recently seen increasing success at solving difficult combinatorial optimization problems. Combining deep networks with effective search procedures has proven critical to finding good solutions. We propose three generic search strategies that can be combined with many neural network models extending the active search approach proposed in Bello et al. (2016). Our search strategies involve updating network weights or output probabilities while searching for a solution, thus allowing deep learning approaches to better generalize to problems they have not been trained on. Our approach offers significant performance improvements on two routing problems and the job shop scheduling problem.

■ MB32

CC Room 208B

In Person: Learning and Data-driven Algorithms

General Session

Chair: Ningyuan Chen, University of Toronto, Mississauga, ON, L5L 1C6, Canada

1 - Corruption-robust Exploration in Episodic Reinforcement Learning

Thodoris Lykouris, Assistant Professor, Massachusets Institute of Technology, Cambridge, MA, 10011-2014, United States, Max Simchowitz, Aleksandrs Slivkins, Wen Sun

We initiate the study of episodic reinforcement learning under adversarial corruptions in both the rewards and the transition probabilities of the underlying system extending recent results for the special case of multi-armed bandits. We provide a framework which modifies the aggressive exploration enjoyed by existing reinforcement learning approaches based on "optimism in the face of uncertainty", by complementing them with principles from "action elimination". Importantly, our framework circumvents the major challenges posed by naively applying action elimination in the RL setting, as formalized by a lower bound we demonstrate. It yields efficient algorithms which (a) attain near-optimal regret in the absence of corruptions and (b) adapt to unknown levels of corruption, enjoying regret guarantees which degrade gracefully in the total corruption encountered.

2 - Dynamic Exploration and Exploitation: The Case of Online Lending

Mingxi Zhu, Graduate School of Business, Stanford University, Stern School of Business, Stanford, CA, 10012, United States

This paper studies exploration/exploitation tradeoffs in the context of online lending. In the case of unsecured online lending, the lender effectively gives away money in order to learn about the borrower's ability to repay. In our model, the lender maximizes the expected net present value of the cash flow she receives by dynamically adjusting the loan amounts and the interest rate as she learns about the borrower's unknown income. The lender has to carefully balance the trade-offs between earning more interest when she lends more and the risk of delinquency. We formulate the problem as an infinite-horizon dynamic program and establish the structure of optimal policy for a large class of income distributions. We analyze the relative regret compared with the full-information case and show there is a distribution under which it is unbounded.

3 - Model-free Assortment Pricing with Transaction Data

Saman Lagzi, University of Toronto, Toronto, ON, Canada, Ningyuan Chen, Andre Augusto Cire, Ming Hu

We study a problem in which a firm sets prices for products based on the transaction data, i.e., which product past customers chose from an assortment and what were the historical prices that they observed. Our approach does not impose a model on the distribution of the customers' valuations and only assumes that purchase choices satisfy incentive-compatible constraints. The individual valuation of each past customer can then be encoded as a polyhedral set, and we maximize the worst-case revenue assuming that new customers' valuations are drawn from the empirical distribution implied by the collection of such polyhedra. We show that the optimal prices in this setting can be approximated at any arbitrary precision by solving a compact mixed-integer linear program. Moreover, we design approximation strategies that are of low computational complexity and interpretable.

■ MB34

CC Room 209B

In Person: Service Science IBM Best Student Paper Competition (I)

Award Session

Chair: Jinsheng Chen, Columbia University, New York, NY, 10027-6714, United States

1 - Online Policies for Efficient Volunteer Crowdsourcing

Scott Rodilitz, Yale University, New Haven, CT, 90278, United States

Nonprofit crowdsourcing platforms encourage volunteers to complete tasks by using nudging mechanisms to notify a subset of volunteers with the hope that at least one of them responds positively. However, since excessive notifications may reduce volunteer engagement, the platform faces a trade-off between notifying more volunteers for the current task and saving them for future ones. Motivated by these applications, we introduce the online volunteer notification problem. We develop an online randomized policy that achieve constant-factor guarantees, and we demonstrate the effectiveness of our policy by testing them on data from a volunteer-based food recovery platform.

2 - Can Autonomous Vehicles Solve the Commuter Parking Problem

Neda Mirzaeian, Carnegie Mellon University, Pittsburgh, PA, 15217-1249, United States

We investigate the effect of autonomous vehicles (AVs) on the morning commute, and characterize a user equilibrium for commuters by developing a continuous-time model that takes into account parking fees and traffic congestion as key economic deterrents to driving. We illustrate our results using data from Pittsburgh, and show that AVs result in a high total system cost. To reduce this cost, a social planner can regulate commuters' decisions by adjusting parking fees and congestion tolls, and/or adjusting infrastructure (e.g., converting downtown parking spots to drop-off spots). Our results indicate that these measures can reduce the total system cost substantially (e.g., by 70% in Pittsburgh).

3 - Optimal Routing under Demand Surges

Jinsheng Chen, Columbia University, New York, NY, 10027-6714, United States

Many service systems employ dedicated staffing with cross-training to provide partial flexibility. Servers primarily serve specific classes of customers, but may serve other classes if necessary, at the cost of inefficiency. For example, during a pandemic, nurses trained in other specializations may be reassigned to take care of patients who have contracted the infectious disease. We consider a multi-class multi-pool parallel server system with partial flexibility, under general time-varying arrival rates. We derive near-optimal scheduling policies that minimize the sum of holding and "overflow" costs. Our policy is simple, intuitive, and makes use of future arrival rate information.

■ MB35

CC Room 210A

In Person: Election Logistics/Shared Fleet

General Session

Chair: Negin Shariat, University of California, Irvine, CA, United States

1 - Simulation Optimization Based Robust and Fair Allocation of Resources to Voting Locations

Praveen Muthukrishnan, ISyE Georgia Tech, Atlanta, GA, United States, Benoit Montreuil, Dima Nazzal, Anjana Anandkumar, Sukanya R. Iyer, Sandro Zangiacomi

The allocation of resources to voting locations influences throughput capacity and waiting time distribution across locations in a political territory (e.g. county), where each location is targeted to serve a subset of the territory (e.g. precinct). Usually subject to tight budget constraints and having significant impact on multi-criteria performance, election boards allocate poll pads, ballot marking devices and scanners using simple ratios such as voters-per-resource. These do not account for local differences in voter turnout, hour-of-the-day voter arrival, and poll time distributions. We introduce a simulation-optimization approach that maximizes robust wait-time performance, enforces fairness across voting locations, and respects budget constraints. We benchmark our approach against actual allocation in Fulton County for the 2020 US Election.

2 - Hypothetical Networks for Analysis of Transit and Shared Mobility Systems

Negin Shariat, University of California, Irvine, CA, United States, R. Jayakrishnan

Transportation planners usually consider many geographical or social demographic factors when designing frameworks for transit system or a shared mobility option for an area. These frameworks are limited in application and constrained to the situational context in the study area. Therefore, contextual transferability of studies is often questionable. We present an unlimited hypothetical but realistic network database that includes the network and its supply and demand to help planners in testing their algorithms and taking different aspects of the area into consideration. Finally, we generate a set of scalable networks with desired assumptions and topologies and test transit planning approaches as well as a shared mobility algorithm to evaluate their capabilities for application in different networks.

■ MB36

CC Room 210B

In Person: Demand Management for Last-mile Logistics and On-demand Mobility

General Session

Chair: Vienna Klein, Neubiberg

1 - Policy-based Dynamic Pricing in Shared Mobility Systems

Matthias Soppert, Bundeswehr University-Munich, Munich, Germany, Claudius Steinhardt

Shared mobility systems have become a wide-spread alternative within the inner-city mobility. Modern systems offer one-way trips, which yield high flexibility to the customer but also cause imbalances between supply and demand that need to be rebalanced for profitable operation. Pricing has turned out to be a promising means. We consider the on-line problem of a shared mobility system provider to simultaneously set discrete minute prices for all zones of the operating area. The action space of this stochastic dynamic decision problem grows exponentially with the number of zones, such that value-based approaches do not scale. Instead, we propose a policy-based approach, adapted from the realm of deep reinforcement learning, which can handle the large actions space. Preliminary results indicate that our approach surpasses the optimal static as well as dynamic benchmarks.

2 - Implications of Different Dynamic Modelling Approaches for Integrated Demand Management and Vehicle Routing Problems

Vienna Klein, Bundeswehr University Munich, Neubiberg, Germany, David Fleckenstein, Claudius Steinhardt, Robert Klein

Demand control problems in the field of vehicle routing are characterized by a stream of customers arriving dynamically over a booking horizon and requesting logistical services which are fulfilled by a given fleet of vehicles. Demand management methods can be applied to exploit heterogeneous customer preferences in order to optimize the booking process with the aim of maximizing total profit. As the quality of demand management decisions depends to a large extent on an accurate estimation of opportunity cost, we formalize its definition specifically for vehicle routing applications. Furthermore, we discuss their properties for different dynamic modelling approaches to derive and discuss implications for approximate dynamic programming solution approaches.

■ MB38

CC Room 210D

In Person: Innovations in Agricultural Value Chains

General Session

Chair: Dan Andrei Iancu, Stanford University, Stanford, CA, 94305-7216, United States

Chair: Xavier Warnes, Stanford University Graduate School of Business, Stanford, CA, 94305, United States

1 - Crop Minimum Support Price Versus Cost Subsidy: Farmer and Consumer Welfare

Prashant Chintapalli, Ivey Business School, London, ON, Canada, Christopher S. Tang

We analyze and compare the performance of cost subsidy and credit-based MSP. We find that (i) Although both cost subsidy and MSP induce more production, cost subsidy leads to a higher crop production than MSP; (ii) MSP improves farmer's and consumer's surpluses; however, cost subsidy improves consumer's surplus but it can decrease farmer's surplus; (iii) Although both programs achieve the same optimal net value (i.e., sum of farmer's and consumer's surpluses minus shortage cost and expenditure), MSP always offers higher farmer's surplus than cost subsidy and (iv) it is beneficial to invest only in cost subsidy, in both cost subsidy and MSP, and only in MSP, when the budget availability is low, moderate, and high, respectively, so that the net surplus (i.e., sum of farmer's and consumer's surpluses less the shortage cost) is also maximized along with the net value.

2 - Balancing Natural Capital and Farmer Welfare: Optimal Mechanisms and Operational Implications

Xavier Warnes, Stanford University Graduate School of Business, 74 Barnes Court, Apt 816, Stanford, CA, 94305, United States

Many of the global agricultural commodities are produced by poor smallholders, often through illegal deforestation. The destruction of forest cover reduces the Natural Capital generated by these ecosystems. In our work we analyze these commodity supply chains and compare several supply-chain interventions that balance the Natural Capital and farmers' welfare.

■ MB39

CC Room 211A

In Person: Editorial Positions in Journals Lessons Learned and Best Practices

Panel Session

Chair: Alice E. Smith, Auburn University, Auburn, AL, 36849, United States

1 - Editorial Positions in Journals Lessons Learned and Best Practices

Alice E. Smith, Auburn University, Auburn, AL, 36849, United States

This session will be a panel discussion about editorial roles in journals ranging from reviewing, associate editor, area/department editor, to editor-in-chief. The panelists, all experienced editors of INFORMS journals, will give their experiences and provide lessons learned and best practices. This session will have a focus on underrepresented groups and the challenges of engaging successfully with the peer reviewing and peer editing system. Important topics to be covered are how to get involved as a journal editor, how to manage your time for such a role, and how to advance your editorial career to more responsible positions.

2 - Panelist

Ann Melissa Campbell, University of Iowa, Iowa City, IA, 52242-1994, United States

3 - Panelist

Archis Ghate, University of Washington, Seattle, WA, 98105, United States

4 - Panelist

Katya Scheinberg, Cornell University, Ithaca, NY, 14853, United States

5 - Panelist

Alejandro Toriello, ISyE Georgia Tech, Atlanta, GA, 30318, United States

■ MB40

CC Room 211B

In Person: Policy-Enabling Models in the Energy Sector

General Session

Chair: Afzal Siddiqui, Stockholm University, London, WC1E 6BT, United Kingdom

1 - Energy Expenditure Incidence in the Presence of Prosumers
Yihsu Chen, Professor, University of California Santa Cruz, Santa Cruz, CA, United States, Makoto Tanaka, Ryuta Takashima

DERs owned by prosumers are considered an effective way of fortifying grid resilience and enhancing sustainability. We analyze how their growing presence in the market may negatively affect less affluent consumers who are financially unable to adopt new technologies. Comparison of the energy expenditure incidence among different income groups when prosumers are subject to a net-metering and a net-billing policy demonstrates that policies exclusively based on volumetric consumption for recovering fixed costs are likely to favor the affluent income group. A hybrid policy, which also features an income-based fixed charge and an annual (re)connection fee or a grid access fee on prosumers, may improve energy equity by leveling the energy expenditure incidence. The policy is also more acceptable by and appealing to the utilities because of revenue certainty.

2 - Equilibrium-based Modeling of Carbon Intensity-based Standards for Transportation Fuels
Adam Christensen, Technical Staff, GAM S. Development Corporation, Fairfax, VA, United States, Colin Murphy, Julie Witcover, Daniel Mazzone

Several jurisdictions have enacted or proposed market-based lifecycle carbon intensity standards to promote the use of renewable transportation fuels, e.g., California's Low Carbon Fuel Standard (LCFS). We develop a policy-oriented market model by combining multiple discrete agent (primal) optimization problems into a single mixed complementarity problem using the Extended Mathematical Programming (EMP) syntax available in GAMS.

3 - Lyapunov-regularized Reinforcement Learning for Power System Transient Stability
Wenqi Cui, University of Washington, Seattle, WA, United States, Baosen Zhang

Transient stability of power systems is becoming increasingly important with the growing integration of renewable resources. Their power electronic interfaces can implement almost arbitrary control laws, which provide increased flexibility in frequency responses. To design optimal non-linear policy for these controllers, reinforcement learning (RL) has emerged as a powerful method. A key challenge is to enforce that a learned controller must be stabilizing. This paper proposes a Lyapunov regularized RL approach for optimal frequency control for transient stability in lossy networks. Because the lack of an analytical Lyapunov function, we learn a Lyapunov function parameterized by a neural network. The learned Lyapunov function is then utilized as a regularization to train the neural network controller by penalizing actions that violate the Lyapunov conditions.

■ MB41

CC Room 212A

In Person: Operation Research for Emerging Resources: Hybrid Power Plants, Virtual Power Plants, Batteries and Beyond

General Session

Chair: Nawaf Nazir, University of Vermont, Burlington, VT, 05401, United States

1 - Reducing Forecasting Error by Optimally Pooling Wind Energy Generation Sources Through Portfolio Optimization
Alexander Vinel, Auburn University, Auburn, AL, 36832-5418, United States, Chanok Han

It is widely documented that it is often possible to reduce the severity of generation intermittency by pooling together geographically diverse renewable sources. This paper aims at evaluating the potential for a similar approach targeted at addressing the related issue of limited predictability of wind energy generation. We design a portfolio optimization model based on Conditional Value-at-Risk methodology for intelligently constructing a wind energy portfolio for a given harvesting region. We then employ it to evaluate potential improvement in (day ahead) generation predictability for a collection of locations in the USA. The study concludes that if intelligent pooling is used, wind energy generation forecasting error can be significantly reduced without sacrificing much efficiency, with the effect directly related to the size of the harvesting region.

2 - Guaranteeing a Physically Realizable Battery Dispatch Without Charge-discharge Complementarity Constraints
Nawaf Nazir, Pacific Northwest National Lab, Richland, WA, United States, Mads Almassalkhi

The non-convex complementarity constraints present a fundamental computational challenge in energy constrained optimization problems. In this work, we present a new, linear, and robust battery optimization formulation that sidesteps the need for battery complementarity constraints and integers and prove analytically that the formulation guarantees that all energy constraints are satisfied which ensures that the optimized battery dispatch is physically realizable. In addition, we bound the worst-case model mismatch and discuss conservativeness. Simulation results further illustrate the effectiveness of this approach.

■ MB42

CC Room 212B

In Person: Analytics

Contributed Session

Chair: Divya Mehrish, CapsicoHealth Intern; Stanford University Student, CapsicoHealth, Palo Alto, CA, United States

1 - Detecting Bias in Jury Selection Using Optimal Trees
Daisy Zhuo, Interpretable AI, Cambridge, MA, United States, Jack W. Dunn

To support 2019 U.S. Supreme Court case Flowers v. Mississippi, there was a previous analysis using backward stepwise logistic regression to assess whether the State exhibited a racial bias in striking potential jurors. Their method is only a heuristic, and additionally cannot consider interactions between features. We apply Optimal Feature Selection to identify the globally-optimal subset of features and affirm significant evidence of racial bias. We also use Optimal Classification Trees to segment the juror population subgroups with similar characteristics and probability of being struck, and find that three groups exhibit significant racial disparity, pinpointing specific areas of bias.

2 - Visualizing the Intellectual Structure of the Impact Of COVID-19 on E-learning
Hyaejung Lim, Kyungpook National University, Daegu, Korea, Republic of, Chang-Kyo Suh

E-learning platforms developed enormously over time since the appearance of the Internet. However, COVID-19 pandemic made the ways of e-learning change on another level. This study intended to explore the visualization of the intellectual structure of the e-learning field concentrated on the appearance of the COVID-19 pandemic using CiteSpace(Chen, 2017). In this research, we collected the articles through the Web of Science on e-learning field related to the COVID-19 crisis. We analyze the references of the papers through author-co-citation analysis. Then, we classify the major research domains and characteristics. The results and interpretation will be further discussed in the conference.

3 - Extensions on Antminer Algorithms for Rule-based Classification
Sayed Kaes Maruf Hossain, PhD Candidate, New Mexico State University, Las Cruces, NM, United States, Sajia Afrin Ema, Hansuk Sohn

In this research, we have suggested multiple extensions on the AntMiner algorithms for rule-based classification. Firstly, we incorporated a strategy to dynamically balance the weight of exploration and exploitation during the rule discovery process. Secondly, we have suggested a probabilistic approach to improve the existing exhaustive rule pruning procedures. Thirdly, we performed a modular analysis to explore how the algorithm behaves for a range of probability functions. The early experimental results show competitive results for the proposed strategies over their counterparts.

4 - The Analytics of a Hybrid Workforce
Edward Tuorinsky, Managing Principal, DTS, Arlington, VA, United States

Missions haven't changed, but day-to-day operations have. The pandemic is driving a modernization of the government workforce, introducing a truly hybrid model. Though the situation seems new, existing organizational data can reveal how agencies meet their mission today and provide direction for the future. This session will draw on our experience with the U.S. Fish and Wildlife Service to illustrate how human data analytics can be used to understand the impact of a hybrid workforce and better position government agencies for change. We will cover tools and techniques to capture and organize relevant data, using data visualization to make data actionable, and leveraging human data analytics.

5 - Impact and Risk Models on COPD-related Hospitalizations and Emergency Room Visits by Combining Multi-year Claims Data with Environmental Data Sets

Divya Mehrish, CapsicoHealth Intern; Stanford University Student, CapsicoHealth, Palo Alto, CA, United States, J. Sairamesh, Laurent Hasson, Monica Sharma, Rudy Banerjee, Jakob Bjorner

Chronic obstructive pulmonary disease (COPD) is the fourth-leading cause of death in the U.S. Our study examines clinical and environmental impacts on 90-day hospitalizations, ER visits and readmissions. We integrate 2017-18 CMS claims data with daily weather and pollution data in FL, NY and PA (high annual hospitalization rates). Our logistic regression models show 88% accuracy for 90-day hospitalizations and 74% for ER visits; 94% and 79% with boosted tree-based models. Our models all show 64% accuracy for 30-day readmissions. Our results, which show the clear relationship between the environment and COPD hospital and ER cases, can help care managers target high-risk populations.

■ MB43

CC Room 213A

In Person: Computer Science Applications to OR

Contributed Session

Chair: Mesut Yavuz, University of Alabama, Tuscaloosa, AL, 35487, United States

1 - Exactly Solving Linear Systems via the Sparse Exact (SPEX) Framework: History and Theoretical Foundation

Erick Moreno-Centeno, Texas A&M University, College Station, TX, United States, Christopher Lourenco

Solving sparse linear systems has a central role in solving linear programs and other optimization problems. Exactly solving linear programs and systems is necessary for some applications (e.g., theoretical results, feasibility problems, military applications, applications with hefty costs, ill-conditioned problems, etc.). To address this, we are developing the Sparse Exact (SPEX) Factorization Framework: a high-performance, well-documented, and extremely robust software package. This talk will focus on the history and the theoretical foundations of the package, and a companion talk by Christopher Lourenco will focus on the recent developments and computational results.

2 - Exactly Solving Linear Systems via the Sparse Exact (SPEX) Framework: Moving Towards Exact Optimization

Christopher Lourenco, Assistant Professor, U S. Naval Academy, Annapolis, MD, United States, Erick Moreno-Centeno

Solving sparse linear systems, via LU, Cholesky, and other factorizations, is a fundamental subroutine in mathematical programming. Though most solvers operate exclusively in double precision; applications where more precision is needed are increasingly forcing solvers to move towards quad precision or even fully exact solutions. This talk presents a framework to exactly solve sparse linear systems like those in mathematical programming. Our presented algorithms operate exclusively in integer-arithmetic and we provide computational results showing that they outperform the alternate exact approaches of rational-arithmetic and exact iterative methods.

3 - Throughput-fairness Tradeoffs in Mobility Platforms

Arjun Balasingam, Massachusetts Institute of Technology, Cambridge, MA, United States, Karthik Gopalakrishnan, Radhika Mittal, Venkat Arun, Ahmed Saeed, Mohammad Alizadeh, Hamsa Balakrishnan, Hari Balakrishnan

We study the problem of scheduling, routing, and allocating tasks from different customers to vehicles in shared mobility platforms (e.g., food and package delivery, ridesharing, and mobile sensing). We introduce Mobius, a system that uses guided optimization to navigate the inherent tradeoffs between fairness and throughput caused by shared mobility. Mobius supports spatiotemporally diverse and dynamic customer demands. Our evaluation demonstrates these properties, along with the versatility and scalability of Mobius, using traces gathered from ridesharing and aerial sensing applications.

4 - A Study of Software Development Practice in Operations Research

Mesut Yavuz, University of Alabama, Tuscaloosa, AL, United States, Huseyin Ergin

Software is a crucial part of operations research (OR). In this talk, we present the results of two studies. The first explores all papers published in INFORMS Journal on Computing in the 5-year window (2016-2020) and the second one is a survey of 389 OR scholars. The results shed light on the current state of software development practice in OR, reveal the relationship of the OR scholars with research software, and present the expectations and concerns of them regarding code and data sharing practices.

■ MB44

CC Room 213B

In Person: Supply Chain Management III

Contributed Session

Chair: Yasamin Salmani, Bryant University, Smithfield, RI, 02917-1220, United States

1 - Data-Driven Distributionally Robust Supply Chain Contracting with Stock-Out Substitution

Xuejun Zhao, Purdue University, West Lafayette, IN, United States, William Haskell

We study supply chain contracting with stock-out substitution, when the supplier only has partial information about demand distribution obtained from the past demand realizations and retailer's ordering decisions. We propose a distributionally robust contract for the supplier to hedge against the risks of extremal demand distributions. The uncertainty set combines the information from the retailer's ordering decisions and the past demand realizations, based on the Wasserstein distance. We will show both analytical and computational properties of our new uncertainty set.

2 - Weather Rebate Contracts with Buyback Policy

Piyal Sarkar, PhD Candidate, Ryerson University, Toronto, ON, Canada, Mohamed Wahab Mohamed Ismail, Liping Fang

Firms dealing with weather sensitive products often face a problem with demand management. A class of contract for a supplier-retailer supply chain to address this issue is proposed. This contract provides an incentive to the retailer in the form of a weather rebate to induce the retailer to increase the ordering quantity and takes care of the inventory risk by an inventory buyback policy. The supplier uses weather derivatives to hedge risk depending on the risk attitude. CVaR is used to model the risk attitude. The results show that the designed contract performs better than a traditional buyback contract. The study designs a new class of contract that can be used to manage a supply chain under weather risk.

3 - Supply Chain Viability During Pandemic

Yasamin Salmani, Bryant University, Smithfield, RI, United States, Amin Ariannezhad

Companies respond differently to the pandemic: some sink into bankruptcy, some resist the shock, and some get better. In this study, utilizing a data-driven approach, we investigate the impacts of various established supply chain partner models on the resilience and viability of the companies in the context of the COVID-19 pandemic. We use the companies' performance data before and during the pandemic to address this problem.

■ MB45

CC Room 213C

In Person: Manufacturing and Inventory Management

Contributed Session

Chair: Erik Bertelli, University of California-Berkeley, Alameda, CA, 94501, United States

1 - Resource Allocation of Inspections in Genetic Manufacturing Systems by Using MDP Approach

Mohammad Maydanchi, Auburn University, Auburn, AL, United States, Gregory T. Purdy, Daniel F. Silva

Genetic Manufacturing System (GMS) is a new type of manufacturing with a genetic construct as the final product. In GMS, like other manufacturing systems, having a defective outcome increases the cost and time of the operation. Mid-process inspection is used to check the quality, but the type and number of inspections could adversely affect the time and cost of the product. This work deploys a Markovian Decision Process (MDP) approach to indicate preferred inspection strategies to minimize the total cost and improve the quality based on the non-conforming rate of operations and Type I and Type II error rates.

2 - Manufacturing Localization and its Performance Implications: An Empirical Study in the Automotive Industry

Zhenzhen Yan, Ph.D. Candidate, Michigan State University, East Lansing, MI, United States, Sriram Narayanan, Tobias Schoenherr, Sourish Sarkar

Literature on manufacturing relocation focuses on the decision drivers while the decision consequences are understudied due to the difficulty of data collection. This study contributes to this stream of literature by investigating the performance implications of manufacturing localization, firms' decision of relocating manufacturing activities closer to the target market. Specifically, we use the automotive industry as an empirical context and apply a causal estimation to a uniquely assembled dataset across recalls, inventory, and other industry-specific proprietary data compiled over a 20-year period. Our findings provide practical insights to firms that consider relocation.

3 - Double Tolerance Design or a Product Family
Di Liu, Clemson University, Clemson, SC, United States

We consider a production process with multiple types of products that are inspected on the same quality characteristic with target values are different for each product type. We use double tolerance sets to determine which products require reworking. The nonconforming products with measurements that are between two adjacent target values are separated by a shared outer tolerance. This outer tolerance is used to determine into which product type these products should be reworked. We develop a non-linear optimization model to identify the optimal locations of the shared outer tolerances to maximize profit given the trade-off among selling prices, processing costs and quality loss costs.

4 - Integrated Guaranteed Service Approach for Multi-echelon Inventory Optimization
Victoria G. Achkar, INTEC (UNL-CONICET), Santa Fe, Argentina and Facultad de Ingeniería Química (UNL), Santa Fe, Argentina, Braulio Brunaud, Rami Musa, Carlos A. Méndez, Carlos A. Méndez, Ignacio E. Grossmann

The purpose of Guaranteed Service Model (GSM) is to allocate safety stocks across the network so as to reach target service levels at the lowest cost, accounting for demand uncertainty. The main contribution of this work is the development of an extended integrated approach that accounts for stochastic lead times, raw materials and manufacturing centers management, non-nested review periods, batch sizes, external demand at intermediate nodes, and non-serial network topologies. We propose different NLP and MINLP formulations and evaluate their performance by solving several illustrative ase studies.

5 - Final Production Run and Trade-in Offers for High-tech Products under Warranty
Erik Bertelli, University of California-Berkeley, Berkeley, CA, United States, Candace Arai Yano

High-tech products have short life cycles but may have relatively long warranty periods that a firm must consider when deciding when to end production. However, warranty claims may be satisfied by new or refurbished items. We develop a model to dynamically optimize how long to continue contracting for production by a third-party manufacturer when the firm can later make a one-time trade-in offer to owners of the product to source refurbished inventory.

■ MB46

CC Room 213D

In Person: Optimization

Contributed Session

Chair: Hector Perez, Pittsburgh, PA, 15217, United States

1 - Multi-armed Bandits for Short-lived High-volume Contents
Su Jia, CMU, Pittsburgh, PA, United States

Consider the problem of recommending short-lived, high-volume content e.g. in content aggregation platforms and platforms with user-generated contents.We collaborated with Glance, a ``zero-screen" content platform with over 100 million daily active users and thousands of content pieces, called ``cards", produced daily.To recommend these cards to users, they currently deploy a DNN -based recommendation system that does not use online feedback. We show that our policy improves upon the current system by nearly 30\% in offline simulations based on historical data. A large field experiment to test the effectiveness of our policy is now underway.

2 - Training a Single Bandit Arm
Eren Ozbay, University of Illinois at Chicago, Chicago, IL, United States, Vijay Kamble

Motivated by the problem of optimizing job assignments to train novice workers of unknown quality in labor platforms, we consider a new objective in the classical stochastic multi-armed bandit setup. We consider the cumulative rewards earned from K arms at the end of T pulls, and aim to maximize the expected value of the highest cumulative reward across K arms. This corresponds to the objective of training a single, highly skilled worker using a limited supply of training jobs. We show that any policy must incur an instance-dependent asymptotic regret of $\Omega(\log T)$ and an instance-independent regret of $\Omega(K1/3T2/3)$. We design an explore-then-commit policy achieving these bounds up to logarithmic factors.

3 - University Course Classroom Assignment During A Pandemic
Mohammad Khamechian, PhD Candidate, University of Wisconsin Milwaukee, Milwaukee, WI, United States, Matthew Petering

University course classroom assignment is a challenging real-world problem. This year the pandemic made this task harder due to reduced classroom capacities needed to implement social distancing. This study investigates university course classroom assignments with limited classroom capacities and the option for more than one classroom to be used for the same course at the same time (e.g. for exam scheduling). Distances between rooms assigned to a course and distances from instructors' offices to assigned rooms are considered. A math model is developed, coded in C++, and solved with CPLEX.

4 - A Flexible Rolling Regression Framework for Time-varying Epidemiology Models
Javier Rubio-Herrero, Assistant Professor, University of North Texas, Denton, TX, United States, Yuchen Wang

We present a data-driven framework for describing the time-varying nature of an epidemiology model in the context of COVID-19. By embedding a rolling regression in a mixed integer bilevel nonlinear programming problem, our aim is to introduce a model that reproduces the observed changes in the number of infected, recovered, and death cases, while providing information about the time dependency of the parameters that govern our model. We propose this optimization model and a genetic algorithm to tackle its solution. Moreover, we test this algorithm with 2020 COVID-19 data and found that our results are consistent both qualitatively and quantitatively.

5 - A Digital Twin for Online Optimization of Business Processes in a Supply Chain
Hector D. Perez, Carnegie Mellon University, Pittsburgh, PA, United States, John M. Wassick, Ignacio E. Grossmann

We present a virtual replica of the order-to-cash process that mimics process behavior via a stochastic queueing network representation. Discrete event simulation is used to: 1) estimate order fulfillment dates, 2) forecast potential order delays, 3) identify and mitigate bottlenecks, 4) quantify the impact of design changes, and 5) test optimization policies. An optimization module in the digital twin provides heuristics and mixed-integer scheduling models that can be used to dynamically assign orders to queues and assign order priorities in those queues during process execution.

Monday, 9:45AM-10:45AM

■ MP01

CC - Ballroom E /Virtual Theater 1

Plenary: From Learning to Optimize to Learning to Explore

Plenary Session

1 - Plenary: From Learning to Optimize to Learning to Explore
Yoshua,Bengio, University of Montreal, Dept IRO, Montreal, QC, H3C 3J7, Canada

We consider a discrete combinatorial space and a given objective function where the goal is not to find the maximum of the objective function but rather to discover its main modes, which can be turned into the question of sampling values with probability proportional to the objective function. By taking a power of the objective function, that formulation can smoothly transform the problem of finding the leading modes (with more or less emphasis on the really larger ones) into focussing on just the argmax of the objective. This problem comes up in drug discovery and material discovery tasks, where the objective function is only a proxy (e.g. from a simulator, or imperfect assays) for what we really care about (e.g., more expensive assays, like with mice models, or even clinical trials). Finding a diversity of good solutions is therefore important, because the single argmax solution may not in the end be appropriate. Although MCMC methods can in principle be used for that, we present an alternative approach based on deep generative models seen as policies sampling a sequence of discrete actions and that has the potential to use the power of systematic generalization in order to guess the presence of isolated modes of the objective function. This avoids the mode mixing issue which often comes up with MCMC in high-dimensional spaces where local search methods get stuck and even annealing is not enough, but instead relies on the potential of machine learning to generalize out-of-distribution, a rapidly expanding area of research in deep learning.

Monday, 11:00AM-12:30PM

■ MC01

CC Ballroom A / Virtual Theater 1

INFORMS TutORial Good and Bad Optimization Models: Insights from Rockafellians

Tutorial Session

Chair: John Gunnar Carlsson, University of Southern California, Los Angeles, 90089, United States

1 - Good and Bad Optimization Models: Insights from Rockafellians
Johannes Royset, Naval Postgraduate School, Monterey, CA, 93943-5285, United States

A basic requirement for a mathematical model is often that its solution (output) shouldn't change much if the model's parameters (input) are perturbed. This is important because the exact values of parameters may not be known and one would like to avoid being misled by an output obtained using incorrect values. Thus, it is rarely enough to address an application by formulating a model, solving the resulting optimization problem and presenting the solution as the answer. One would need to confirm that the model is suitable, i.e., "good," and this can, at least in part, be achieved by considering a family of optimization problems constructed by perturbing parameters as quantified by a Rockafellian function. The resulting sensitivity analysis uncovers troubling situations with unstable solutions, which we referred to as "bad" models, and indicates better model formulations. Embedding an actual problem of interest within a family of problems via Rockafellians is also a primary path to optimality conditions as well as computationally attractive, alternative problems, which under ideal circumstances, and when properly tuned, may even furnish the minimum value of the actual problem. The tuning of these alternative problems turns out to be intimately tied to finding multipliers in optimality conditions and thus emerges as a main component of several optimization algorithms. In fact, the tuning amounts to solving certain dual optimization problems. In this tutorial, we'll discuss the opportunities and insights afforded by Rockafellians.

■ MC02

CC Ballroom B / Virtual Theater 2

Hybrid Fair Optimization and Learning under Uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Qing Ye, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Weijun Xie, Virginia Tech, Blacksburg, VA, 24061, United States

1 - A Stochastic Alternating Balance K-means Algorithm for Fair Clustering
Suyun Liu, Lehigh University, Smags Apts Lehigh Univ 13 Duh Dr Apt 212, Building, Bethlehem, PA, 18015-3749, United States, Luis Nunes Vicente

In the application of data clustering, the clustering outcome might discriminate against people in different demographic groups, leading to unfairness. A natural conflict occurs between the clustering cost and the balance, leading to a nonconvex and nonsmooth biobjective problem. To determine the complete trade-off between the two competing goals, we design a novel stochastic alternating fair k-means (SAfairKM) algorithm consisting of alternating k-means updates and swap updates. Moreover, we propose a novel companion algorithm, the stochastic alternating biobjective gradient descent algorithm, which can handle a smooth version of the biobjective fair k-means problem. A sublinear convergence rate is established under strong convexity for the determination of a stationary point of a weighted-sum function parameterized by the number of updates on each function.

2 - Fair and Interpretable Decision Rules for Binary Classification
Connor Lawless, Cornell University, Ithaca, NY, United States, Oktay Gunluk

In this talk we consider the problem of building Boolean rule sets in disjunctive normal form (DNF), an interpretable model for binary classification, subject to fairness constraints. We formulate the problem as an integer program that maximizes classification accuracy with explicit constraints on two different measures of classification parity: equality of opportunity, and equalized odds. Column generation framework, with a novel formulation, is used to efficiently search over exponentially many possible rules. When combined with faster heuristics, our method can deal with large data-sets. Compared to other fair and interpretable classifiers, our method is able to find rule sets that meet stricter notions of fairness with a modest trade-off in accuracy.

3 - Learning Fair Optimal Classification Trees
Sina Aghaei, University of Southern California, Los Angeles, CA, 90007, United States, Jack Benson, Andres Gomez, Phebe Vayanos

The increased use of machine learning (ML) in high stakes domains has created an urgent need for ML algorithms that are fair and interpretable and that leverage the available data to its full extent to yield the most accurate predictions. In this paper, we propose a versatile framework for learning optimal and fair classification trees based on mixed integer optimization technology. Our framework is flexible to capture arbitrary fairness notions from the literature such as statistical parity, conditional statistical parity, etc. We evaluate our method on numerous datasets from the literature and investigate the trade-off between accuracy and fairness. We provide an R package that is freely distributed for academic and non-profit use.

4 - A Statistical Test for Probabilistic Fairness
Bahar Taskesen, EPFL, Lausanne, Switzerland

Algorithms are now routinely used to make consequential decisions that affect human lives. While algorithms empower us to harness all information hidden in vast amounts of data, they may inadvertently amplify existing biases in the datasets. This concern has sparked increasing interest in fair machine learning. Machine learning models should undergo intensive tests to detect algorithmic biases before being deployed at scale. We use ideas from the optimal transport theory to propose a statistical hypothesis test for detecting unfair classifiers. The test statistic quantifies the distance of the empirical distribution supported on the test samples to the manifold of distributions that render a pre-trained classifier fair. We develop a rigorous hypothesis testing mechanism for assessing the probabilistic fairness of any pre-trained logistic classifier.

5 - Unbiased Subdata Selection for Fair Classification: A Unified Framework and Scalable Algorithms
Qing Ye, Virginia Tech, Blacksburg, VA, United States, Weijun Xie

Fair classification concerns the biases in the classical machine learning models. Due to high nonconvexity of fairness measures, existing methods often approximate fairness measures via convex programs. This paper fills the gap by developing a unified framework to incorporate fairness measures precisely. In the proposed framework, when the classification outcomes are known, the resulting problem, termed unbiased subdata selection, can be used to enhance the classification fairness by selecting more representative data points. This motivates us to develop an iterative refining strategy (IRS) to improve the classification accuracy and conduct the unbiased subdata selection in an alternating fashion. We prove approximation guarantee of IRS and numerically demonstrate that the proposed framework can yield better fair classification outcomes than existing ones.

■ MC03

CC Ballroom C / Virtual Theater 3

Hybrid APS Special Session on 'Causal Inference'

Sponsored: Applied Probability Society

Sponsored Session

Chair: Pengyi Shi, Purdue University, West Lafayette, 47907, United States

1 - Tutorial on Causal Inference in Medicine and Public Health
Miguel Hernan, Harvard University, Cambridge, MA, United States

This session will provide an introduction to causal inference, including the definition of causal effects, key conditions for their identifiability and methods for their estimation. These concepts will be illustrated with several real world applications to study interventions for the treatment and prevention of disease.

■ MC04

CC Ballroom D / Virtual Theater 4

Hybrid Emerging Issues in Supply Chain Finance and Risk Management Practice

Sponsored: MSOM/iForm

Sponsored Session

Chair: Gill Eapen, Decision Options, LLC, Groton, CT, 06340, United States

Co-Chair: Selvaprabu Nadarajah, Information and Decision Sciences, University of Illinois at Chicago, Woodridge, IL, 60517, United States

1 - Emerging Issues in Supply Chain Finance and Risk Management Practice

Gill Eapen, Decision Options, Groton, CT, 06340, United States

This panel explores emerging topics at the interface of finance, operations, and risk management. The increasing number of shocks (e.g., COVID, weather events) on integrated supply chains has placed a premium on quantifying their impact on physical and financial flows, as well as the need for forward looking design. Thought leaders from academia and industry will discuss this burgeoning theme by considering the interactions between financial and operating risks, the role of risk management, and the value of recent technologies (e.g., blockchains and digital platforms) and practices.

2 - Panelist

Volodymyr O. Babich, Georgetown University, Washington, DC, 20057, United States

3 - Panelist

John R. Birge, University of Chicago, Chicago, IL, 60637-1656, United States

4 - Panelist

Aurelien Ouattara, Amazon Luxenburg, Luxenburg, Germany

5 - Panelist

Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States

■ MC05

CC Ballroom E / Virtual Theater 5

Hybrid TSL Award II

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States

■ MC06

CC Room 303A

In Person: OR for Vulnerable Populations

General Session

Chair: Shima Azizi, Shrewsbury, MA, 01545-4285, United States

1 - Assessing Transportation Barriers to Opioid Treatment in Tennessee

Anna White, Ann Arbor, MI, 48103-2911, United States

Lack of access to transportation keeps individuals from accessing regular treatment for opioid misuse disorder. In this work, we evaluate the transportation needs and potential investment solutions to improve access to treatment in Tennessee. We conduct case studies of rural, suburban, and urban regions. This work helps to better understand where transportation investments may be needed to connect individuals to treatment services.

2 - Sex Trafficking Analytics: Data, Predictions, And Interdictions

Burcu B. Keskin, University of Alabama, Tuscaloosa, AL, 35406-4062, United States, Nickolas K. Freeman, Gregory Bott

Human traffickers have been using mobile technologies, online classified advertisement sites, and social media but the volume and frequency of ads and the obfuscation tactics complicate the law enforcement investigations. Analyzing over ten million records, our approach combines machine learning models with network theory to understand real/fake posts, identify patterns, predict the movement of the sex trafficking organizations, and inform interdiction efforts.

3 - Refugee Camp System Aid Allocation with Uncertain Demand and Replenishment Cycles

Shima Azizi, Worcester Polytechnic Institute, Worcester, MA, 01545-4285, United States, Erhun Kundakcioglu, Andrew C. Trapp, Cem Deniz Caglar Bozkir, Ali Kaan Kurbanzade

Camp-based refugees seek shelter in camps, and urban refugees in nearby areas. Aid distribution to camps should prioritize camp-based refugees, yet share excess inventory with urban refugees when able. Amid uncertainty in demands and replenishments, we derive an inventory policy to govern a camp's aid sharing with urban refugees. We use the policy to construct expected costs of referring urban refugees elsewhere, depriving camp-based refugees, and holding, and embed them in a cost-minimizing aid allocation problem. Our study reveals insights into humanitarian aid allocation amid uncertainty.

■ MC07

CC Room 303B

In Person: Machine Learning in Action

General Session

Chair: Sara Masoud, Wayne State University, Detroit, MI, 48201-1111, United States

Co-Chair: Dan Li, Georgia Institute of Technology, Atlanta, GA, 30309-4360, United States

1 - An AI Driven Virtual Reality Platform for Human Robot Interaction

Ali Kamali Mohammadzadeh, Wayne State University, Detroit, MI, United States, Sara Masoud, Jessica Rajko

In this work, a smart virtual platform is developed by integrating a physics-based model with room-scale virtual reality, where a virtual cobot developed in Unity game engine is interacting with human(s) immersed using HTC Vive Pro-Eye Arena Bundle. This platform provides an opportunity for safe data collection, feeding ensemble deep artificial neural networks for intention classification and trajectory tracking.

2 - Autoencoders for Detecting Anomalies in Neonatal MRI Brain Scans

Jad Raad, Ford Motor Company, Bloomfield Hills, MI, 48301, United States

Anomalydetection in and analysis of adult MRI brain scans is a well studied field, butfew endeavors have been made to apply similar concepts to the neonatal brain.The challenges involved with analyzing the neonatal brain range from practicalto physiological, and cannot be understated, particularly due to the rapidgrowth and development seen in the developing brain. In this talk, we will discussthe successes and failures we've encountered in the process of developingautoencoders to detect anomalies in neonatal MRI brain scans.

3 - Pm2.5Forecasting Utilizing Graph Convolutional And LSTM Neural Networks

Sara Masoud, Wayne State University, MI, 48201-1111, United States, Ali Kamali Mohammadzadeh, Abd Ali Hussain, Marisa O'Dea, Yaoxian Huang

PM2.5, as inhalable particles with maximum diameters of 2.5 micrometers, are the cause of many serious health problems. Here, a PM2.5 forecasting framework is developed by integrating convolutional and recurrent neural networks. Although it is common to use recurrent neural networks to study the temporal behavior of PM2.5, this is the first work to take advantage of the geo-correlation of monitoring stations. Here, graph convolutional neural networks are implemented to exploit the nested structure of the data, composed of different time series of various meteorological factors over different monitoring stations in Michigan, feeding an LSTM model to improve the forecasting accuracy of PM2.5.

4 - Vertical Federated Learning for Anomaly Detection in Multi Component Cyber Physical Systems

Paritosh Ramanan, Georgia Institute of Technology, Atlanta, GA, 30305-4240, United States

Federated Learning (FL) is a distributed machine learning paradigm that accomplishes large scale learning tasks among multiple user devices with full data privacy. However, classical FL schemes assume homogeneity of features as well as labels across all user devices. In case of large scale multi component systems, classical FL might be infeasible owing to a heterogenous feature set that is scattered across all components/devices. In this talk we present a Vertical Federated Learning framework that eliminates the need to move data for multicomponent systems. Instead, our VFL based approach uses a combination of local and global embeddings to capture interdependencies in the performance at the component level. We demonstrate our results using anomaly detection for a large scale multi component system with a heterogenous feature set at the component level.

■ MC07

CC Room 201B

In Person: Diversity, Equity, and Inclusion: Challenges and Opportunities in Social Media Analytics

General Session

Chair: Jorge Mejia, Indiana University, Bloomington, IN, 47401-5931, United States

Chair: Christopher Dalton Parker, American University, Washington, 20011, United States

1 - Dancing to the #challenge: The Effect of TikTok on Closing the Artist Gender Gap

Yifei Wang, University of Maryland, College Park, MD, United States, Jui Ramaprasad, Anand Gopal

While creative industries have a reputation for being liberal and tolerant, this has not historically translated into greater actual inclusivity. In this study, we examine how technology platforms may impact on artist success on social media and digital music streaming platforms, and importantly may particularly help women getting their work noticed. More specifically, we explore the impact of the TikTok hashtag dance challenge on artists' popularity across two types of social media platforms: Instagram and Spotify, and investigate if the effect varies between male and female artists. Our findings shed new light on social media marketing and artist self-promotion, especially making the music industry more inclusive and attractive to female music artists.

■ MC08

CC Room 303C

In Person: spORts II

General Session

Chair: Brayden Park, Colorado School of Mines, Golden, CO, United States

1 - Clinch and Playoff Magic Numbers for the English Premier League

Mark Husted, Colorado School of Mines, Golden, CO, 80401, United States

The English Premier League (EPL) is the top-level soccer league in England composed of 20 teams. At the end of the regular season, highly ranked teams qualify for one of two international tournaments, the more prestigious Champions League and the Europa League, and low ranked teams are relegated to the second tier for next year's EPL season. An integer-programming model determines when a team has guaranteed its position, or, conversely, when it has been eliminated from international play or relegation before the completion of the regular season.

2 - Improving the Crystal Ball in Professional Sports

Brayden Park, Colorado School of Mines, Golden, CO, United States, Sam King, Eli Olinick, Alexandra Newman

So-called magic numbers capture the attention of fans across a variety of professional sports, and provide information regarding when a team has clinched or been eliminated from a playoff spot, and, additionally, when a team has captured or lost the opportunity for a first-place final standing prior to post-season play. The RIOT sports project determined these numbers exclusively for major league baseball in the United States. Using marketing research, we demonstrate how and why we have expanded to other leagues. We illustrate with a newly remodeled website and behind-the-scenes computations.

■ MC09

CC Room 303D

In Person: APS Special Session on 'High-dimensional Statistics, Algorithms, and Algorithmic Intractability'

General Session

Chair: Daniela Hurtado Lange, Georgia Institute of Technology, Atlanta, GA, United States

1 - Star And Rats: Multilevel Dispatching Policies

Rhonda L. Righter, Professor, University of California-Berkeley, Industrial Engineering And Ops Research, Berkeley, CA, 94720-1777, United States, Esa Hyytia

We consider how to improve dispatching decisions (routing jobs to servers) in large computing systems by combining basic assignment policies into two levels: the first level dispatcher assigns jobs to a set of second level dispatchers, each with their own pool of servers. At each level the decision is made by a static (STA) policy (such as random routing or routing based on job size) or by a Round-Robin (R) policy. Such policies are fast and scale well as only local information is needed. The order of policies, whether RR should be first or second, gives rise to two dispatching policy classes, RATS and STAR. We show that the two-level STAR policy always outperforms RATS, and often outperforms any single-level policy. Moreover, STAR policies are robust across a range of parameter values and distributions for inter-arrival times and job sizes.

2 - On the Convergence Rate of Entropy-regularized Natural Policy Gradient with Linear Function Approximation

Semih Cayci, Urbana, IL, United States, Niao He, R. Srikant

We study the convergence rate of entropy-regularized Natural Policy Gradient (NPG) algorithms with linear function approximation. We show that NPG exhibits linear convergence within an approximation error and O(1/T) convergence to the optimal value function under standard assumptions on the distribution mismatch and the representation power of the feature vectors.

3 - Lower Bounds On Information Requirements for Causal Network Inference

Xiaohan Kang, University of Illinois at Urbana–Champaign, Urbana, IL, 85281, United States, Bruce Hajek

Recovery of the causal structure of dynamic networks from noisy measurements has long been a problem of intense interest across many areas of science and engineering. Many algorithms have been proposed, but there is no work that compares the performance of the algorithms to converse bounds in a non-asymptotic setting. As a step to address this problem, this paper gives lower bounds on the error probability for causal network support recovery in a linear Gaussian setting. The bounds are based on the use of the Bhattacharyya coefficient for binary hypothesis testing problems with mixture probability distributions. Comparison of the bounds and the performance achieved by two representative recovery algorithms are given for sparse random networks based on the Erd s-Rényi model.

■ MC10

CC Room 304B

In Person: Behavior-Aware Modeling of Service Systems

General Session

Chair: David Cho, Woodbury University, Burbank, CA, 91504-1052, United States

1 - Silent Abandonment in Contact Centers: Estimating Customer Patience from Uncertain Data

Antonio Castellanos, Technion – Israel Institute of Technology, Haifa, Israel, Galit B. Yom-Tov, Yair Goldberg

Contact centers are one of the favorite channels of communication with companies. However, they face operational challenges common proxies for customer experience are subject to information uncertainty. A main source of such is silent abandonment by customers. These customers leave the system while waiting for a reply, but give no indication for doing so. As a result, agent capacity is wasted. In two case studies we show that up to 70% of the abandoning customers abandon silently, and that such behavior reduces system efficiency by up to 15%. We develop methodologies to identify silent abandonment and to estimate customer patience. We show how accounting for silent abandonments in a queueing model improves the estimation accuracy of key measures of performance. Finally, we suggest strategies to operationally cope with the phenomenon.

2 - On Two Models of Choice Between an Observable and an Unobservable Queue with Heterogeneous Servers

Jonathan Milo, Tel Aviv University, Tel Aviv, Israel, Refael Hassin

We consider a queueing system where customers arrive according to a Poisson process and select one out of two servers with exponentially distributed service durations. Customers observe the first queue length and make an irrevocable decision on whether or not to enter it, without observing the second queue. We analyze two models where the first server is slower than the second. In both models there is no queue in front of the first server. In one model there is also no queue at the second server and customers who reach it when it is busy are lost. In the second model, there is a queue in front of the second server. We characterize the equilibrium behavior and investigate the relation between the equilibrium and optimal strategies, including the price-of-anarchy.

3 - Behavior Aware Service Staffing

David D. Cho, Woodbury University, Burbank, CA, 91504-1052, United States, Kurt M. Bretthauer, Kyle D. Cattani, Alex Mills

Empirical studies of service systems have shown that workers exhibit different service rates depending on their assigned workload. We model two commonly observed behavioral effects, speedup and slowdown, then incorporate the model into a multi-period workforce staffing problem to study their joint impact on service staffing. Our results show that a workload that maximizes the service rate is typically not optimal. We also find that the effectiveness of the widely practiced single-ratio workload staffing policy depends on the strength of the speedup and slowdown effects.

■ MC11

CC Room 304C

In Person: Economics and Computation II

Award Session

Chair: Ignacio Rios, University of Texas at Dallas, Richardson, TX, 75080, United States

Co-Chair: Shipra Agrawal, Columbia University, New York, NY, 10027-6623, United States

1 - Robustly-optimal Mechanism for Selling Multiple Goods
Weijie Zhong, Stanford University, Stanford, CA, United States, Yeon-Koo Che

We study robustly-optimal mechanisms for selling multiple items. The seller maximizes revenue against a worst-case distribution of a buyer's valuations within a set of distributions, called an "ambiguity" set. We identify the exact forms of robustly optimal selling mechanisms and the worst-case distributions when the ambiguity set satisfies a variety of moment conditions on the values of subsets of goods. We also identify general properties of the ambiguity set that lead to the robust optimality of partial bundling which includes separate sales and pure bundling as special cases.

2 - Equilibrium Computation of Generalized Nash Games: A New Lagrangian-Based Approach
Jong Gwang Kim, Purdue University, West Lafayette, IN, United States

This paper presents a primal-dual method, based on a new form of Lagrangian, for computing an equilibrium of generalized Nash game (GNEP) where each player's feasible strategy set depends on the other players' strategies. We establish the equivalence between a saddle point of the Lagrangian and an equilibrium of the GNEP. We then propose a simple algorithm that is globally convergent to the saddle point. Our method has novel features over existing approaches; it does not require any boundedness assumptions and is the first design of an algorithm to solve general GNEPs in a distributed manner. Numerical experiments are performed on test problems to demonstrate the effectiveness of the proposed method.

3 - Improving Match Rates in Dating Markets Through Assortment Optimization
Ignacio Rios, University of Texas at Dallas, Richardson, TX, United States, Daniela Saban, Fanyin Zheng

We study how a dating platform should dynamically select the profiles to show to each user in each period to maximize the expected number of matches in a time horizon. We model the platform's problem as a dynamic optimization problem, and we use econometric tools to estimate the inputs of our model using our partner's data. We find that the number of matches obtained in the recent past has a negative effect on the like behavior of users. Leveraging our data findings, we propose heuristics to solve the platform's problem. Through simulations and a field experiment, we show that the proposed algorithms can substantially improve the number of matches generated by the platform.

4 - Online Learning via Offline Greedy Algorithms: Applications in Market Design and Optimization
Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, United States, Negin Golrezaei, Fransisca Susan, Joshua Wang, Ashwinkumar Badanidiyuru

Motivated by online decision-making in time-varying combinatorial environments, we study the problem of transforming offline algorithms to their online counterparts. We focus on offline combinatorial problems that are amenable to a constant factor approximation using a greedy algorithm that is robust to local errors. For such problems, we provide a general framework that efficiently transforms offline robust greedy algorithms to online ones using Blackwell approachability. Demonstrating the flexibility of our framework, we apply our offline-to-online transformation to several problems at the intersection of revenue management, market design, and online optimization.

■ MC12

CC Room 304D

In Person: Supply Chain Payments and Financing

General Session

Chair: Kyle Hyndman, University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - An Experimental Investigation of Supplier Financing
Rihuan Huang, Cornell University, Ithaca, NY, 14853-6900, xvUnited States, Andrew M. Davis, Kyle Hyndman

We behaviorally study the newsvendor setting with capital constraint and supplier financing. In our setting, a retailer with some initial wealth orders from a supplier who sets a wholesale price, and will pay the supplier after demand realization if the initial wealth is insufficient. If demand is too low, the retailer goes bankrupt and transfers all of its wealth to the supplier. We consider three treatments varying degree of bankruptcy risk. Preliminary results show that human retailers with high risk significantly understock while retailers with low risk slightly overstock.

2 - A Theoretical and Experimental Investigation into the Welfare Consequences of Late Payments
Kyle Hyndman, University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Matthew Walker

We analyse how late payments affect market entry and price competition. Buyers first send a signal to potential suppliers about their intended payment date. Suppliers then decide whether to incur a fixed and irreversible cost to enter into price competition. After the seller and winning bid is determined, the buyer chooses the ex-post payment date, which may or may not coincide with the ex-ante date promised. We show that in theory, if firms value payment made or received late below its nominal value, payment delays feed into higher consumer prices and reduced competition. Reneging on a promise to pay on-time entails a cost for the buyer. If this cost is not set carefully, a welfare loss arises. We find support for the main predictions of the model in an experiment.

3 - Sourcing Mechanisms for a Single Product under Unstructured Bargaining
Haokun Du, University of Texas at Dallas, Richardson, TX, United States, Bin Hu, Elena Katok

Product sourcing is critical in operations and has attracted great attention. In this paper, we consider unstructured bargaining between suppliers and retailer for a single product. Using "Nash-in-Nash" solution, we have found that the procurement cost decreases with the number of suppliers under simultaneous sourcing mechanism. Sequential sourcing mechanism has also been considered. Minimized cost under this mechanism will award all desired quantities to the first supplier, leaving the other supplier(s) as a mere threat. This suggests that the information update that we are hypothesizing will never occur in equilibrium. We have also shown which mechanism leads to cheaper cost of procurement under a simpler setting theoretically. Experiments are proposed to test the theory.

■ MC13

CC Room 201A

In Person: Simulation

Contributed Session

Chair: Patrick Deenen, University of Technology-Eindhoven, Eindhoven, 5623CH, Netherlands

1 - Optimal Control Models of a Biological Invader using Gaussian Kernels
Sevilay Onal, University of Illinois Springfield, Springfiled, IL, United States, Sabah Bushaj, Esra Buyuktahtakin Toy, Jennifer Smith, Gregory Houseman

Weeds have been detrimental to the crop acreage and yield. Sericea lespedeza is recognized as a biological invader in the Federal Noxious Weed Act in 2000. Control programs to such infestation have been designed to reduce the harmful impacts on biodiversity and bioeconomy in the Great Plains of the U.S. An integrated simulation-optimization model estimates the seed dispersal using Gaussian cell-to-cell transition probabilities, and the treatment locations are prescribed over a predetermined time period depending on the infestation level.

2 - Simulation-based Optimization for Convex Functions over Discrete Sets
Eunji Lim, Adelphi University, Garden City, NY, United States

We propose a new iterative algorithm for finding a minimum point of a real-valued function f* with the domain X, when f* is known to be convex, but only noisy observations of f*(x) are available at each point x in X. The proposed algorithm not only estimates the minimum point of f*, but also provides the probability of each point in X being a minimum point of f*, using the fact that f* is convex. Numerical results indicate that the proposed algorithm converges to a minimum point of f* as the number of iterations increases and shows fast convergence especially in the early stage of the iterations.

3 - Consumer Rental Intentions for Electric Vehicles: Are Green Consumers Quality-conscious or Price-conscious?
Adeela Gulzari, University of North Texas, Denton, TX, United States, Yuchen Wang, Victor R. Prybutok

Research has demonstrated that green consumers who have a positive attitude towards environmental protection are inclined to purchase an eco-friendly car such as an Electric Vehicle (EV). However, individuals who are interested in using an EV without purchase intention can also be concerned about the environment. Renting a car is a low-involvement decision and explores a different dimension of a consumer's thought process. In this research, we study consumer rental intentions for EVs and evaluate whether price or quality-related constructs significantly affect rental intentions using a covariance-based structural equation model.

4 - Selection of the Most Probable Best under Input Uncertainty
Taeho Kim, KAIST, Daejeon, Korea, Republic of, Kyoung-Kuk Kim, Eunhye Song

We suggest a novel robust ranking and selection under input uncertainty named "selection of the probable best". Our formulation aims to find the most probable alternative over the posterior of input parameters. The finite support case on the input posterior is considered first. Our theoretical results provide an optimal computing budget allocation (OCBA) scheme derived by a lower bound on the large deviation rate of the false selection probability. Further, several dynamic sampling algorithms which achieve this bound in the limit are presented. Numerical experiments support our findings.

5 - Representation for Conditional Expectation with Application To Dynamic Programming
Yi Zhou, University of Maryland, College Park, College Park, MD, United States, Michael Fu, Ilya O. Ryzhov, Steven I. Marcus

We consider the problem of estimating a conditional expectation. By formulating the conditional expectation as a ratio of two derivatives, we can apply the generalized likelihood ratio method to represent the conditional expectation using ordinary expectations. We then apply this representation tool in stochastic dynamic programming problems to derive new estimators that can be incorporated into existing learning algorithms, which improves their performances.

6 - Wafer Lot Scheduling in a Real-world Semiconductor Photolithography Bay
Patrick Deenen, University of Technology-Eindhoven, Eindhoven, Netherlands

A semiconductor wafer fabrication facility (fab) consist of many different bays, one of these is the photolithography bay. Since this bay often forms the bottleneck of the fab, scheduling lots in this area is of key for the overall fab's performance. A real-world case study at Nexperia is presented, to demonstrate the benefit of scheduling opposed to current dispatching operations. A simulation model which accurately represents represents the real fab. This model is used to analyze different production control techniques and access their performance (1) the throughput of the photolithography bay, (2) the realization of the operational due-date of jobs and (3) the WIP balance of the downstream bays.

■ MC15

CC Room 201C

In Person: Statistical Methods for Contemporary Business Applications

General Session

Chair: Gourab Mukherjee, University of Southern California, Los Angeles, CA, 90089-0809, United States

1 - Personalized Treatment Selection Using Causal Heterogeneity
Kinjal Basu, LinkedIn Corporation, Sunnyvale, CA, 94085-4172, United States, Ye Tu, Cyrus DiCiccio, Romil Bansal, Preetam Nandy, Padmini Jaikumar, Shaunak Chatterjee

Randomized experimentation (or A/B testing) is widely used in the internet industry to measure the metric impact obtained by different treatments. A/B tests identify the treatment variant showing the best performance, which then becomes the selected treatment for the entire population. However, the effect of a given treatment can differ across experimental units, and a personalized approach for treatment selection can greatly improve upon the usual global selection strategy. In this work, we develop a framework for personalization through (i) estimation of heterogeneous treatment effect at either a cohort or member-level, followed by (ii) selection of optimal treatment variants for cohorts (or members) obtained through (deterministic or stochastic) constrained optimization. Through simulations and real-life experiments, we show the efficacy of the method.

2 - Estimating Promotion Effectiveness in Email Marketing: A High-dimensional Bayesian Joint Model for Nested Imbalanced Data
Gourab Mukherjee, University of Southern California, Los Angeles, CA, 90089-0809, United States

We consider a large-scale, cross-classified nested joint model for modeling customer responses to opening, clicking, and purchasing from promotional emails. Our logistic regression-based joint model contains crossing of promotions and customer effects, and allows estimation of the heterogeneous effects of different promotion emails after adjusting for customer preferences, attributes, and historical behaviors. Using data from an email marketing campaign of an apparel company, we exhibit the varying effects of promotions. We conduct Bayesian estimation by using a block Metropolis-Hastings algorithm that not only incorporates nested subsampling to tackle the severe imbalance between conversions and no conversions, but also uses additive transformation-based modifications of random walk Metropolis to scale estimation for large numbers of customers.

3 - Analyzing Consumer Choice of Hybrid Cars: A New Multinomial Probit Model with Spatially Correlated Preference and Response Coefficients
Sivaramakrishnan Siddarth, University of Southern California, Los Angeles, CA, 90089-1424, United States

We propose a new spatial multinomial probit model that allows different subsets of the preference and choice coefficients to have their own unique spatial structures. We apply the model to vehicle choice data from the Sacramento market in 2008 and show how the estimated parameters can help improve the effectiveness of target marketing programs designed to accelerate hybrid adoption.

■ MC17

CC Room 202A

In Person: INFORMS Prize

Informs Special Session: INFORMS Prize

Informs Special Session Session

Chair: Erica Z. Klampfl, Ford Motor Company, Dearborn, MI, 48124, United States

1 - Operations Research at Amazon Transport
Tim L. Jacobs, Amazon, Tempe, AZ, 85284-3961, United States, Maurico Resende, Nilay Noyan Bulbul

Amazon applies OR and analytics throughout its business, including facility location, inventory management, androuting. Transportation plays a key role in giving our customers a great experience. Though last-mile delivery is perhapsthe most customer-facing mode of transportation, middle-mile transportation is just as critical. We focus on Amazon'smiddle-mile transportation research science team. The Middle-Mile Planning, Research and Optimization Sciences teamof Amazon Transportation Services is built on three pillars: surface research, air science & tech, and pricing & yieldmanagement. We describe their impact on provisioning Amazon's retail delivery network.

■ MC18

CC Room 202B

In Person: Climate Impacts on the Electric Power System

General Session

Chair: Brian Tarroja, University of California, Irvine, CA, United States

1 - Estimating the Sensitivities of Power System Components to Heat and Drought for Climate-informed Planning
Ana Dyreson, Assistant Professor, Michigan Technological University, Houghton, MI, United States, Sean Turner, Ariel Miara, Thushara De Silva, Stuart Cohen, Naresh Devineni, Nathalie Voisin, Jordan Macknick

Climate-informed planning for future power systems requires understanding the sensitivity of physical assets including power plants, buildings, and transmission lines to climate stress. Capturing physically-based impacts is difficult in regional-to-national scale capacity expansion and operational power grid models because of computational tractability and the diversity in individual systems. We review representations of hydroelectric, thermoelectric and demand components and their sensitivities to climate change, focusing on the characteristics of the Western U.S. interconnect. We discuss systematic uncertainty characterization moving forward.

2 - Extending Energy System Modeling to Include Extreme Weather Risks
Jeffrey A. Bennett, University of Virginia, Charlottesville, VA, United States, Joseph F. DeCarolis, Andres F. Clarens

Electric power system planning is supported by energy system optimization models which project future power plant and storage installations in order to meet demand at the lowest possible cost. These models have generally not incorporated the costs of damage to the electric power grid resulting from extreme weather events such as wind or flooding damage from hurricanes or fires caused by drought. In this talk, we present an extended energy system optimization model that incorporates hurricane risks and apply it to the context of Puerto Rico, an island territory of the United States that had its electric grid severely damaged by Hurricane Maria in 2017. When hurricane trends are included, 2040 electricity cost projections increase by 32% based on historical hurricane frequencies and by 82% for increased hurricane frequencies resulting from climate change.

3 - Implications of Climate Change for Decarbonized Electricity System Planning: Examples from California
Brian Tarroja, Professional Researcher, University of California, Irvine, Irvine, CA, United States

Regional electricity systems are evolving to incorporate more zero-carbon energy resources and transform the infrastructure that underpins such electric grids. To ensure that these efforts are successful, these must be adapted to account for how climate change affects regional electricity supply, demand, and infrastructure. Here, we provide examples of how climate change affects decarbonized electricity system planning through effects on hydropower generation, water availability for thermally-based electricity resources, and building electricity demand. California is used as an example due to its combination of susceptibility to drought, temperature extremes, and policies to decarbonize their electricity system. Further, we explore the effectiveness of different solutions to mitigate undesirable impacts on decarbonized electricity system planning.

■ MC19

CC Room 203A

In Person: Emergency Medicine Operations?

General Session

Chair: Saharnaz Mehrani, The George Washington University, Washington, 20052, United States

1 - A Machine-learning Framework for Addressing Emergency Department Crowding Problem
Abdulaziz Ahmed, University of Minnesota-Crookston, Crookston, MN, United States, Omer Ashour

We develop a machine learning framework for predicting whether a patient is hospitalized or discharged based on the patient's information. Such information is vital signs, demographic data, and the complaints a patient presents while arriving in an emergency department.

2 - Dynamic Coordination of Exams in a Radiology Practice
Saharnaz Mehrani, University of Connecticut, Storrs, CT, United States, Miao Bai, David Bergman, Carlos Henrique Cardonha

We study dynamic coordination of exams on multiple diagnostic machines in a radiology practice with inpatients, outpatients, and patients from emergency department. There is stochasticity in both patients' itinerary and radiologic care. There are different costs per unit wait time associated with different patient urgencies to receive radiologic care. Our goal is to minimize total expected wait cost in one day. We formulate the problem as a Markov decision process and adopt an approximate dynamic programming algorithm to solve it. We evaluate the performance of our model and algorithm on a real-world problem and show that the resulted policy outperforms two baseline heuristic policies.

■ MC20

CC Room 203B

In Person: Data Analytics in Opioids Use/Misuse

General Session

Chair: Sujee Lee, Soongsil University, Seoul, 06978, Korea, Republic of

1 - Data-driven Models for Identifying Risk Factors Leading to Opiate Abuse
Jinha Lee, Bowling Green State University, Bowling Green, OH, 43403-0154, United States, Arthur Yeh, Qizhen Lan, Jung Im Choi, Hyojung Kang

Drug addiction, abuse, and overdose deaths have become the most pressing public health issue in the U.S. Understanding drug abuse and overdose patterns from a geo-spatial framework can empower communities to develop strategy for responding to the drug abuse based on where incidents take place. Therefore, it is imperative to identify behavioral and socioeconomic factors that affect community level and subsequently develop a geo-spatial model to assess drug abuse risk. The essential idea is to harness the potential of data analytics to identify the behavioral geo-spatial model that identifies risk factors in local communities given drug abuse-related socioeconomic features, and to develop optimal data-drive strategies and guidelines for minimizing abuse.

2 - A Machine Learning Integrated Opioid Prescription Optimization Framework
Sujee Lee, Soongsil University, Seoul, Korea, Republic of, Philip A. Bain, Jingshan Li

We propose a framework that integrates machine learning and optimization models to determine the optimal amounts of opioids in the initial and subsequent prescriptions. For this purpose, the amounts of opioids consumed by total joint placement (TJR) patients in SSM Health, Madison, WI were investigated through patient surveys. In the framework, the machine learning model is trained to estimate the opioid demand level for each patient. Then, the proposed optimization model minimizes the expected opioid leftovers as well as the number of opioids refills to determine the optimal amount of opioid prescription for each demand level. The resulting prescription decisions are compared with the current practice in SSM Health. The results prove that the model can help reduce opioid leftovers, without increasing the burden of hospitals and patients.

■ MC21

CC Room 204A

In Person: Recent Advances in Multistage Stochastic Programming

General Session

Chair: Harsha Gangammanavar, Southern Methodist University, Dallas, TX, 75275, United States

1 - Multistage Stochastic Programming with Optimal Stopping
Rui Peng Liu, Georgia Institute of Technology, Atlanta, GA, United States

The theory of optimal stopping finds interesting applications in house selling, one-armed bandit, option trading, etc. In this talk, we present a general formulation of multistage stochastic programming that incorporates optimal stopping. This formulation can be solved, as usual, by writing down the Bellman equation and applying dynamic programming. Our focus will be on applications and computational aspects of the formulation.

2 - Risk Bounds and Rademacher Complexity in Batch Reinforcement Learning
Yaqi Duan, Princeton University, Princeton, NJ, United States

We consider batch Reinforcement Learning (RL) with general value function approximation. Our study investigates the minimal assumptions to reliably minimize Bellman error, and characterizes the generalization performance by (local) Rademacher complexities of general function classes. Concretely, we view the Bellman error as a surrogate loss for the optimality gap, and prove: (1) In double sampling regime, the excess risk of Empirical Risk Minimizer (ERM) is bounded by the Rademacher complexity of the function class. (2) In the single sampling regime, sample-efficient risk minimization is not possible without further assumptions, regardless of algorithms. However, with completeness assumptions, the excess risk of FQI and a minimax style algorithm can be again bounded by Rademacher complexities. (3) Fast statistical rates can be achieved by using localization.

■ MC22

CC Room 204B

In Person: Healthcare Policy and Regulation

General Session

Chair: Anqi Wu, University of Illinois, Champaign, IL, 61821, United States

1 - The Impact of Uncertainty Avoidance Culture on Patient Engagement During the Covid-19 Pandemic
Kellas Cameron, Assistant Professor, University of South Florida, Tampa, FL, 33602, United States, Lu Kong

National Cultures have played an undeniable role in how different countries have been able to effectively tackle the Covid-19 pandemic. We posit the countries that exhibit a higher uncertainty avoidance index had better responses due to their population's willingness to adapt to new social and health directives, as this risk averse nature has been associated with higher patient engagement. Our model demonstrates how these dimensions of national culture as opposed to individual preferences directly impacted the implementation of novel mitigation processes to lower infections rates. We outline ways in which those in health operations can leverage these cultural norms to maximize positive patient health outcomes.

2 - Healthcare Reimbursement Policy Impact on Multiple-provider Readmission Reduction Programs
Jon M. Stauffer, Texas A&M University, College Station, TX, 77843, United States, Jonathan Eugene Helm, Kurt M. Bretthauer

We examine the transition from Fee-for-Service to alternative reimbursement plans, such as bundled payments and the Hospital Readmission Reduction Program, and how this impacts the motivation for providers to reduce readmissions. Results show that bundled payment plans do motivate cost-effective readmission reduction effort from hospitals, but if post-discharge providers are included in the gain-sharing contracts they may perform insufficient or excessive effort. We discuss two redesigned structures (single-controlling provider and risk-adjusted) for bundled payment plans to address these readmission reduction effort misalignment issues.

3 - The More Monitoring, the Better Quality? Empirical Evidence from the Generic Drug Industry

Anqi Wu, University of Illinois at Urbana-Champaign, Urbana, IL, 61821, United States, Yixin Iris Wang

With growing concerns on drug safety issues, FDA has implemented major moves to allocate more inspections to high-risk manufacturers. The actions of FDA implicitly assume that the frequent inspections at low-quality facilities could reduce the drug safety concerns. However, whether more monitoring guarantees better quality remains unclear. In this study, we directly examine the validity of this assumption in the generic drug industry and test the impact of inspection frequency on the manufacturing quality. Overall, we do not find evidence that supports the link between more frequent inspections and fewer recall events, suggesting that the current risk-based inspection model alone might not help bring down the quality failures in drug products. We propose two explanations for the results the organizational culture and the inherent quality levels.

■ MC23

CC Room 204C

In Person: Service Economics and Revenue Management

General Session

Chair: Andrew E. Frazelle, The University of Texas at Dallas, Dallas, TX, 75205-3685, United States

Co-Chair: Pnina Feldman, Boston University, Boston, MA, 2215, United States

Co-Chair: Ricky Roet-Green, University of Rochester, Pittsford, NY, 14534-2883, United States

1 - Ownership Utility of Rental Products in Rent-to-own Businesses

Milad Armaghan, University of Texas at Dallas, Richardson, TX, 75080-3021, United States

Rent-to-own (RTO) businesses offer products to renters in exchange for a periodic fee. Renters can also purchase the already-rented product at a dynamically determined buyout price set by the firm. To model renter decisions in this market, we develop a new utility framework that takes full advantage of the unique features of the RTO space, namely the repeated signals about each renter's ownership utility provided by his acceptance or rejection of different buyout prices. Within our framework, we propose several different specifications of renter ownership utility, and we use maximum likelihood estimation to identify optimal parameter estimates analytically and, where necessary, numerically. In particular, we propose one structure in which utility is independent and identically distributed across periods and renters, and another in which utility is heterogeneous across renters but constant across periods for each renter. We also model the spectrum between these extremes, first by developing an algorithm to attribute different utility structures to different renters, and second by proposing a stochastic process with utilities in successive periods imperfectly correlated. Our methodology and results can be used by RTO firms to estimate renter willingness to pay when setting buyout prices. Furthermore, using transaction data from a prominent RTO firm, we test the estimation performance of the various utility specifications. While some specifications perform better than others on our data, we believe that all of the utility structures that we propose and analyze are of independent interest for estimating renter ownership utility in different settings.

2 - Cherry Picking and Service Segmentation on On-demand Service Platforms

Qiaowen Guo, Washington University in St. Louis, St. Louis, MO, United States, Kaitlin M. Daniels, Panos Kouvelis

We study an on-demand platform that facilitates a marketplace in which servers serve two types of customers patient and impatient. Like non-platform firms, the platform can construct a menu of prices and expected wait times tailored to each type of customer. Our platform, however, only has indirect control over the wait experienced by customers. Instead, customer wait depends on the decisions of individual servers, who choose for themselves which jobs to serve and may exhibit "cherry picking," a behavior in which a server strategically declines a low-value job to be available to serve a high-value future job. We study the platform's optimal incentive design.

3 - Strategic Behavior in Queues with Arrival Rate Uncertainty

Binyamin Oz, Hebrew University of Jerusalem, Jerusalem, Israel, Refael Hassin, Moshe Haviv, Moshe Haviv

We consider a general queueing model with a Poisson arrival process whose rate is random, and realized once for the entire process. We show that the distribution of the arrival rate at arrival instants is the size-biased counterpart of the original distribution. In particular, the ASTA (arrivals see time averages) property does not hold but rather a rate-biased version of it that we define and coin by the term RASTA (Rate-biased ASTA). We show that the RASTA phenomenon plays a crucial role in the analysis of strategic behavior of customers who evaluate the consequences of the actions they take upon arrival. We study such a system with a single server and strategic customers who decide whether to join or balk without observing the queue.

■ MC24

CC Room 205A

In Person: Emerging Pricing and Sales Promotion Strategies

General Session

Chair: Rim Hariss, McGill University, Montreal, QC, H3A 1G5, Canada

1 - A Near-optimal Algorithm for Real-time Order Acceptance: An Application in Post-acute Healthcare Services

Zihao Qu, University of Texas at Dallas, Richardson, TX, United States, Milind Dawande, Ganesh Janakiraman

We study a joint capacity investment and real-time accept/reject optimization problem in an infinite horizon with an application in post-acute care. To maximize the average profit per period, the firm accepts/rejects stochastic referral arrivals in real time. Accepted referrals require different resources over an episode. A referral differs in the revenue, the resource requirement, the frequency of resource usage, and the stochastic duration of the episode. Using a simple policy, we derive a worst-case guarantee on its optimality gap, and show that our policy is asymptotically optimal. We also illustrate the impressive numerical performance of our policy using public healthcare data.

2 - Pay-to-win in Video Games: Microtransactions and Fairness Concerns

Duc Vu, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Xuying Zhao, Kathryn E. Stecke

Microtransaction (selling add-on items in games) is a commonly observed in video games. Although microtransaction generates extra revenue, it also leads to fairness concerns from players who do not buy the add-on. A publisher needs to consider the cross-externalities between game players and add-on buyers, when deciding whether to adopt a microtransaction strategy, or a bundling strategy. We identify two determinant ratios of the optimal strategy: the market size ratio and valuation ratio of high-type (hardcore players) to low-type (casual players) game players. Although microtransaction may create fairness concerns, it actually generates higher consumer surplus than bundling if properly implemented. Our results provide plausible explanations for successes and failures of a microtransaction strategy in different games and guidance for future publishers.

3 - Optimal Promotional Budget Allocation for Customer Retention In Subscription Retailing

Rim Hariss, Assistant Professor, McGill University, Montreal, QC, 02139, Canada, Yu Ma

Many consumer-facing companies often adopt promotions to attract customer demand. In doing so, they have limited promotions budgets that they need to allocate strategically across different products categories in order to increase sales. Other than sales, subscription-based retailers have an additional revenue stream from memberships or subscriptions fees. To ensure the long-term profitability of these programs, these companies need to develop capabilities to accurately assess the demand and revenue implications of their promotion strategy as well as to how it affects customer churn. In particular, types, volumes and frequency of promotions for different product assortments could affect subscribed customers'willingness to extend their membership, which in turn affect these companies' total revenue.

■ MC25

CC Room 205B

In Person: Circular Economy Strategies and Products' End of Life Cycle/Socially Responsible and Sustainable Operations

General Session

Chair: Yen-Ting (Daniel) Lin, University of San Diego, San Diego, CA, 92110, United States

1 - Show, Don't Tell: Education and Physical Exposure Effects in Remanufactured Product Markets

Huseyn Abdulla, Ph.D. Candidate, Mays Business School, Texas A&M University, 301A Wehner Building, TAMU 4127, College Station, TX, 77840, United States, James Duane Abbey, Selin Atalay, Margaret Meloy

We empirically examine the effectiveness of managerially-relevant, process- and product-related interventions to increase the appeal of and willingness-to-pay (wtp) for remanufactured consumer products: educating consumers about remanufacturing processes and providing physical exposure to a remanufactured product. We find that education does not cause a significant increase in the appeal of and wtp for toward remanufactured products. However, providing physical exposure to remanufactured products results in a significant increase in both the appeal of and willingness-to-pay for the remanufactured products. We discuss the practical implications of our findings for sellers of remanufactured products and circular economy policy-makers.

2 - How do Producers Fare with Fair Trade?
Yen-Ting (Daniel) Lin, University of San Diego, Olin Hall, School of Business Administration Univ, San Diego, CA, 92110, United States, Adem Orsdemir, Ying Zhang

Fair trade certificate promotes a sustainable livelihood for producers in developing countries. It ensures that producers are paid at a fair wage and potentially protects producers from the volatility in the commodity market. We examine the impact of fair trade certificate on a company's decisions, profitability and participating producers' welfare. We also examine a firm's choice between fair trade and direct trade, another common socially responsible sourcing strategy.

■ MC26

CC Room 206A

In Person: Sequential Decision Making and Machine Learning in Healthcare/Innovations in Procurement and Utilization of Deceased-donor Organs

General Session

Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States

1 - Feature-Based Design Of Priority Queues: Digital Triage in Healthcare
Simrita Singh, Kellogg School of Management at Northwestern University, Evanston, IL, 160071, United States

We study data-driven classification where a classifier assigns jobs (e.g., patients or medical images) based on observed features to priority queues for human review. Traditional classifiers are designed to minimize misclassification loss functions but may underperform when integrated with queueing systems. We propose an integrated approach where the classifier and the queueing system are optimized to minimize the workflow's average waiting cost. We demonstrate the value of our approach using an actual data set covering 560,486 patient visits to three emergency rooms over three years.

2 - Patient Prioritization in the Emergency Department
Gizem Yilmaz, PhD Candidate, University of Chicago, Chicago, IL, 60615, United States, Daniel Adelman

In the emergency department, triage nurses assign arriving patients to an urgency class. Although urgency class is an essential factor for patient prioritization, it is not the only one. We aim to understand the current prioritization rule for the ED bed allocation by leveraging the high-fidelity emergency data and machine learning literature. We build a model that predicts the next patient assigned to a bed and evaluate the viability of deploying this prediction model in operations to support prioritization decisions. The prediction model gives us insights into the current prioritization rule for the ED bed allocation. We leverage these insights to develop an improved prioritization rule.

3 - A Simple Incentive Mechanism to Alleviate the Burden of Organ Wastage in Transplantation
Sait Tunc, Virginia Tech, Blacksburg, VA, 24061, United States

Despite efforts to increase the supply of donated organs for transplantation, organ shortages persist. We study the problem of organ wastage in a queueing-theoretic framework. We establish that self-interested individuals set their utilization levels more conservatively in equilibrium than the socially efficient level. To reduce the resulting gap, we offer an incentive mechanism that recompenses candidates, who have accepted a pre-defined set of organs and returned to the waitlist for re-transplantation, for giving up their position in the waitlist and show that it increases the equilibrium utilization of organs while also improving social welfare.

4 - Does Transportation Mean Transplantation? Impact of New Airline Routes on Sharing of Cadaveric Kidneys
Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States, Guihua Wang, Ronghuo Zheng

Every year, nearly 5,000 patients die while waiting for kidney transplants, and yet an estimated 3,500 procured kidneys are discarded. Such a polarized co-existence of dire scarcity and massive wastefulness has been mainly driven by insufficient pooling of cadaveric kidneys across geographic regions. Although numerous policy initiatives are aimed at broadening organ pooling, they rarely account for a key friction— efficient airline transportation, ideally direct flights, is necessary for long-distance sharing, due to the time-sensitive nature of kidney transplantation. Conceivably, transplant centers may be reluctant to accept kidney offers from far-off locations without direct flights. In this paper, we estimate the effect of the introduction of new airline routes on broader kidney sharing.

■ MC27

CC Room 206B

In Person: Optimization Modeling Software

General Session

Chair: Steven P. Dirkse, GAMS Development Corporation, Fairfax, VA, 22031-4342, United States

1 - Recent Improvements to MathOptInterface
Benoît Legat, MIT, Cambridge, MA, United States

MathOptInterface (MOI) provides a intrinsically flexible and extensible API.Such design often comes at the cost of reduced performance over specialized interface.In this presentation, we discuss the challenges for MOI to both be generic and performant.We focus on two specific approaches to this: mutable arithmetics and matrix representations.

2 - New Connections to the AMPL Modeling Language: Spreadsheets and Callbacks
Robert Fourer, AMPL Optimization Inc., Evanston, IL, 60201-2308, United States, Filipe Brandão

Optimization applications are often concerned as much with making connections as with building models. This presentation describes two connections recently implemented in the AMPL modeling language and system. A direct spreadsheet connection reads and writes xlsx-format files, defining correspondences between common spreadsheet layouts and AMPL's data definitions. Support is included for "two-dimensional" spreadsheet tables in which one index labels the columns and one or more indices label the rows. A solver callback connection enables AMPL's APIs to communicate with algorithms as they are running, uniting the ease of modeling in AMPL with the flexibility of programming to customize algorithmic behavior. This facility can be used to write specialized routines that report progress, change settings, and generate constraints that cut off fractional solutions.

3 - GAMS/Engine A New System for Solving Models on Centralized Compute Resources
Steven P. Dirkse, GAM S. Development Corporation, Fairfax, VA, 22031-4342, United States, Frederik Proske, Hamdi Burak Usul

Typically, personal computers have been powerful enough to quickly solve the model instances generated by GAMS. If not, users (or their expert IT staff) have implemented custom scheduling systems to run large optimization jobs on central compute resources.Increasingly, users want to run large jobs or large streams of jobs on the cloud. This enables them to access more powerful machines than typically found on a desktop and also to utilize a scalable pool of worker machines if their job stream benefits from this, but arranging for all this still requires the expert IT staff.To relax this requirement, we have developed GAMS Engine, a powerful GAMS job-scheduling system. Central to Engine is a modern REST API that provides an interface to a scalable Kubernetes based system of services, providing API, database, queue, and a configurable number of GAMS workers.

■ MC28

CC Room 207B

In Person Technology Tutorial: Nonlinear Optimization Using Artelys Knitro

Technology Tutorial

1 - Nonlinear Optimization Using Artelys Knitro
Richard Waltz, Artelys, Los Angeles, CA, 90045-2603, United States

Nonlinear optimization is used in many applications in a broad range of industries such as economy, finance, energy, health, 3D modeling, and marketing. With four algorithms and great configuration capabilities, Artelys Knitro is the leading solver for nonlinear optimization and demonstrates high performance for large scale problems. This session will introduce you to Artelys Knitro, its key features and modeling capabilities, with a particular emphasis on the latest major improvements including recent advances in solving mixed-integer nonlinear optimization problems. We will also provide benchmarks highlighting the power of Knitro to efficiently solve large-scale, nonlinear models with hundreds of thousands of variables and constraints."

■ MC28

CC Room 207B

In Person Technology Tutorial: High Performance Computing Capabilities in Purdue's MS BAIM Program

Technology Tutorial

1 - High Performance Computing Capabilities in Purdue's MS BAIM Program

Matthew A. Lanham, Purdue University, Lafayette, IN, 47905-4803, United States

This tech tutorial will showcase the HPC capabilities at Purdue University and how masters' students in our top-ranked MS Business Analytics & Information Management (BAIM) program are leveraging our capabilities to achieve outcomes with industry partners.

■ MC29

CC Room 207C

In Person: Last Mile Science and OR/ML Practice at Amazon

General Session

Chair: Liron Yedidsion, Amazon, Redmond, WA, 98052, United States

1 - Multi-stage Newsvendor Problem: Applications to Contact Center Staffing

Kevin A. Melendez, Amazon.com, Seattle, WA, 33613, United States, German Riano

We introduce an extension of the classical Newsvendor Problem in which we consider heterogeneous suppliers for the same stochastic demand. Each supplier has different fixed and variable cost, and are used in a given order. The problem is to allocate the demand into the available suppliers to minimize cost. We develop a heuristic algorithm that can solve the problem to optimality if certain conditions are met. We show an application of our model to dynamically staff Amazon contact center network. To the best of our knowledge, this approach has not been used in this context before.

2 - A Practical Take on Decomposition Algorithms for Stochastic Programming

Semih Atakan, Amazon.com, Seattle, WA, 98121, United States

Typical operations research aims to develop the fastest methodology to solve established problems of value to the community. In practice, business problems can evolve constantly and demand a fast answer, or else the opportunity to influence the business may go away. In stochastic programming, some of the "fastest" methodology comes with restrictive assumptions, which may get violated as soon as the underlying problem changes deeming more methodological effort necessary. In this talk, we put on a practitioner's hat, and describe (and justify) the algorithmic choices we made when building our stochastic program capabilities. Our talk will focus on versatility challenges, practical concerns to stochastic programming (which we cannot resolve easily), and some bonuses of having flexible decomposition algorithms in our toolset.

3 - Demand Forecasting for New Nodes in a Delivery Network

Chinmoy Mohapatra, Research Scientist II, Amazon, Seattle, TX, United States, Rohit Malshe, Liron Yedidsion, Abhilasha Katariya, Jin Ye, Dipal Gupta

Effective demand forecasting is a crucial element in the short-term and long-term planning process of any logistic network. We study the demand forecasting problem for new nodes that are added to an existing logistic network. Such nodes may have very limited historical data and may share limited time-invariant features with existing nodes in the network. We propose a hybrid optimization and machine learning based forecasting approach that considers both time-varying and static features of different nodes. We show the effectiveness of the proposed approach through a real-life case study from a logistics network.

■ MC30

CC Room 207D

In Person: Spatial & Temporal Analytics and Applications I

General Session

Chair: Jian Liu, University of Arizona, Tucson, AZ, 85719-0505, United States

1 - Spatiotemporal Monitoring of Melt-pool Variations in Additive Manufacturing

Siqi Zhang, United States

Advancements in image sensing systems offer great opportunities for in-situ monitoring and control of melt-pool characteristics in Additive Manufacturing. However, prior efforts are more concerned about feature-based modeling and analysis of melt-pool imaging data. Little work has been done to leverage the tensor decomposition to transform the time-varying melt-pool imaging data into low-dimensional profiles, and then utilize the Gaussian process to model these low-dimensional profiles for in-situ monitoring of AM process. In this paper, we present a novel Gaussian process framework for statistical modeling and monitoring of melt-pool imaging data. Experimental results show that the proposed framework shows great potential for process monitoring and control of AM process.

2 - Online Nonparametric Monitoring for Asynchronous Processes with Serial Correlation

Ziqian Zheng, University of Wisconsin-Madison, Madison, WI, United States

With the development of modern sensor technology, more and more complicated data streams are involved in process monitoring. However, most of the existing studies assume that the sampling intervals of all the data streams are the same, and process observations at different time points are independent. In this paper, we propose a generic nonparametric MSPC scheme that can handle asynchronous process data with serial correlation. Specifically, we first propose a nonparametric method for the pairwise correlation function estimation. Then an asynchronous monitoring framework is proposed to monitoring the decorrelated process. The performance of the proposed method is evaluated based on both synthetic data and a real-world dataset.

3 - StressNet Deep Learning to Predict Stress with Fracture Propagation in Brittle Materials

Xiaowei Yue, Virginia Tech, Blacksburg, VA, 24061, United States, Yinan Wang, Weihong Guo

Accurate prediction of internal stress is critical to improving the fracture resistance and reliability of materials. To reduce computational cost of Finite-Discrete Element Model (FDEM), a deep learning model, StressNet, is proposed to predict the entire sequence of internal stress. Specifically, the Temporal Independent Convolutional Neural Network is designed to capture the spatial features like fracture path and spall regions, and the Bidirectional Long Short-term Memory is adapted to capture the temporal features. By fusing these features, the evolution in time of the internal stress can be accurately predicted. Moreover, an adaptive loss function is designed to reflect the fluctuations in internal stress. The proposed model can realize accurate multi-step predictions in about 20 seconds, as compared to the FDEM run time of 4 h, with an average MAPE 2%.

4 - Spatial-Temporal Trip Demand Prediction Considering Trip Chaining Effect

Fenglian Pan, University of Arizona, Tucson, AZ, United States, Jian Liu

Effectiveness of traffic management relies on accurate prediction of trip demand. In daily life, people usually travel in a chain of trips, which influence each other spatially and temporally. Without explicitly considering such spatial-temporal (ST) interdependence, existing methods fall short in prediction accuracy. In this research, a Hawkes process model is proposed to predict trip demand, with trip interdependence represented as a ST triggering pattern in the form of structural kernel function. An algorithm is developed to enable the estimation of the model with latent triggering pattern parameters. The performance of proposed model is demonstrated in a real-world case study.

■ MC31

CC Room 208A

In Person: Advanced Machine Learning Techniques in Manufacturing Systems

Joint Session

Chair: Hao Yan, Tempe, AZ, 85281-3673, United States

Co-Chair: Imtiaz Ahmed, Texas A & M University, College Station, TX, 77840-6717, United States

1 - Deep Multistage Multitask Learning for Quality Prediction Of Multistage Manufacturing Systems

Hao Yan, Arizona State University, Tempe, AZ, 85281-3673, United States, Nurettin Dorukhan Sergin, William A. Brenneman, Shan Ba

In multistage manufacturing system, modeling multiple quality indices based on the process sensing variables is important. However, the classic modeling technique predicts each quality variable one at a time, which fails to consider the correlation within or between stages. We propose a deep multistage multi-task learning framework to jointly predict all output sensing variables in a unified end-to-end learning framework according to the sequential system architecture in the MMS. Our numerical studies and real case study have shown that the new model has a superior performance compared to many benchmark methods as well as great interpretability through developed variable selection techniques.

2 - Surprise Driven Autonomous Experimentation Platform

Imtiaz Ahmed, Texas A. & M, Plantation, College Station, TX, 77840-6717, United States

Imtiaz Ahmed, West Virginia University, Morgantown, WV, United States, Yu Ding

Physical experiments are often costly and refrain us from exploring high dimensional parameter spaces to find the most suitable design or approximating the underlying response surface . In this work, we develop an autonomous experimentation platform for discovering new, efficient design. We introduce the notion of 'surprise' and propose a surprise guided exploitation-exploration trade off policy. We combine our surprise driven active learning techniques with computer-controlled simulated experiments to guide the sequential physical experiment selection process. Our platform can plan and execute the sequential experiments autonomously and reach the desired design using minimal search and resource. We compare our approach with the Bayesian optimization based sequential experimentation policy to illustrate its benefits and potential applications.

■ MC32

CC Room 208B

In Person: Empirical Research in Operations Management

General Session

Chair: Abhishek Deshmane, IESE Business School, United States

1 - Reading Between the Stars: understanding the Effects of Online Customer Reviews on Product Demand

Hallie Cho, Vanderbilt, Nashville, TN, 37203, United States, Manuel Sosa, Sameer Hasija

Consumer perceptions of product quality—and how they are shared via customer reviews—are of extreme relevance to the firm, but we still do not understand how the quantitative and qualitative aspects of customer reviews affect product demand. Our paper seeks to fill this critical gap in the literature by analyzing star ratings, the sentiment of customer reviews, and their interaction. Using the US automobile market data, we find robust empirical evidence that 1) review sentiment and star ratings both have a decreasingly positive effect on product demand and 2) the effect (on demand) of their interaction suggests that the two components of reviews are complements. Positive sentiments in text reviews increase the positive effect of ratings when the effect of ratings is decidedly positive and they compensate for the tendency of consumers to discount extremely high star ratings.

2 - Exploring the Trilateral Productivity in Surgery Teams: Do Agents, Pairs, and Teams Affect Each Other?

Jaeyoung Kim, PhD Candidate, Clemson University, Clemson, SC, United States, Lawrence Fredendall, Ahmet Colak, Robert Allen

We study the effect of micro-level foundations of surgical teams on team productivity: interactions among individuals (agents), dyads (pairs), and teams. Using six datasets containing the micro-level characteristics of surgical teams (e.g., patient, operation, staff, procedure, scheduling, and surgeons) obtained from a large south-eastern hospital, we show that surgical teams have trilateral relationships where the micro-level team characteristics affect each other: while individuals and dyads affect the macro-level team performance, the rest of the team also affect the micro-level individual and dyad performance. Our study adds to the prior literature by showing the different effects of learning on individuals and dyads, which enhances the micro-level organizational design of hospitals.

■ MC33

CC Room 209A

In Person: Empirical Research in Retail Operations

General Session

Chair: Sahar Hemmati, University of Maryland, United States

1 - Strategic Visual Merchandising of New and Open-box Products: Evidence From Experiments and Retail Data

Yuanyuan(Amy) Ding, University of Minnesota, MN, United States, Necati Ertekin, Karen L. Donohue

Retailers are increasingly selling returned products as open-box along with their new counterparts, which raises the question of what's the most effective visual merchandising strategy for this assortment? While some retailers position open-box products side-by-side with their new counterparts in the assortment (i.e., the side-by-side strategy), others position them separately in a different part of the retail space/different page on a website (i.e., the separate strategy). We conduct multimethodology research to empirically investigate the economic effectiveness of these two visual merchandising strategies.

2 - Impact of Price Markdown Framing on Product Returns

Wedad Elmaghraby, University of Maryland, College Park, MD, United States, Sahar Hemmati, Ozge Sahin

Percentage discounts and bundle discounts are among the mostly used marketing tools in retail, the impact of which on sales and customers' purchase behavior has been extensively studied in the extant literature. However, the effect of different pricing strategies on product returns has not been well-explored. Our objective is to understand how percentage discounts and bundle discounts impact customers' product choice and return decision. Using the data from one of the largest apparel retailers in Turkey, we find that bundle promotions not only increase the incidence, but also decrease the return probability of each product, controlling for price, discount depth and item characteristics. We find that returns of products purchased with a bundle discount decrease on average by 21% compared to returns of the same products while purchased with a percentage discount.

■ MC34

CC Room 209B

In Person: Service Science IBM Best Student Paper Competition (II)

Award Session

Chair: Yunzong Xu, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States

1 - Ownership Utility Estimation in Rent-to-Own Businesses

Milad Armaghan, University of Texas, Richardson, TX, 75080-3021, United States

Rent-to-own firms rent products in exchange for a periodic fee and offer the already-rented products for purchase at buyout prices to their renters. The renters' ownership utility for a rented product determines their willingness to pay the buyout price for the product. To model renter decisions, we develop a utility framework that incorporates the unique features of the RTO business, namely the repeated signals about each renter's utility from his responses to different buyout prices. Using transaction data from an RTO firm, we compare the estimation performance of utility specifications.

2 - Blind Network Revenue Management and Bandits with Knapsacks under Limited Switches

Yunzong Xu, Massachusetts Institute of Technology, Cambridge, MA, 02142, United States

We study both the classical price-based network revenue management problem in the distributionally-unknown setup, and the bandits with knapsacks problem. Beyond the classical resource constraints, we introduce an additional switching constraint to these problems, which restricts the total number of times that the decision-maker makes switches between actions to be within a fixed switching budget. For such problems, we show matching upper and lower bounds on the optimal regret, and propose computationally-efficient limited-switch algorithms that achieve the optimal regret.

■ MC35

CC Room 210A

In Person: Intersection Control with Connected and Autonomous Vehicles

General Session

Chair: Mojtaba Abdolmaleki, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Stochastic Reservations for Autonomous Intersection Management

Carlin Liao, University of Texas at Austin, Austin, TX, 78705-3030, United States, Stephen D. Boyles

Automated intersection management relies on sequencing movements with tight clearances to increase throughput compared to traffic signals, but this assumes that all vehicles are automated and precise. To accommodate human drivers, the intersection must increase the space reserved for them at the cost of efficiency. Since these vehicles can't use the entire area allocated to them, this presentation will introduce the concept of stochastic reservations to allocate one timespace unit to multiple vehicles to be both safe and efficient, informed by driving simulator experiments with real human drivers.

2 - Performance Evaluation of Modified Cyclic Max Pressure Controlled Intersections in Realistic Corridors

Simanta Barman, University of Minnesota, Minneapolis, MN, United States, Michael W. Levin

Max pressure is an actuated decentralized signal control policy, proven to be stable for any stabilizable demand. This study focuses on evaluating the performance of this policy compared to the current signal control. Simulation models of seven intersections comprising two corridors, County Road (CR) 30 and CR 109 from Hennepin county, Minnesota were created. Then a cyclic max pressure control with realistic first-in-first-out queueing behavior was implemented. Comparisons based on average waiting time, vehicle speed etc. were then made to determine the better policy. This study aims to demonstrate that max pressure performs better than current signal timing based on realistic simulations.

3 - A Unifying Framework for Intersection Control Based on Graph Coloring

Mojtaba Abdolmaleki, Graduate Student Research Assistant, University of Michigan, Ann Arbor, MI, United States, Yafeng Yin, Neda Masoud

This talk discusses a unifying mathematical framework for intersection control that aims to allocate right-of-way to conflicting traffic movements to minimize delay or maximize throughput. Given the problem's NP-hardness, we devise a hybrid LP-relaxation graph coloring approximation algorithm to find the optimal control for a generic demand pattern. Assuming the footprint of the intersection is sufficiently large, we prove the algorithm is a polynomial-time approximation scheme. Our scheme is unifying in the sense that it includes as a special case the traditional signal control for manually driven vehicles and the reservation-based signal-free schemes for automated vehicles.

4 - A Multiclass Link Transmission Model for Dynamic Network Loading of Mixed Legacy and Automated Vehicle Flow

Michael W. Levin, University of Minnesota, Minneapolis, MN, United States, Di Kang

Many cities will experience a mixed traffic flow consisting of both legacy and automated vehicles. Although the overall market penetration may be known, the proportion of automated vehicles may vary in space and time. Since automated vehicles are expected to behave differently than legacy vehicles, this results in a flow-density relationship that varies in both time and space with the local proportion of automated vehicles. We model this scenario using a multiclass kinematic wave theory. We develop a multiclass Newell's method for finding exact solutions to the multiclass kinematic wave theory. We then extend this method to a multiclass link transmission model. Numerical results from dynamic traffic assignment on the downtown Austin network demonstrate the computational tractability of this method and explore the effects of automated vehicles on traffic congestion.

■ MC36

CC Room 210B

In Person: Future Mobility and Urban Community

General Session

Chair: Ziwei Cao, University of Maryland, College Park, MD, 20740, United States

1 - An Integrated Personalized Incentive Scheme for Shared Autonomous Vehicles

Somayeh Dejbord, University at Buffalo, Tonawanda, NY, 14150-2856, United States

Operations of the fleet of shared autonomous vehicles (SAVs) can lead to an increase in empty trips such as repositioning trips with negative impacts on overall traffic and on the SAV fleet operator's profit. To reduce inefficiencies of such services, this study proposes a personalized incentive scheme which is innovatively established based on a win-win strategy between households and the operator. Due to computational complexity, the scheme is iteratively developed upon an integrated framework consisting of the travel behavior model of households and an SAV fleet operations model. The results of the empirical investigation show that the framework offers the service provider an effective incentive scheme resulting in higher profit and more efficient operations of the fleet and presents travelers more SAV rides within the same budget.

2 - Service Bundle Design and Pricing for Shared Autonomous Vehicles (SAV)

Qingyang (Tom) Xiao, SUNY at Buffalo, Buffalo, NY, 14228-3226, United States

With the adoption of Autonomous Vehicles (AVs) and the rise of the concept of Mobility-as-a-Service (MaaS), we tackle the service bundles design and pricing problem. Through service bundles, travelers receive services at lower cost compared to Pay-Per-Ride scheme and in return, operators secure more demand. We formulate a two-stage hierarchical optimization model with the first stage problem of designing and pricing service bundles and second stage of minimizing operations for the service. A case study based on forecasting demand data for New York City (NYC) by New York Metropolitan Transportation Council (NYMTC) is conducted to derive insights of this system.

3 - Adopting Automated Vehicles and Creating Equitable Transport Markets

Amir Brudner, The Hebrew University of Jerusalem, Mount Scopus Campus, Jerusalem, 9190501, Israel, Nicole Adler

Automated vehicles (AV) provide opportunities to improve public transportation (PT) in low-density suburbs. However, AVs may adversely affect PT demand and service. In this research, we aim to maximize positive AV externalities such as under-served population mobility whilst minimizing negative externalities like congestion. We develop a stylized model connecting a suburb to a central business district and compare outcomes over multiple market structures. We assess monopolistic to competitive AV markets and AV-PT cooperation for a single representative period and peak / off-peak periods, taking into account AV fixed costs. We compare the market structure results to an optimal social welfare outcome and derive subsidies and congestion charges. The findings may aid policymakers to develop regulatory tools which generate positive transport equilibria outcomes.

4 - Mixed Employment Modes for On-demand Platforms Facing Worker Benefit

Ziwei Cao, University of Maryland-College Park, College Park, MD, 20740, United States, Michael O. Ball

New regulations for gig-economy workers seek to convert independent contractors to employees. In this paper, we consider the pricing and staffing strategies of an on-demand ride-sharing platform adopting the mixed employment mode, i.e., hiring both part-time and full-time drivers, under mandatory benefit rules for full-time drivers. In our analytical model, drivers may decide whether to work for the platform and if so, whether to choose a full- or part-time work schedule. Our results, based on both analytical and numerical studies, show the impact on worker compensation and company profits under a variety of assumptions. Insights into potential government policies are also provided.

■ MC37

CC Room 210C

In Person: Telecommunications and Network Analytics 1

General Session

Chair: Austin Buchanan, Oklahoma State University, Stillwater, OK, 74078-5017, United States

1 - Heuristics for the Budget-Constrained Immobile Server Problem

Adam Quentin Colley, Southern Methodist University, Florence, AL, 35630-2617, United States

Given a set of Poisson traffic streams (customers) and a fixed budget for opening and provisioning M/M/1 service queues at a set of potential locations, the Budget-Constrained Immobile Server Problem (BCISP) is to determine the number, location, and service capacities of the queues, and an assignment of customers to the queues that minimizes a cost function comprising fixed queue-setup costs and variable costs for customer assignment and waiting time. We propose heuristics for the BCISP that are easy and inexpensive to implement, and compare their performance against exact methods implemented with commercial mathematical programming software.

2 - Two-stage Robust Edge Service Placement and Sizing under Uncertainties

Duong T. Nguyen, Arizona State University, Tempe, AZ, United States, Ni Trieu, Hieu T. Nguyen, Jiaming Cheng, Vijay K. Bhargava

We study the optimal service placement and workload allocation problem under uncertainties from the perspective of a service provider who can procure resources from numerous distributed edge nodes. To tackle this problem, we propose novel two-stage and multi-period robust optimization models which aim to balance between minimizing the operating cost for the provider and improving the experience for its users, considering various uncertainties such as resource demand and edge node failures. We employ and tailor the column-and-constraint generation method to develop iterative algorithms to solve the proposed robust models, which show significant advantages compared to benchmark solutions.

■ MC38

CC Room 210D

In Person: Financial Frictions and Operations Management

General Session

Chair: Christopher J Chen, Indiana University Kelley School of Business, Bloomington, IN, 47405-1703, United States

Chair: Danko Turcic, University of California, Riverside, Riverside, CA, 92521-9800, United States

1 - Inventory Productivity in Manufacturing Networks

Nikolay Osadchiy, Emory University, Atlanta, GA, 30322-1059, United States, Deepak Agrawal

We identify drivers of inventory productivity in manufacturing networks, including traditional and novel ones based on the supply chain position, and discuss implications for performance benchmarking and valuation.

2 - Blockchain Technology in Agriculture: Tipping the Farmers and its Implications

Saed Alizamir, Yale University, New Haven, CT, 6520, United States, Basak Kalkanci, Foad Iravani

We examine an emerging financial innovation in agricultural supply chains that is enabled by the Blockchain technology. This innovation empowers socially-conscious customers to identify the individual farmers of their sustainably-sourced products and send them direct payments, or tips, through mobile apps. We investigate the implications of this new capability on farmers' and consumers' welfare and agricultural firm profits. We show that farmers' expected and actual income and consumer welfare may reduce in the presence of tipping if certain conditions on model parameters hold. In contrast, if tipping is implemented under the right conditions, it can create a triple win for agricultural firms, farmers, and consumers.

3 - Managing Operations of a Hog Farm Facing Volatile Markets: Inventory and Selling Strategies of the Maschhoffs

Ye Liu, Washington University in St. Louis, St. Louis, MO, 100081, United States, Panos Kouvelis, Yunzhe Qiu, Danko Turcic

We study the problem of a wean-to-finish hog farmer who gets to see how market-ready hogs she has available at the beginning each week for sale and the current market prices. Then, she must decide how many hogs to sell through to a meatpacker and on the open market. We view the farmer's problem as a dynamic, multi-item inventory model with random yields and prices. We show that there are two thresholds: one for the under-weight and the other for the regular-weight hogs. Whenever the number of animals in a particular weight pool is below that threshold, the farm should do nothing. When the number of market-ready animals exceeds that threshold, the farm should sell the excess on the open market or to the meatpacker, depending on the prevailing market prices. Calibrated numerical experiments show that the optimal policy has around 25% improvement over the existing practice.

■ MC39

CC Room 211A

In Person: DEI Ambassador Program Session

Flash Session

Chair: Anahita Khojandi, University of Tennessee, Knoxville, TN, 37996, United States

Co-Chair: Daniel Reich, Naval Postgraduate School, Monterey, CA, 93943, United States

1 - Who Are the Gatekeepers? An Examination of Diversity in INFORMS Journal Editorial Boards

Margaret L. Brandeau, Stanford University, Stanford, CA, 94305-4121, United States, Laker Newhouse

Publishing in respected scholarly journals is critical to academic success. However, if journal editorial boards fail to reflect the diversity of thought in a field, worthy work may be overlooked. This study assesses the level of diversity in the editorial boards of the 16 INFORMS journals. We examine gender, whether an individual is an underrepresented minority, and institutional affiliation, and perform a network analysis to identify coauthor relationships between editorial board members.

2 - A Safe Platform for INFORMS Minority Groups

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States, Christopher Tang

The objective of this Ambassador Program is to establish a support group to discuss challenges facing minority groups within the INFORMS community. The support group will be organized in the form of three panels led by a broadly inclusive set of panelists from both academia and industry and supported by the INFORMS leadership. To create a safe environment, participants will have the option to stay anonymous for all the panels.

3 - MIF undergraduate Students Day at the INFORMS Annual Meeting

Trilce Encarnacion, University of Missouri- St. Louis, Saint Louis, MO, 63121, United States, Ruben Proaño

Hispanics and African Americans are consistently underrepresented in STEM disciplines, the MIF Undergraduate Students Day is a short workshop prior to the 2021 INFORMS Annual Meeting for a selected group of undergraduate minority students in sophomore and junior years, interested in OR/MS. These students will receive funding from MIF to attend the Annual Meeting, and will be introduced to the field of OR/MS and the potential career pathways. Students will also be offered guidance on how to navigate the Annual Meeting, attend research presentations, and explore career opportunities in the field. By offering young URM undergraduate students the opportunity to explore cutting edge research presented at the meeting, we seek to encourage URM students to join the OR/MS community, and take advantage of mentoring opportunities through MIF and INFORMS.

4 - Sustaining An Empowered Community for Women of Color in ORMS

Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States, Karen Hicklin, Maria Mayorga

With DEI funding for the 2020 Ambassadors Program project "Building An Empowered Community for WoC in ORMS," the team successfully established the first cohort of 21 Empowered Women of Color (EWoCs). The objective of this project is to sustain the community of WoC (both in academia and industry) that was initiated through the DEI Ambassadors Program inaugural award in 2020. The goal of sustaining this community for WoC within INFORMS is to increase the number of WoC in academia and empower them to navigate the tenure track. Additionally, this community supports the growth and development of women of color in industry positions who oftentimes experience issues with imposter syndrome resulting from microaggressions and unconscious bias. This community plays a unique role in INFORMS as we are the only community focused on intersectionality and the unique needs of WoC in OR/MS, as such we have created a safe space within INFORMS for professional and community development.

5 - We're Here: LGBTQ+ Stories of Identity, Community, and Mentorship from INFORMS Members

Tyler Perini, Georgia Institute of Technology, Atlanta, GA, 30318, United States

This virtual camp was developed by the Tapia Center and Google's Operations Research Team, and funded by INFORMS DEI. Participants will learn computational thinking skills and design their own algorithm for an important societal challenge: college admissions. The 7th-12th graders will analyze how equitable and fair their algorithm is in deciding which students are allowed to enroll in which colleges. They will interact with college students and STEM Operations Research professionals.

6 - Building an Approach to DEI-Informed Research in OR/Analytics
Michael P. Johnson, University of Massachusetts-Boston, Boston, MA, 02125-3393, United States, Tayo Fabusuyi

The goal of this project is to develop principles by which researchers in OR/analytics may integrate ideas about diversity, equity and inclusion, racial and social justice and antiracism into research ideas that span application areas, disciplinary modes and analytic methods.

7 - "Now What?" A Mid-Career Faculty Colloquium for Underrepresented Groups
Illya V. Hicks, Rice University, Houston, TX, 77005-1827, United States, Julie Ivy, Maria Mayorga

The tenure track can be complex for faculty, this is particularly true for mid-career faculty, for underrepresented minority faculty and for women of color faculty [3]. While significant attention is paid to preparing faculty to begin a tenure track faculty career and to some extent to attain tenure, less attention has been paid to mid-career faculty who are post-tenure associate professors seeking to be promoted to full professor. This ambiguity can be even more taxing for underrepresented faculty. The objective of this project is to empower underrepresented minority mid-career faculty in operations research and management science to navigate the promotion and tenure track to facilitate their successful promotion. Our project will develop and host a mini-professional development workshop for underrepresented minority faculty who are late stage assistant professors and associate professors modeled after the NSF-funded ACW: Academic Career Workshop for Underrepresented Junior Faculty and Senior Graduate Students workshop.

8 - Stimulating Participation of underrepresented Groups in INFORMS Editorial Boards
Alice E. Smith, Auburn University, Auburn, AL, 36849, United States

This project aims to increase the diversity of participants in journal editor activities, with an emphasis on INFORMS journals. Journals, as the main outlet for scholarly publications, are hallmarks of careers in academia and research. Participation is crucial to the advancement and sharing of knowledge, as editors and reviewers provide the key input and decision making in the dissemination of research. This talk will cover the objectives and the activities of this project, which include a webinar in May and a planned panel at the annual conference.

9 - Computational Thinking and Equity an Online Tapia Camp for 7-12th Graders
Paul Hand, Northeastern University, Boston, MA, United States, Richard Tapia, Juan Pablo Vielmo, Leticia Velazquez

This virtual camp was developed by the Tapia Center and Google's Operations Research Team, and funded by INFORMS DEI. Participants will learn computational thinking skills and design their own algorithm for an important societal challenge: college admissions. The 7th-12th graders will analyze how equitable and fair their algorithm is in deciding which students are allowed to enroll in which colleges. They will interact with college students and STEM Operations Research professionals.

■ MC40

CC Room 211B

In Person: Machine Learning for Power Systems

General Session

Chair: Kyri Baker, University of Colorado-Boulder, Boulder, CO, 80309, United States

1 - Learning a Good Chance-Constraint Approximation From Data: a Tuning-based Approach to Chance-Constrained Optimal Power Flow
Line Roald, University of Wisconsin Madison, Los Alamos, NM, United States, Ashley Hou

Chance constrained optimization is a popular approach to ensure secure and economic operations of power systems with renewable energy. Chance constrained optimization can be challenging and typically involves a trade-off between solution quality (solution cost and feasibility guarantees) and numerical tractability (e.g., number of considered scenarios). In this talk we describe a tuning-based approach which utilizes intentionally simplistic chance-constraint formulations combined with data-driven tuning to obtain high quality solutions at low computational effort. We further discuss why a naïve implementation of such methods does not provide probabilistic performance guarantees, and propose a two-step approach with a solution generation step and solution verification step to restore such guarantees.

2 - Speeding Up Power Systems Optimization Problems with Deep Learning
Kyri Baker, University of Colorado Boulder, 1111 Engineering Dr., UCB 428, Boulder, CO, 80309, United States, Mostafa Mohammadian

As more fast-fluctuating renewable energy is being introduced into power grid operations, the need for computationally efficient solutions to optimize the operation of these resources is increasing. In this talk, we discuss ways that neural networks can be used to greatly speed up AC optimal power flow (OPF), distributed DC OPF, and economic dispatch problems with inter-temporal constraints, pursuing optimality while preserving feasibility of the resulting solutions.

■ MC41

CC Room 212A

In Person: Quantitative Modeling of Non-cost Outcomes in Energy Systems Planning Models

General Session

Chair: Neha Patankar, Princeton University

1 - Demand Side Risk Management For Electricity Supply
Shmuel S. Oren, Professor of the Graduate School, University of California, Berkeley, Berkeley, CA, United States

The proliferation of distributed resources and renewables into the electricity supply mix and growing demand side participation in the power system requires new market mechanisms for integrating demand flexibility into the power market. We propose Virtual Power Plants (VPP) consisting of a portfolio of flexible demand resources controlled by edge technologies and dispatched according to priority service contracts. We describe the construction of a supply function for such VPPs which will be offered in the wholesale markets for energy and reserves.

2 - On Efficient Aggregation of Distributed Energy Resources
Zuguang Gao, University of Chicago, Chicago, IL, 60637, United States, Khaled Alshehri, John R. Birge

The rapid expansion of distributed energy resources (DERs) is one of the most significant changes to electricity systems around the world. Due to the small supply capacities of these DERs, it is impractical for them to participate directly in the wholesale electricity market. We study in this paper an efficient aggregation model where a profit-maximizing aggregator procures electricity from DERs, and sells them in the wholesale market. The interaction between the aggregator and the DER owners is modeled as a Stackelberg game: the aggregator adopts two-part pricing by announcing a participation fee and a per-unit price of procurement for each DER owner, and the DER owner responds by choosing her payoff-maximizing energy supplies. We show that our proposed model preserves full market efficiency.

3 - Land Use Trade-offs in Decarbonization Of Electricity Generation in the American West
Neha Patankar, Princeton University

Land use availability conflicts may present critical non-cost related bottlenecks to least-cost portfolios for electricity decarbonization. This study employs a spatially-temporally- and operationally resolved electricity system capacity expansion model and the modeling to generate alternatives (MGA) technique to generate a set of diverse technology portfolios to reach zero-carbon electricity supply in the Western Interconnection, all with similar costs. The methods demonstrated in this study are well suited to evaluate other non-cost related trade-offs and multiple system-wide objectives of a decarbonized electricity system such as reducing air pollution or achieving regional equity in renewables-related employment.

■ MC42

CC Room 212B

In Person: OR/MS and the Public Sector

Contributed Session

Chair: Justin T. Huang, University of Michigan Ross School of Business, Ann Arbor, MI, 48104-1754, United States

1 - Coalition Formation and Cost Allocation in Humanitarian Supply Chain
Sogand Sabahfar, PhD Student, Kansas State University, Manhattan, KS, United States, Jessica Heier Stamm

Collaboration in humanitarian supply chains may lead to higher quality services and significant cost savings. To achieve these benefits, two main questions must be answered: who should cooperate with whom and how should the savings be allocated among cooperative partners to ensure stability? We address these questions by (1) proposing and testing heuristics to identify coalition structures that minimize total social cost, and (2) identifying allocation mechanisms that belong to the coalition structure core. The results provide insights for managing humanitarian operations.

2 - Practical Redistricting for Missouri Using Recombination
Kiera Dobbs, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Rahul Swamy, Ian Griffith Ludden, Douglas M. King, Sheldon H. Jacobson

Over the past decade, numerous optimization methods have been presented to create fair district plans. Since states will redraw their districts in 2021, it is critical

to show how these optimization methods can be effectively combined and applied to a realistic instance. We use a recent spanning tree algorithm (Recombination) to create congressional and state legislative district plans for Missouri that are optimized for various fairness metrics. To satisfy Missouri's legal requirements, we use edge weights and a combination of counties, census tracts, and census block groups as graph nodes.

3 - Inmate Overcrowding and Prison Operations: A Review
Ben Lewis, Research Fellow, University of Michigan, Ann Arbor, MI, United States

Overcrowding has been an ongoing issue in federal and state prisons for decades, and many US prisons are still operating over capacity despite efforts to reduce prison populations in the wake of COVID-19. This systematic literature review aims to 1) highlight the individual, group, and societal impacts of inmate overcrowding, 2) illustrate the current landscape of prison operations literature, and 3) identify optimization approaches that could reduce overcrowding in prisons. Co-citation analysis suggests that overcrowding generally has negative impacts on prisoners and prison operations and that assignment and queuing approaches are best suited for minimizing prison populations.

4 - Effective, Fair and Equitable Pandemic Rationing
Aram Grigoryan, Duke University, Durham, NC, United States

We study the problem of allocating scarce and heterogeneous medical resources such as COVID-19 vaccines. Our solutions optimize for aggregate match-effectiveness subject to fairness and distributional constraints. The main solution uses a novel cutoff characterization result for fair and equitable allocations and a minimum-cost flow formulation. Match-effectiveness gains from optimization are substantial. Even when there are only two types of vaccines, in equal quantities, our algorithm results in more than 33% larger aggregate match-effectiveness compared to the random allocation benchmark.

5 - The Cost of "Kung Flu": Negative Social and Economic Impacts of Anti-China Rhetoric on Asian Americans
Justin T. Huang, Assistant Professor of Marketing, University of Michigan Ross School of Business, Ann Arbor, MI, United States, David Rothschild, Julia Lee Cunningham, Francesca Gino, Masha Krupenkin

The past year saw a rise in hate directed towards Asian Americans in the US. We track these events back to the onset of Covid-19 and statements directing blame to China ('Kung Flu'). In a series of analyses combining surveys, online search trends, and consumer location data, we show how biases intensified and led to changes in both search and choice behavior. Survey respondents rated Asians as less American than other groups, and searches for stereotypes around Asian restaurants spiked. Asian restaurant traffic dropped 10.9% relative to non-Asian restaurants. We explore heterogeneity in these effects and identify ethnic misidentification as a driver of spillovers to non-Chinese Asian restaurants.

■ MC43

CC Room 213A

In Person: Computing/Auctions/Mechanism Design

Contributed Session

Chair: Manxi Wu, University of California, Berkeley, CA, United States

1 - Learning-based Resource Management for Mobile Edge Computing Systems
Hana Khamfroush, University of Kentucky, Lexington, KY, United States, Sam Heshmati

With the growing needs of real-time data analytics, mobile edge computing (MEC) is becoming a popular technology to process large scale data at the edge of the system and close to the users. MEC however comes with its own limitations such as limited computing, communication, and storage resources. Therefore, smart resource management strategies are needed to provide efficient use of these resources. This talk will address the use of deep learning models for resource management in the mobile edge computing systems. Challenges and opportunities are presented, while discussing some preliminary results.

2 - Numerical Solutions to a Fredholm Form Of Integral Equations for Finite Measures
Shukai Li, Northwestern University, Evanston, IL, United States, Sanjay Mehrotra

We study a form of integral equations for finite measures, which arise in many applications including stationary distribution problems and Markov chain Monte Carlo. We exploit the properties of our equations and apply a discretization approach for approximate solutions. Specifically, we construct a Banach space of distribution functions to reformulate the problem into a Fredholm-form operator equation and outline necessary and sufficient conditions for applying collective compactness theory. We provide convergence results for the discretization approach and analyze how to compute the approximate solutions as well as their error bounds via a linear program under appropriate assumptions.

3 - Scarcity and Waste in Allocation Mechanisms
Junxiong Yin, University of Southern California, Los Angeles, CA, United States, Peng Shi

Variants of wait-lists are used to allocate scarce resources such as cadaver kidneys. However, around 20% of successfully procured cadaver kidneys are discarded. In this paper, we study the wastage problem from a theoretical perspective with a focus on the wait-list with choice, which is an approximation to the current mechanism for cadaver kidney allocation. We find that 1) it is not always possible to Pareto improve upon the wait-list with choice even when there is waste; and 2) it is impossible to Pareto improve upon the wait-list with choice using a mistake-tolerant mechanism. The findings suggest that reducing waste requires hard discussions among stakeholders.

■ MC44

CC Room 213B

In Person: Supply Chain Optimization

Contributed Session

Chair: Elham Taghizadeh, Wayne State University, Clinton Township, MI, 48035-5630, United States

1 - Multi-Year, Multi-Commodity Supply Chain Network Design
Seyed Mohammad Nourbakhsh, Walmart, San Bruno, CA, United States, Seth Kim, Willie Montgomery

We developed a two-step heuristic optimization model that minimizes the total network cost for SAM's club supply chain network. The proposed model determines the optimum plan of future expansion, new fulfillment construction, and other decisions for the next 10 years.

2 - Responsive Production Planning and Replenishment Scheduling for a Two-echelon Supply Chain
Sepideh Alavi, California State University-San Bernardino, San Bernardino, CA, United States

In this research, we study the integrated production and inventory replenishment problem for a two-echelon supply chain. The literature on replenishment planning focuses on specific types of replenishment policies. Such policies have operational shortcomings in a sense that they do not reflect the flexibility of adjusting the replenishment schedules based on changing market conditions. We will consider the problem of obtaining a detailed responsive replenishment plan over a planning horizon.

3 - A Dynamic Resilience Management Framework for Deep-tier Automotive Supply Networks
Elham Taghizadeh, Wayne State University, Clinton Township, MI, United States, Ratna Babu Chinnam, Saravanan Venkatachalam

We propose a framework to manage the resilience of deep-tier automotive supply networks. We integrate a simulation-based resilience assessment scheme with an efficient optimization-based framework for resilience management. The framework promotes the use of network analysis techniques combined with discrete-event simulation informed by secondary data sources and global supply risk databases for improving resilience management. We validate the effectiveness of the proposed framework using a global automotive OEM case study.

■ MC45

CC Room 213C

In Person: Production & Scheduling

Contributed Session

Chair: Stanislaus Solomon, Sam Houston State University, Huntsville, TX, 77341, United States

1 - An Agent-based Approach to the Job Shop Scheduling Problem with Order Rejection
Omar Abbaas, Graduate Assistant, Pennsylvania State University, University Park, PA, United States, Jose Antonio Ventura, Sara Abu Aridah, Kevin Bunn

This study considers the job shop scheduling problem with order rejection and earliness and tardiness penalties using an agent-based approach with a combinatorial auction mechanism. A set of jobs is offered. Each job has a revenue, ready time, due date, deadline, and consists of a set of operations with unique precedence relationships. A mathematical model is presented, then Lagrangian relaxation is used to decompose the problem into a set of job-level scheduling problems. Profitable jobs at the individual level submit their bids to an auctioneer. Then, the auctioneer resolves conflicts to reach a feasible solution, records the profit upper and lower bounds, and updates the dual variables.

2 - Overhaul Planning and Exchange Scheduling for Maintenance Services with Rotable Inventory
Ameen Alshikh, University of Miami, Coral Gables, FL, United States, Murat Erkoc

We study joint optimization of scheduling and rotable inventory management in overhaul operations with a primary focus on the MRO aviation industry. In this setting, an incoming equipment set that requires overhaul is exchanged with a ready-to-go set from the MRO service provider's inventory. When the overhauling for the former set is completed, it is placed in the service provider's inventory for a future exchange. The service provider's available capacity and exchange inventory may necessitate that early arrivals of MRO orders with respect to their requested dates. We propose a mixed integer programming model that minimizes total earliness and inventory costs for the service provider.

3 - A Novel Problem of Scheduling Resource Constrained Preventive Maintenance and Production Simultaneously for the Unrelated Parallel Machine Environment
Michael Geurtsen, Eindhoven University of Technology, Eindhoven, Netherlands, Jelle Adan

This study proposes a new mathematical formulation and a Memetic Algorithm for a novel integrated maintenance and production scheduling problem. The novelty lies in the combination of two constraints, i.e. (1) a single maintenance activity can only be scheduled in one of its set of available time windows, and (2) a maintenance activity demands additional scarce resources. A case study is performed with real-world production data from a semiconductor manufacturer, where production and maintenance are currently scheduled separately. It is shown that scheduling production and maintenance activities simultaneously enables significant improvements.

4 - Marginal Cost Pricing in Flow Shop Scheduling
Stanislaus Solomon, Assistant Professor of Supply Chain Management, Southern Illinois University Edwardsville, Edwardsville, IL, United States, Kevin D. Sweeney, William A. Ellegood, Mitchell Millstein

In this research we use simulation to examine the performance of several priority scheduling rules in both total utility (value) created and make span for a flow shop where customer balking is allowed in response to shop congestion. In addition to developing two new priority scheduling rules based on marginal cost pricing, we also imbed a random choice utility model into the simulation model to more accurately mirror the customer's decision to use the flow shop or an alternative. We find that the optimal priority scheduling rule depends on the perspective of the decision maker.

■ MC46

CC Room 213D

In Person: Discrete Optimization/Online Optimization

Contributed Session

Chair: James Patrick Bailey, Texas A&M University, College Station, TX, 77840, United States

1 - A Polyhedral Approach to Some Max-min Problems
Thomas Lidbetter, Assistant Professor, Rutgers Business School, Newark, NJ, United States, Lisa Hellerstein

We consider a max-min variation of the classical problem of maximizing a linear function over the base of a polymatroid. In our problem we assume that the vector of coefficients of the linear function is some unknown vertex of a simplex, and we maximize the linear function in the worst case. Equivalently, we formulate the problem as a zero-sum game. We show how to efficiently obtain optimal strategies for both players and an expression for the value of the game. Furthermore, we give a characterization of the set of optimal strategies for the minimizing player. We consider four versions of the game and discuss the implications of our results for problems in search, sequential testing and queueing.

2 - Strategic Defense of Feedback-controlled Parallel Servers Against Reliability and Security Failures
Qian Xie, New York University, Brooklyn, NY, United States, Zhengyuan Zhou, Li Jin

In this research, we analyze the reliability/security risk of feedback-controlled queuing systems and propose advice for strategic defense. We consider a system of parallel servers and queues with dynamic routing subject to reliability and/or security failures. For the reliability setting, we formulate it as a Markov decision process. We prove that the system operator's optimal protecting policy is threshold-based and use dynamic programming to compute it. For the security setting, we formulate it as an attacker-defender game. We characterize the equilibria regimes and apply Shapley's algorithm to compute the equilibria. We also present examples to illustrate our proposed models and methods.

3 - Robust Machine Learned Predictions for Online Allocation
Thomas Lavastida, Carnegie Mellon University, Pittsburgh, PA, United States, Benjamin Moseley, R. Ravi, Chenyang Xu

This talk considers a beyond-worst-case analysis model that integrates machine learned predictions into algorithm design. We give an end-to-end framework for incorporating predictions into online allocation problems including Adwords, matching, flow allocation, and scheduling. Our algorithms give near optimal performance with good predictions. Moreover, they are robust to prediction error and the quality degrades gracefully in terms of the error. Empirical results demonstrating the quality of the algorithms as well as the learnability of the predictions validate our theoretical findings.

4 - 1/T Regret and Convergence for Multiagent Optimization
James Patrick Bailey, Texas A&M University, College Station, TX, United States

In a repeated multiagent game, the standard implementation of gradient descent results in agents' strategies that diverge from Nash equilibria and where regret grows overtime. In this paper, we provide a different implementation of gradient descent and show that an agent can obtain finite regret via arbitrarily fixed step-size regardless of the actions of all other agents. This is the first known algorithm to guarantee finite regret in general network games. Further, in the adversarial setting, we show that if all agents use this different implementation then strategies cycle around the set of Nash equilibria and the time-average of the strategies converge to Nash at rate 1/T.

Monday, 1:30PM-2:30PM

■ Monday Keynote 01

CC Ballroom A /Virtual Theater 1

Keynote: Multiagent Reasoning for Social Impact: Results from Deployments for Public Health and Conservation

Keynote Session

1 - Multiagent Reasoning for Social Impact: Results from Deployments for Public Health and Conservation
Milind Tambe, Harvard University & Google Research, Cambridge, Massachusetts, United States

With the maturing of AI and multiagent systems research, we have a tremendous opportunity to direct these advances towards addressing complex societal problems. I focus on the problems of public health and conservation, and address one key cross-cutting challenge: how to effectively deploy our limited intervention resources in these problem domains. I will present results from work around the globe in using AI for HIV prevention, Maternal and Child care interventions, TB prevention and COVID modeling, as well as for wildlife conservation. Achieving social impact in these domains often requires methodological advances. To that end, I will highlight key research advances in multiagent reasoning and learning, in particular in, computational game theory, restless bandits and influence maximization in social networks.In pushing this research agenda, our ultimate goal is to facilitate local communities and non-profits to directly benefit from advances in AI tools and techniques.

■ Monday Keynote 02

CC Ballroom B /Virtual Theater 2

Keynote: Stochastic First Order Oracles and Where to Find Them

Keynote Session

1 - Stochastic First Order Oracles and Where to Find Them
Katya Scheinberg, Cornell University, Ithaca, NY, 14853, United States

Continuous optimization is a mature field, which has recently undergone major expansion and change. One of the key new directions is the development of methods that do not require exact information about the objective function. Nevertheless majority of these methods, from stochastic gradient descent to "zero-th order" methods use some kind of approximate first order information. We will overview different methods of obtaining this information, including simple stochastic gradient via sampling, robust gradient estimation in adversarial settings, traditional and randomized finite difference methods and more. We will discuss what key properties of these inexact, stochastic first order oracles are useful for convergence analysis of optimization methods that use them.

■ Monday Keynote 03

CC Ballroom C /Virtual Theater 3

Omega Rho Distinguished Lecturer: A Journey through Public Sector Operations Research

Informs Special Session: Keynote

Informs Special Session Session

1 - A Journey through Public Sector Operations Research

Laura Albert, University of Wisconsin-Madison, Madison, WI, 53562, United States

Societally important problems have driven the theory and application of operations research since its origins in World War II. Recent events have highlighted the enormous number of challenges that require expertise from operations research and analytics. The operations research community has a long history of stepping up to address challenging problems in the public sector through modeling, computation, and data analytics that has influenced policy and impacted practice. This has been a central theme of my academic career, which has focused on security, emergency response, public safety, and risk management. This talk discusses several research problems, focusing on how operations research has made a difference, and offers a blueprint for how the operations research community can tackle future challenges, impact society, and broadcast our message to the world.

■ Monday Keynote 04

CC Ballroom D /Virtual Theater 4

Keynote: A Dynamic Queueing Road Map from Communication Systems to Resource Sharing Services

Keynote Session

1 - A Dynamic Queueing Road Map from Communication Systems to Resource Sharing Services

William A. Massey, Professor, Princeton University, ORFE Department, Sherrerd Hall, Princeton, NJ, 08544, United States

The field of operations research applies mathematics to the creation of quantitative languages designed for strategic decision making. Queueing theory was invented just over a century ago to design efficiency into communication systems. In the 21st century, it plays this same role in the design of resourcesharing services.Rates for customer service demand can easily be dependent on the time of day, week, or seasonal effects. Hence dynamic rate queues are more realistic stochastic models than their traditional constant rate counterparts. Moreover, since they are not amenable to classical steady state analysis techniques, dynamic rate problems lead to greater mathematical challenges. Along with many collaborators, this talk covers a personal research journey to develop a dynamic rate queueing theory. We also show how the guideposts for our path evolved from communication systems to resource-sharing services.

Monday, 2:45PM 4:15PM

■ MD01

CC Ballroom A / Virtual Theater 1

Hybrid Panel Discussion on Editor's Perspective in Publishing Data Science-Focused Papers

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xiaowei Yue, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Raed Al Kontar, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - Panelist

Yu Ding, Texas A&M University, Dept Industrial & Systems Engineering, College Station, TX, 77843-3131, United States

2 - Panelist

Jing Li, Georgia Institute of Technology, School Of Computing Informatics & Decision Sy Po B, Tempe, AZ, 85287-8809, United States

3 - Panelist

Ramaswamy Ramesh, SUNY Buffalo, East Amherst, NY, 14051-1687, United States

4 - Panelist

L. Allison Jones-Farmer, Miami University, Information Systems & Analytics, Farmer School of, Oxford, OH, 45056, United States

■ MD02

CC Ballroom B / Virtual Theater 2

Hybrid Recent Advances in Planning and Scheduling Under Uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Karmel S. Shehadeh, Lehigh University, Bethlehem, PA, 18015-1518, United States

1 - Optimized Scenario Reduction: Solving Large-scale Stochastic Programs with Quality Guarantees

Wei Zhang, Faculty of Business, The Hong Kong Polytechnic University, MN037, Hong Kong, Hong Kong, Alexandre Jacquillat, Kai Wang, Shuaian Wang

Stochastic programming involves large-scale optimization with exponentially many scenarios. We propose an optimization-based scenario reduction approach to generate high-quality solutions and tight lower bounds by only solving small-scale instances. First, we design a scenario subset selection model that minimizes the recourse approximation error over a pool of solutions. We provide theoretical results to support our formulation, and a tailored heuristic algorithm to solve it. Second, we propose a scenario assortment optimization approach that generates a lower bound—hence, a solution quality guarantee—by relaxing nonanticipativity constraints across scenario bundles. We formulate an optimization model to maximize this lower bound, and design exact row-generation and column-generation algorithms to solve it.

2 - Strategic Idling in Appointment Systems with Sequential Servers

You Hui Goh, Nanyang Technological University, Singapore, Singapore, Zhenzhen Yan

This paper studies an appointment scheduling problem with two sequential servers from a distributionally robust optimization (DRO) perspective. Conventionally, schedules are optimized to minimize the expected total cost including customers' waiting costs and servers' overtime costs. Yet, the schedule obtained can lead to imbalanced waiting times in two servers, concentrating on the downstream server. To ensure a balanced waiting time in two servers without rescheduling patients, we adopt an idea in the queueing literature to strategically idle the upstream server. We propose a DRO model to calculate the optimal strategic idling (SI) policy considering the correlations in service times.

3 - Distributionally Robust Home Service Routing and Appointment Scheduling with Random Travel and Service Times

Man Yiu Tsang, Lehigh University, Bethlehem, PA, United States, Karmel S. Shehadeh

We study an integrated routing and appointment scheduling (RAS) problem arising from home service practice. Given a set of customers within a region that an operator needs to serve, we seek for the operator's route and time schedule. The travel time and service time of each customer are random with unknown distributions. Only a possibly small set of historical data is available. To address this, we propose and analyze two distributionally robust home service RAS (DHRAS) models that search for decisions to minimize the worst-case expectation of operational costs over distributions residing within an ambiguity set. We use a moment based ambiguity set and a 1-Wasserstein distance based ambiguity set. We derive equivalent MILP reformulations of both models. In an extensive numerical experiment, we investigate the proposed models' performances and derive insights into DHRAS.

4 - Presenter

Chrysanthos Gounaris, Carnegie Mellon University, Pittsburgh, PA, United States

5 - Valid Inequalities for Approximating the Robust Surgery Scheduling Problem

Ankit Bansal, University of Minnesota, Minneapolis, MN, United States, Jean-Philippe P. Richard, Bjorn Berg, Yu-Li Huang

An approximation of the two-stage robust optimization surgery-to-OR allocation problem is presented. The second-stage problem is linearly relaxed and three types of valid inequalities which approximate the integer hull are derived. The resulting linear relaxation of the second stage problem is then dualized and integrated into the first-stage problem. A column-generation based approach is used to solve the resulting MILP, yielding an approximation of the problem. Data from an academic medical center is used to compare the computational performance of the approximate approach and its solution quality with the only known exact approach in the literature. Managerial insights are discussed.

■ MD03

CC Ballroom C / Virtual Theater 3

Hybrid Michael H. Rothkopf Junior Researcher Paper Prize

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Robert Day, University of Connecticut, Storrs, CT, 06269-1041, United States

1 - Designing Approximately Optimal Search On Matching Platforms
Alexander Wei, University of California-Berkeley, Berkeley, CA, United States

We study the design of a two-sided matching market in which agents' search is guided by a platform. The platform determines the rates at which agents of different types meet, while agents strategically accept or reject the potential partners whom they meet. We focus on the platform's problem of optimal search design in a continuum matching market model where agents have symmetric pairwise preferences. The platform's objective is to find meeting rates that maximize the equilibrium social welfare of the resulting game. Incentive issues arising from congestion and cannibalization make this design problem intricate. Nonetheless, we give an efficiently computable solution that achieves 1/4 the optimal social welfare. Our solution shows the platform can substantially limit choice while maintaining approximately optimal welfare through a carefully chosen search design.

2 - Award Presenter
Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, 94305-5008, United States

3 - When is Assortment Optimization Optimal?
Will Ma, Columbia University, New York, NY, 02139-3516, United States

A classical question in economics is whether complex, randomized selling protocols can improve a firm's revenue beyond that of simple, take-it-or-leave-it posted prices. Myerson (1981) answered this question with an emphatic ``No" for a monopolist selling a single good. By contrast, for multiple goods, randomized lotteries can significantly increase revenue. We ask the same question for assortment optimization, where the firm cannot control the pricing but must decide on a set of substitute products to offer. To formalize such a question, we introduce a Bayesian mechanism design problem with fixed prices and ordinal customer preferences which captures assortment optimization. We show that generally, a top-k lottery can increase revenue, but for specific choice models the best deterministic assortment is revenue-optimal.

■ MD04

CC Ballroom D / Virtual Theater 4

Hybrid Online Platform Design and User Engagement

Sponsored: Information Systems

Sponsored Session

Chair: Qinglai He, Arizona State University, Tempe, AZ, 85281, United States

1 - Access to IT and Future of Work in the U.S.
Leting Zhang, Temple University, Philadelphia, PA, 19122, United States, Taha Havakhor, Rajiv Sabherwal

These digital transformations in working conditions post-COVID-19 can be resource-intensive for less-ready businesses. Capitalizing on the opportunity provided by the staggered introduction of stay-at-home orders across 48 states in the U.S. during the first wave of COVID-19 and natural variations in availability of IT services and resources in different regional (county-level) areas, we examine if the lack of sufficient access to businesses to IT resources posed as a barrier in the seamless transformation to WFH during those stay-at-home periods. Our findings show that counties without adequate business access to IT resources experience higher rates of unemployment after stay-at-home orders. We also identify the types of IT resources that help and hurt during the WFH transformation.

2 - How Data Privacy Regulations Affect Competition: Emprical Evidence From Mobile Application Market
""Ix" "Xi Wu, Temple University, Philadelphia, PA, 19122, United States, Min-Seok Pang

Data has become a new type of asset for firms, provoking a discussion of data privacy and security. Government regulators start enacting privacy regulations to ensure the transparency of data collection and processing. How these regulations impact competition is a critical question that has not been thoroughly studied. Our study applies a DID framework to examine the effect of GDPR on the mobile app market. We find that the competition in the free app market has become more volatile after the implementation of GDPR than before. Interestingly, however, the opposite effect is found in the paid app market. Our results suggest that GDPR has significantly affected the competition in the app market. Also, the apps' pricing strategies influence this impact. Our work contributes to multiple streams of the IS literature and provides meaningful insights for policymakers and firms.

3 - Herding Effects of Subjectivity on Emotional Polarization and Hate Speech in Online Political Discourse
Amin Sabzehzar, Arizona State University, Tempe, AZ, United States

A recent study by Pew Research Center shows that most Americans can only identify 60% of fact-based political statements from subjective opinions. This paper speaks to this issue by studying the influence of subjective comments on the quality of political discourse in the Reddit r/politics subreddit. Our results shed light on the effect of herding behavior in online political discourse by showing that the subjectivity of top-level comment triggers a subjective, high emotional, and low analytical political discourse. Further, we demonstrate the negative role of subjectivity on the quality of political discourse in terms of emotional polarization and hate speech. Our findings contribute to the discussion about social media use and political polarization, highlighting design implications for online platforms to battle political polarization.

4 - A Fair Framework for Unsupervised Outlier Detection Ensembles
Moez Farokhnia Hamedani, University of South Florida, Tampa, FL, United States

Outlier detection ensembles are among the most valuable ML-driven decision support systems. Extensive applications of performance metrics such as accuracy and computational complexity for the evaluation of ML-driven decisions have raised concerns about the fairness of the decisions with regards to different groups of entities. e.g. EM R. system auditing might be biased toward specific positions in the system that leads to biased managerial decisions which are made on the basis of the algorithmic outcomes. To address fairness, we propose a fair-framework for debiasing unsupervised ensembles. The proposed framework can be generalized to any ensemble, regardless of the aggregation strategies.

■ MD05

CC Ballroom E / Virtual Theater 5

Hybrid A Day in the Life of a Practitioner

Informs Special Session: Informs Section on Practice

Informs Special Session Session

Chair: Sharon Arroyo, Boeing Company, Seattle, WA, 98124-2207, United States

1 - A Day in the Life of a Practitioner
Sharon Arroyo, Boeing Company, Seattle, WA, 98124-2207, United States

In this session, we will be discussing the various responsibilities of an OR practitioner's role in an organisation. This session will be highly informative for graduate students and early career professionals who are looking forward to building an OR practitioner's career.

2 - Panelist
Sharon Arroyo, Boeing Company, Seattle, WA, 98124-2207, United States

3 - Panelist
William Christian, Paygevity, Inc., Severn, MD, 21144-1905, United States, William Christian, DOD, MD, United States

4 - Panelist
Rajeev Namboothiri, GE Research, John F. Welch Technology, Bangalore, 560066, India

■ MD06

CC Room 303A

In Person: Leveraging PTC and Advanced Technologies to Increase Rail Capacity

General Session

Chair: Dharma Acharya, GE Transportation, a Wabtec Corporation, Ponte Vedra, FL, 32081-8471, United States

Chair: Ken Kenjale, Wabtec

1 - Capacity and Planning Toward a Moving/Virtual Block Future
Ken Kenjale, Wabtec Corporation, Pittsburgh, PA, United States

We will discuss various approaches and pros and cons for utilizing moving/virtual block technologies for rail capacity and planning. Moving/Virtual blocks along with automated dispatching will help railroads increase rail capacity without any capital investment to improve physical infrastructure.

2 - Comparing the Effectiveness of Different Train Following Control Algorithms for Freight Trains in Moving Block

Geordie Roscoe, University of Illinois at Urbana-Champaign, IL, 61801-2350, United States, Tyler Dick

To create capacity for a projected increase in freight rail transportation demand of 24% by 2045, advanced train traffic control systems utilizing Positive Train Control (PTC) infrastructure, including moving block systems, may be developed and utilized. Moving block systems increase network capacity through decreasing train spacing compared to existing fixed block systems. However, running trains very near to their individual PTC braking distances requires quick and precise control actions to avoid both PTC penalty braking applications and uncontrolled oscillatory action between closely following trains. This research develops and evaluates several train following control algorithms that are derived from highway vehicle following literature as well as first principles.

3 - How Positive Train Control Can Help a Railroad Run on Schedule With Precision, Safety, Efficiency, and Profitability and Please its Customers

Steven R. Ditmeyer, Principal, Transportation Technology and Economics, Alexandria, VA, United States

PTC systems, comprised of digital radios, GPS receivers, sensors, and on-board and control center computers, generate continuous, real-time information on the location and speed of trains. This enables dispatchers and their computers to plan improved meets and passes of trains, thus shortening, and improving the predictability of, their running times. This, in turn, increases the capacity of the tracks while improving the utilization of assets locomotives, cars, and crews. Railroads are using the continuous, real-time information on train location and speed to improve the safety of train operations, but as yet are not using it to improve the efficiency of train operations.

4 - Designing and Rolling Out Movement Planners for European and North American Operations: A Comparison

Leonardo Lamorgese, Head of R&D, Optrail, Rome, Italy

Numerous projects and undertakings around the world indicate how the rail industry is increasingly aware of the potential of movement planning technology and the opportunity it presents in terms of increasing efficiency in operations. In this talk we discuss European and North American railroading: similarities, differences and the mathematical challenges faced in modelling them within a movement planner. We also present our first-hand experience in tackling these challenges and deploying state-of-the-art movement planners in both contexts.

■ MD07

CC Room 303B

In Person: Social Media Analytics: New Techniques and Applications

General Session

Chair: Tung Cu, Northeastern Illinois University, Chicago, IL, 60625-4625, United States

1 - Abuse of the Fact-checking Hashtag on Twitter

Yuchen Liu, University of Washington, Seattle, WA, 98105, United States, Elina Hwang

Twitter uses social technology such as hashtags to enable users to exchange information. However, how does the fact-checking hashtag affect the cascade of true and false information remains unknown. Studying the COVID-19 pandemic, we empirically investigate the effect of the fact-checking hashtag on the lifespan of true and false tweets. We find that tweets with the fact-checking hashtag have an 8% lower hazard of stopping cascading. However, there is no significant difference between the effects of the hashtag of the hazard stopping the true tweets and the false tweets cascading. Our results caution the existence of the abuse of the fact-checking hashtag in large online social platforms.

2 - Video Sponsorship in Social Media: A Video Content Analysis

Shahryar Doosti, Chapman University, Argyros School Of Business And Economics, CA, 92866-1005, United States

With the growth of social media contents, video sponsorship has become a popular form of advertising for brands. It is imperative to understand how various marketing strategies affect user engagement with sponsored contents. Using a rich dataset of sponsored videos on a popular social media platform, we implement video content analysis (VCA) to extract key information from the sponsored video. We investigate the role of sponsorship strategies in content dissemination on the social network.

■ MD08

CC Room 303C

Wagner Session

Award Session

■ MD08

1 - Data-Driven Optimization for Atlanta Police Zone Design

Shixiang Zhu, Georgia Institute of Technology, Marietta, GA, 30067, United States, He Wang, Yao Xie

We present a data-driven optimization framework for redesigning police patrol zones in an urban environment. The objectives are to rebalance police workload among geographical areas and to reduce response time to emergency calls. Our proposed design was implemented by the Atlanta Police Department in March 2019. By analyzing data before and after the zone redesign, we show that the new design has reduced the response time to high priority 911 calls by 5.8% and the imbalance of police workload among different zones by 43%.

2 - Solving the Ride-sharing Productivity Paradox: Priority Dispatch and Optimal Priority Sets

Garrett J. van Ryzin; Amazon Corporate LLC, USA.

Transportation Network Companies are often tasked with balancing rideshare markets as they fluctuate between different marketplace balance conditions. During the Covid-19 pandemic, a particularly salient problem has been 'oversupply', where there is an excess of active drivers relative to the stream of passenger requests. The Priority Mode Controller is a novel solution to this problem, granting a certain subset of drivers access to prioritized dispatch. In this paper, we discuss the algorithmic and logical foundations of this product, rolled out successfully by Lyft throughout North America.

3 - Increasing Chip Availability Through a New After-Sales Service Supply Concept at ASML

Douniel Lamghari-Idrissi, ASML and Eindhoven University of Technology, Netherlands, 2Eindhoven University of Technology, Netherlands, Rob Basten, Geert-Jan van Houtum

ASML is the market leader in the photolithography sector. A joint project of ASML and Eindhoven University of Technology began in January 2017 to reform ASML's service supply concept driven by the increased focus of its customers on extreme long downtimes. Changes were made to the service measure and the planning approach. They resulted in a new service concept rolled out to ASML's complete installed base worldwide after successful pilots. The new concept resulted in a yearly benefit of 1.5 Billion euros across the semiconductor industry and increased sustainability.

4 - Collaborating with Local and Federal Law Enforcement for Disrupting Sex Trafficking Networks

Nickolas K. Freeman, Burcu B. Keskin, Gregory J. Bott; University of Alabama, USA.

In the U.S., 95% of human trafficking cases are associated with sex trafficking, and the majority of these cases were facilitated by the use of the internet, in the form of classified sexual service ads. Collaborating with the West Alabama Human Trafficking Task Force, Department of Homeland Security, and Long Island Police Department, UA researchers developed an analytical tool to surveil multiple websites, differentiate fake and real ads, detect sex trafficking networks, and plan interdiction operations. The tool used in undercover stings and led to identifying victims and several arrests.

5 - Interpretable OR for High-Stakes Decisions: Designing the Greek COVID-19 Testing System

Hamsa Sridhar Bastani, Wharton School, USA, Kimon Drakopoulos, Vishal Gupta

After the first wave of the COVID-19 pandemic abated, countries sought to ease restrictions on non-essential travel while still safeguarding public health. In collaboration with Greece, we designed and deployed a national-scale targeted testing system to dynamically allocate Greece's limiting testing resources to screen visitors at the border for COVID-19. The system combines responsive supply-chain design, a novel empirical Bayes estimation strategy, and a new batched, multi-armed bandit algorithm with constrained actions and delayed feedback. We detail the method and impact of our system.

■ MD10

CC Room 304B

In Person: Sequential Learning by Experimentation

Joint Session

Chair: Daniel Russo, Columbia University, New York, NY, 10027, United States

1 - Online Advertising via Bandit Experiments: An Efficient Method Suitable for High-dimensional Problems

Wenjia Ba, Stanford University, Stanford, CA, 94305, United States, Michael Harrison, Harikesh Nair

We consider models of sequential decision-making by an online advertiser. In a sequence of trials, the advertiser first chooses the audience segment to purchase an impression, then chooses the ad for display, and finally observes a binary outcome. The problem becomes high-dimensional if there exist many possible combinations of user and ad choices. Adopting the multi-arm bandit framework, we propose and evaluate an approach (PMDL) that is based on a Poisson regression model, using the debiased Lasso method of Javanard and Montenari (2017) to estimate parameters of that model. In numerical experiments, the performance of PMDL is comparable to that of leading alternatives in low-dimensional settings, and it continues to show good performance in high-dimensional as well as real-data settings where existing alternative methods are computationally infeasible.

2 - Adaptivity and Confounding in Multiarmed Bandit Experiments

Daniel Russo, Columbia University, New York, NY, 10027, United States

Abstract: Bandit algorithms minimize experimentation costs by adapting effort away from poorly performing arms as feedback is observed. But this feature makes them sensitive to confounding. For instance, popular algorithms can't address the problem of identifying the best action when day-of-week effects may confound inferences. In response, we propose deconfounded Thompson sampling, (DTS) which makes critical modifications to the way Thompson sampling is usually applied. Our results suggest DTS strikes a delicate balance between adaptivity and robustness to confounding. It attains asymptotic lower bounds on the number of samples required to confidently identify the best action —- suggesting optimal adaptivity —- but also satisfies strong performance guarantees in the presence of day-of-week effects and delayed observations —- suggesting robustness.

■ MD11

CC Room 304C

In Person: Marketplaces: Empirics and Theory

General Session

Chair: Thayer Morrill, NC, United States

1 - Preparing for the Worst but Hoping for the Best: Robust (Bayesian) Persuasion

Piotr Dworczak, Northwestern University, Evanston, IL, United States, Alessandro Pavan

We propose a robust solution concept for Bayesian persuasion that accounts for the Sender's concern that her Bayesian belief about the environment—which we call the conjecture—may be false. Specifically, the Sender is uncertain about the exogenous sources of information the Receivers may learn from, and about strategy selection. She first identifies all information policies that yield the largest payoff in the "worst-case scenario," i.e., when Nature provides information and coordinates the Receivers' play to minimize the Sender's payoff. Then, she uses the conjecture to pick the optimal policy among the worst-case optimal ones.

2 - Equilibrium Inefficiency in Matching Markets with Interviews

Erling Skancke, Stanford University, Stanford, CA, United States

Recent debate in the medical literature has brought to light issues with the pre-match interview process for residency positions at hospitals. In this paper, I build a game-theoretic model in which hospitals must simultaneously choose which doctors to interview. Increased interview activity by a hospital always has a negative welfare effect on its competitors, while the strategic externality can be decomposed into two opposing terms. When interview costs are low, hospitals interview more when their competitors do, and the equilibrium exhibits an inefficiently high number of interviews. Moreover, an increase in market size may exacerbate the problem of excessive interviewing.

■ MD12

CC Room 304D

In Person: OR and AI approaches for Biodiversity Conservation

General Session

Chair: Bistra Dilkina, University of Southern California, Los Angeles, CA, 90089, United States

1 - Optimal Land Supply for BECCS Considering Biodiversity Conservation

Cindy Azuero, Georgia Tech, Atlanta, GA, United States

Bioenergy with carbon capture and storage (BECCS) will play a major role in mitigation pathways toward the 1.5º and 2ºC scenarios. Estimated land requirements for BECCS are big, ranging from 200 Mha-1500 Mha, for a deployment between 3-30 Gt CO2 per year in 2100 (Creutzig et al., 2021). Current land allocation models used in Integrated Assessment Models (IAMs) do not consider biodiversity impacts when determining the location of the land supplied for bioenergy. Here, we integrate a linear optimization model with a biodiversity impact assessment model, to determine how to optimally supply land for BECCS considering (1) minimizing biodiversity impact subject to a budget constraint and (2) minimizing cost subject to a biodiversity threshold. A pareto frontier is constructed with which the trade-off between biodiversity and cost can be analyzed.

2 - Interdiction of Wildlife Trafficking Supply Chains: An Analytical Approach

Burcu B. Keskin, University of Alabama, Tuscaloosa, AL, 35406-4062, United States, Bistra Dilkina, Aaron Ferber, Emily Barbee, Oakley Prell

Illicit Wildlife Trafficking (IWT) has a negative impact on the environment and communities, enabling the spread of diseases, land degradation, and biodiversity loss. IWT is a global issue, with almost 6,000 different species seized since the 90s and expanding to more than 150 countries. Traffickers operate complex and dynamic networks that require detailed strategies to disrupt. We model disrupting these networks as a network interdiction problem where authorities seek to interdict along specific routes to reduce the trafficker's profitability and force any resulting geographical displacement to be as costly as possible. We characterize the needed and available data in IWT, modeling assumptions, and network interdiction formulations that apply to this complex setting, and we evaluate the proposed methods in the context of global air travel networks.

■ MD13

CC Room 201A

In Person: Stochastic First-order Methods for Constrained Optimization

General Session

Chair: Afrooz Jalilzadeh, The University of Arizona, Tucson, AZ, United States

1 - Inexact-proximal Accelerated Gradient Method for Stochastic Nonconvex Constrained Optimization Problems

Morteza Boroun, University of Arizona, Tucson, AZ, United States, Afrooz Jalilzadeh

Stochastic nonconvex optimization problems with nonlinear constraints have a broad range of applications in intelligent transportation, cyber-security, and smart grids. In this paper, first, we propose an inexact-proximal accelerated gradient method to solve a nonconvex stochastic composite optimization problem where the objective is the sum of smooth and nonsmooth functions and the solution to the proximal map of the nonsmooth part is calculated inexactly at each iteration. We demonstrate an asymptotic sublinear rate of convergence for stochastic settings using increasing sample-size considering the error in the proximal operator diminishes at an appropriate rate. Then we customize the proposed method for solving stochastic nonconvex optimization problems with nonlinear constraints and demonstrate a convergence rate guarantee.

2 - A Stochastic Variance-reduced Accelerated Primal-dualmethod For Finite-sum Saddle-point Problems

Erfan Yazdandoost Hamedani, University of Arizona, State College, PA, 16801-4415, United States, Afrooz Jalilzadeh

In this talk, we propose a variance-reduced primal-dual algorithm for solving convex-concave saddle-point problems with finite-sum structure and nonbilinear coupling function. This type of problem typically arises in machine learning and game theory. Compared with existing methods, our framework yields a significant improvement over the number of required primal-dual gradient samples to achieve an epsilon-accuracy of the primal-dual gap. We implemented our method for solving a distributionally robust optimization problem to show the effectiveness of the proposed algorithm.

3 - Using Deep Reinforcement Learning for Solving the Stochastic Capacitated Lot Sizing Problem

Lotte van Hezewijk, Eindhoven University of Technology, Eindhoven, 3526 WD, Netherlands
Lotte van Hezewijk, ORTEC, Zoetermeer, Netherlands, Nico P. Dellaert, Noud Gademann

We study a multi-item stochastic capacitated lot sizing problem. Inspired by industrial cases, we consider a limited production capacity, stochastic demand, and setup times. The objective is to determine the production quantities, while

minimizing the costs of inventory, backorders and production. We use a Deep Reinforcement Learning (DRL) methodology to find solutions. Larger problem instances encounter some challenges, which we resolve by utilizing domain knowledge to support the DRL algorithm.

■ MD14

CC Room 201B

In Person: Advances in Machine Learning and Optimization Methods

General Session

Chair: Petros Xanthopoulos, Stetson University, DeLand, FL, 32723, United States

1 - Scenario-based Robust Optimization for Decision-making under Binary Uncertainty

Kai Wang, Carnegie Mellon University, Pittsburgh, PA, 02215-4212, United States, Alexandre Jacquillat, Mehmet Aydemir

This paper addresses data-driven optimization problems under categorical uncertainty. We propose a scenario-based robust optimization approach that combines stochastic programming (by constructing scenarios), robust optimization (by building discrete uncertainty sets), and data-driven optimization (by defining scenarios and uncertainty sets from machine learning classification outputs). We implement it on vehicle routing problem and ambulance dispatching problem. Results suggest that our approach outperforms benchmarks based on deterministic, stochastic, and robust optimization.

2 - Unsupervised Ensemble Learning Based on Internal Quality Measures and Modern Portfolio Theory

Petros Xanthopoulos, Stetson University, DeLand, FL, 32723, United States

Unsupervised ensemble learning or consensus clustering is the process of combining multiple clustering solutions into one with more robust characteristics. In this presentation we propose an weighted consensus clustering approach based on internal quality measures. We demonstrate the its advantages in terms of clustering quality and robustness. We also describe its performance improvement in terms of number of cluster identification. We present a tweak based on modern portfolio theory that allows to control the algorithmic robustness through a simple optimization model.

3 - Non-overlapping Group Structured Sparsity Problems: Computations

Miju Ahn, Southern Methodist University, Dallas, TX, 75205, United States

We introduce a new formulation and an iterative algorithm for a group-sparse representation problem where subsets of model variables form non-overlapping groups. The proposed algorithm solves a reweighted group lasso at each iteration, and computes a directional stationary solution which achieves global optimality under some conditions. We present results of numerical experiments conducted with synthetic and real datasets showing that our method achieves superior performance compared existing methods in many criteria including prediction accuracy, relative error, and group recovery success rate.

4 - Logical Sequential Pattern Mining and Classification via Mixed-integer Optimization

Ruilin Ouyang, Northeastern University, Boston, MA, 02120, United States, Chun-An Chou

Mining temporal patterns in times series data is an important data mining task in various application areas. However, the conversion of time series data into symbolic data is often required a priori. Moreover, it remains a challenging task to mine critical temporal patterns which are discriminative with explicit time information. In this work, we present a novel mixed integer linear programming model to optimize a set of logical sequential patterns with a maximum coverage of samples in target class by considering critical patterns appear synchronously among all time-series samples. Furthermore, we propose an efficient algorithm to solve the proposed model in a short run time. Finally, we demonstrate the effectiveness of the proposed methods on both simulated and real datasets comparing with the state-of-art sequential pattern mining method.

■ MD15

CC Room 201C

In Person: Data Analytics in Social Media and Information Systems

General Session

Chair: Derya Ipek Eroglu, Virginia Tech, Blacksburg, VA, 24060-8034, United States

1 - Digital Platforms and Echo Chambers: A Comparison of News Platforms and Social Media

Derya Ipek Eroglu, Virginia Tech, Blacksburg, VA, 24060-8034, United States, Onur Seref, Michelle Seref

Social media enables people to learn about and express their reactions to the current news. Additionally, news platforms provide their readers with a digital public space for expressing their opinions. These platforms differ from each other in their news coverage. When combined with the public digital space provided, these platforms enhance echo chambers in which readers with similar ideological perspectives interact. We expect a higher echo chamber effect on news platforms than social media platforms. We select a sample of the news platforms included in AllSides.com, which covers media bias on a wide spectrum of outlets. We collect news and comment data from these platforms to analyze their biases. We collect data from Twitter, Reddit, and Gab to compare these platforms to social media. We use an automated discourse analysis framework in our study and present our findings.

2 - Analyzing the Dynamic Nature of Firm to Consumer Engagement on Social Media

Sae Hoon Chang, PhD Student, Queen's University, Kingston, ON, Canada, Ceren Kolsarici

We investigate dynamics of firm-consumer interactions on social media platforms. Using sentiment analysis and multiple regularization processes, we examine Tweet characteristics in firm-to-many and firm-to-one communications that lead to different levels of consumer engagement. The results suggest that emotional content in mass engagement, and precision and clarity of the message in individual engagement stages lead to higher likes and retweets.

■ MD16

CC Room 201D

In Person: Healthcare Analytics, During the Pandemic and Beyond

General Session

Chair: Sara Nourazari, California State University, Long Beach, CA, 92648-0906, United States

1 - Using Surgical Schedule Bed Board Modeling Results from Pandemic for Planning Future Hospital Occupancy

Franklin Dexter, Professor, University of Iowa, Department of Anesthesia, Division of Management C, Iowa City, IA, 52242, United States, Richard Epstein, Pengyi Shi

When the hospital census is high, perioperative medical directors or operating room managers may need to postpone some surgical cases scheduled within a few (e.g., <3) workdays. For the COVID-19 pandemic, we used data from state database and detailed data from a large hospital. Monte-Carlo simulations and time series analyses showed that, for purposes of comparing procedures at the same hospital, there is no loss of information by summarizing the probability distributions of hospital length of stay for elective surgical cases using single numbers, the percentages of cases among patients staying longer than overnight. This finding simplifies the mathematics for constructing dashboards or summaries of information system data to help the medical director make decisions.

2 - Machine Learning and Clustering-based Approach for County-level Covid-19 Analysis

Charles D. Nicholson, University of Oklahoma, Norman, OK, 73019, United States

COVID-19 is a global pandemic threatening the lives and livelihood of millions of people across the world. Due to its novelty and quick spread, scientists have had difficulty in creating accurate forecasts for this disease. This is especially true for regionally specific predictive models due to either limited case histories or other unique factors characterizing the region. This paper employs both supervised and unsupervised methods to identify the critical county-level demographic, mobility, weather, medical capacity, and health-related county-level factors for studying COVID-19 propagation. We use this feature subspace to aggregate counties into meaningful clusters to support more refined disease analysis efforts.

3 - Early Detection of Trend Shifts in Emergency Department Surges During the Covid-19 Pandemic

Sara Nourazari, California State University, Long Beach, Long Beach, CA, 92648-0906, United States, Samuel Davis, Rachel Granovsky, Dean J. Straff, Joshua W. Joseph, Leon D. Sanchez

A change detection tool is developed for tracking and early detection of trend shifts to help identify patterns in volume surges and declines in emergency departments during and after the COVID-19 pandemic in the U.S. This will allow studying the impact of different state-level and national guidelines and strategies on COVID-19 related restrictions and their downstream effects. At a macro level, this method can help study the impact of the pandemic on population health and emerging patterns of specific conditions such as mental health.

■ MD17

CC Room 202A

In Person: DAS Flash Talks I

Flash Session

Chair: Kyle J. Hunt, University at Buffalo, Buffalo, NY, 14086, United States

1 - Is it Better to Elicit Quantile or Probability Judgments to Estimate a Continuous Distribution? Elicit Both to Create an Inner Crowd
Asa Palley, Indiana University, Bloomington, IN, 47405-1703, United States, Saurabh Bansal

Two elicitation methods can be used to gather a probability distribution from an expert: (i) quantile judgments for a set of fixed probability values, or (ii) probability judgments based on a set of fixed variable values, but a consensus on which format yields more accurate distribution estimates has not been reached. We conduct 8 experiments with 1,456 participants and 30,870 distribution judgments to answer this question. We find that averaging distributions constructed from quantiles and visual probability elicitation tools delivers superior accuracy and calibration of confidence intervals. We recommend eliciting judgments via both formats and combining the resulting distributions.

2 - On The Adoption of New Technology to Enhance Counterterrorism Measures: Attacker-defender Games
Kyle J. Hunt, University at Buffalo, Buffalo, NY, 14086, United States, Jun Zhuang

To address the adaptive and dynamic threats that terrorists bring to our global society, it is imperative that counterterrorism agencies continue to improve their capabilities. To this end, one important challenge that has received scarce attention in the research community is the adoption of new counterterrorism technologies. Given that the adoption of new technology is common in practice, it is essential to study the strategic advantages of doing so. To help fill the gap in the literature, in this work, we develop attacker-defender models in which a defender seeks to adopt new technology, and an adversary seeks to attack a target.

■ MD18

CC Room 202B

In Person: Discrete Optimization

General Session

Chair: Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY, 10598, United States

1 - Political Districting to Minimize Cut Edges
Austin Buchanan, Oklahoma State University, Stillwater, OK, 74078-5017, United States, Hamidreza Validi

When constructing political districting plans, prominent criteria include population balance, contiguity, and compactness. The compactness of a districting plan, which is often judged by the "eyeball test," has been quantified in many ways. This paper considers the number of cut edges, which has recently gained traction in the redistricting literature as a measure of compactness because it is simple and reasonably agrees with the eyeball test. We study the stylized problem of minimizing the number of cut edges, subject to constraints on population balance and contiguity. With the MIP techniques proposed in this paper, all county-level instances in the USA (and some tract-level instances) can be solved to optimality. Our techniques extend to minimize weighted cut edges (e.g., to minimize district perimeter length) or to impose compactness constraints.

2 - Dual Bounds From Decision Diagram-based Route Relaxations: An Application to Truck-Drone Routing
Willem-Jan Van Hoeve, Carnegie Mellon University, Pittsburgh, PA, United States, Ziye Tang

We propose iterative algorithms to compute dual bounds motivated by connections between decision diagrams (DDs) and dynamic programming (DP) models used for pricing in branch-and-cut-and-price algorithms. We apply techniques from the DD literature to generate and strengthen novel route relaxations for obtaining dual bounds without column generation. Our approaches are general and can be applied to various vehicle routing problems where DP models are available. We apply our framework to the traveling salesman with drone problem, and show that our algorithms produce dual bounds competitive to those from the state-of-the-art, and can scale to larger problem instances.

■ MD19

CC Room 203A

In Person: Data, Learning, and Decision-Making in Healthcare Management

General Session

Chair: Danqi Luo, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States

1 - Modeling HIV/AIDS for Urban Centers in California to Inform Disease Control Goals
Sze-chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States, Anthony Nguyen

In 2019, the federal government launched a new initiative called Ending the HIV Epidemic: A Plan for America (EHE) with the goals of reducing the number of new HIV infections by 75% by 2025 and 90% by 2030. However, it is unclear how this should be achieved, as public health departments can allocate resources over a variety of interventions: growing adoption of pre-exposure prophylaxis (PrEP), increasing new diagnoses, improving retention in antiretroviral therapy (ART), etc. To inform this effort, we partner with state and local public health decisionmakers in California to build a microsimulation model of HIV/AIDS for Los Angeles, San Diego, and San Francisco using city-specific data. We use the model to examine intervention portfolios and assess what level and combination of strategies might be needed to achieve EHE goals.

2 - Conformalized Survival Analysis
Zhimei Ren, Stanford University, Stanford, CA, United States, Emmanuel Candès, Lihua Lei

Existing survival analysis techniques heavily rely on strong modelling assumptions and are, therefore, prone to model misspecification errors. In this paper, we develop an inferential method based on ideas from conformal prediction, which can wrap around any survival prediction algorithm to produce calibrated, covariate-dependent lower predictive bounds on survival times. In the Type I right-censoring setting, when the censoring times are completely exogenous, the lower predictive bounds have guaranteed coverage in finite samples with only the i.i.d. data assumption. Under a more general conditionally independent censoring assumption, the bounds satisfy a doubly robust property. The validity and efficiency of our procedure are demonstrated on synthetic data and real COVID-19 data from the UK Biobank.

■ MD22

CC Room 204B

In Person: Data Driven Applications In Healthcare Operations

General Session

Chair: Sandeep Rath, University of North Carolina at Chapel Hill Kenan Flagler, Chapel Hill, NC, 27599, United States

1 - Inference of Arrival Intensity in a Hospital Network From Count Data
Qianli Xu, Purdue University, West Lafayette, IN, United States, Harsha Honnappa, Pengyi Shi

We consider the arrival prediction problem of a hospital network. We capture patient movements within the hospital network with a multi-station queueing network, where the arrival process is time-varying and follows a doubly stochastic Poisson process. We propose frameworks to infer the arrival intensity process with count data. The first one is based on variational inference and the second one expectation-maximization. In a numerical experiment, we find both our methods perform well for queueing networks with a CIR arrival intensity process.

2 - Data-Driven Surgical Tray Optimization
Nishanth Mundru, UNC Kenan-Flagler, Chapel Hill, NC, United States, Vinayak V. Deshpande, Sandeep Rath

Surgical procedures account for over 60% of the operating cost of a hospital. However, on average less than 20-30% of reusable instruments supplied to surgeries are used. Using actual surgical instrument usage at a large multi-specialty hospital, we formulate a data-driven mathematical optimization model for surgical tray configuration and assignment, to reduce costs of unused instruments. We develop a solution methodology that scales to thousands of surgeries, thousands of instruments, and hundreds of surgical trays. We validate our model with an expert-recommended solution for a subset of trays and find that our model-based solution leads to 20\% lower overage and 21\% lower underage.

3 - Optimal COVID-19 Containment Strategies

Hyun-Soo Ahn, Professor, University of Michigan, Ross School of Business, Ann Arbor, MI, 48109, United States, John M. Silberholz, Xueze Song, Xiaoyu Wu

Policymakers rely on mathematical models to plan non-pharmaceutical interventions (NPIs) such as lockdowns to combat COVID-19, weighing health benefits against economic costs. Many such models have been created, but they vary in forecasts and recommendations. We find an NPI policy (how to change restrictions based on the current pandemic status) optimized wit h a single model can perform poorly (more than double the cost) when evaluated with a different model. We optimize across multiple models and find policies that all models find effective. The most effective policy varies significantly by state, due to differences in the NPIs selected by states and the response of citizens to those NPIs.

4 - To Catch A Killer: A Data-Driven Personalized and Compliance-Aware Sepsis Alert System

Zahra Mobini, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Mehmet U.S. Ayvaci, Ozalp Ozer

In this study, we develop an alert system for early detection of sepsis. Our system personalizes alerts to individual patients and accounts for caregivers' compliance behavior. Integrating predictive approaches with prescriptive ones in an MDP framework, our system determines when to alert for sepsis. We find that personalized alerts are essential for capturing the heterogeneity of sepsis risk among patients, while compliance-aware alerts are necessary when caregivers' compliance varies during a patient's hospital stay. Using data from a large hospital system in the US, we back test and validate our alert policy. On average, our system detects 22% more sepsis cases and triggers alerts 39 hours earlier (ranges 29-53) than the existing alert system. This time difference matters, as every hour of delay in providing proper sepsis treatment can increase mortality by up to 8%.

■ MD23

CC Room 204C

In Person: Service and Quality Operations Management

General Session

Chair: George Ball, Indiana University, Kelley School of Business, Bloomington, IN, 47405-1701, United States

1 - Need for Speed: The Impact of Website Performance on Online Retail

Nil Karacaoglu, Assistant Professor, Fisher College of Business, Ohio State University, Columbus, OH, United States, Santiago Gallino, Antonio Moreno

The share of e-commerce sales is rapidly increasing and so is the relevance of website performance. Weleverage novel retail and website performance data to investigate how website performance impacts onlinesales. The impact of speed and waiting time has been studied in various offline services. We extend thisliterature to online services and quantify the impact of website speed on brands. We estimate sizable adverseeffects of website speed slowdowns on online sales.

2 - Bad Things Come to Those Who Wait: Firm Stock Ownership, Recall Timing, and Stock Market Penalties

George Ball, Indiana University, Kelley School of Business, Bloomington, IN, 47405-1701, United States, Jessica Darby, Dave Ketchen, Ujjal Kumar Mukherjee

Firms often delay the decision to recall faulty medical devices long after they become aware of a defect. We examine how stock ownership of two key actors CEOs and institutional investors influences the speed with which medical devices are recalled. We then examine if the stock market penalizes firms differently based on recall decision-making speed and if this penalty varies with recall severity. We collect time-stamped data on 2,196 medical device recalls across 50 public medical device firms from 2002 to 2015. We find that firms with greater CEO and institutional investor ownership stakes recall medical devices more slowly. We also find that delaying recalls magnifies the stock market penalty attributable to the recall, indicating that bad things in the form of stock penalties may come to those who wait too long to initiate recalls.

3 - The Co-production of Service: Modeling Service Times in Contact Centers Using Hawkes Processes

Andrew Daw, Marshall School of Business, University of Southern California, Los Angeles, CA, 14853-3801, United States, Antonio Castellanos, Galit Bracha Yom-Tov, Jamol Pender, Leor Gruendlinger

In customer contact centers, a successful service interaction involves a messaging dialogue between a customer and an agent. In this talk, we propose, develop, and compare new stochastic models for service co-production in a contact center. Our models distinguish between the role of the customer and of the agent, reflect the service process's dynamic evolution over time based on its own history, and include additional behavioral and operational aspects. To evaluate our models, we apply them to an industry dataset containing nearly 5 million messages. We find that service interactions are characterized by strong customer-agent dependency and the centrality of the process's cross- and self-excitation attributes. Finally, we use our models in a data-driven simulation to improve upon contact center routing algorithms, yielding significant decreases in wait times.

■ MD24

CC Room 205A

In Person: Emerging Topics in Data-Driven Supply Chain and Revenue Management

General Session

Chair: Divya Singhvi, MIT, Cambridge, MA, 02139-4230, United States

1 - Joint Assortment Optimization and Customization under a Mixture of Multinomial Logit Models: On the Value of Personalized Assortments

Omar El Housni, Cornell Tech, New York, NY, 10044, United States, Huseyin Topaloglu

We consider a joint customization and assortment optimization problem under a mixture of MNL models. A firm faces customers of different types, each making a choice according to a different MNL model. In the first stage, the firm picks an assortment of products to carry subject to a cardinality constraint. In the second stage, a customer of a certain type arrives into the system. Observing the type of this customer, the firm customizes the assortment that it carries by, possibly, dropping products from the assortment. We study the complexity of this problem, present tight bounds on the value of customization and design a novel algorithm that gives $\Omega(1/ \log m)$-approximation to the problem, where m is the number of customer types. The problem has obvious connections to assortment optimization under a mixture of MNL models, which can only admit a $O(1/m)$-approximation.

2 - Math Programming Based Reinforcement Learning For Multi-echelon Supply Chain Management

Divya Singhvi, MIT, Cambridge, MA, 02139-4230, United States, Pavithra Harsha, Ashish Jagmohan, Jayant Kalagnanam, Brian Quanz

Reinforcement Learning has lead to considerable break-throughs in diverse areas such as robotics, games and others. But the application to RL in complex decision making problems remains limited. Many problems in Operations Management are characterized by large action spaces and stochastic system dynamics. These characteristics make the problem considerably harder to solve for existing RL methods that rely on enumeration techniques. To resolve these issues, we develop Programmable Actor Reinforcement Learning (PARL), a value iteration method that uses techniques from IP, SAA and optimal discretization of continuous random variables. We then apply our algorithm to real-world inventory management problems with complex supply chain structures and show that PARL outperforms state-of-the-art RL and inventory optimization methods in these settings.

■ MD25

CC Room 205B

In Person: Innovation and Design Management

General Session

Chair: Sidika Tunc Candogan, University College London, London, E14 5AA, United Kingdom

1 - Agile Development is Not (Always) A Panacea: An Experimental Study

Evgeny Kagan, Johns Hopkins Carey Business School, Baltimore, MD, 21202-4673, United States, Tobias Lieberum, Sebastian Schiffels

We experimentally study the effects of Agile project planning techniques on performance in two tasks: (1) a creative task reflective of product innovation with an open solution space and limitless creative possibilities, and (2) a search task reflective of business model innovation, in which subject search through a finite (but complex) solution landscape. Our results suggest that Agile techniques significantly improve performance in the first (creative) task, but harm performance in the second (search) task.

2 - Business Method Innovation in US Manufacturing and Trade
Tian Chan, Emory University's Goizueta Business School, GA, 30030, United States, Anandhi S. Bharadwaj, Deepa Varadarajan

"Kx" "What kind of business method innovation do firms in the manufacturing and trade sectors engage in? Does engagement in business method innovation create value? Using classification and text analysis of the business method patents, we show that business method innovation in these sectors is primarily aimed at improving the ways in which tangible products are marketed, delivered, or enhanced through service offerings. Leveraging the exogenous shock of the State Street ruling, which first recognized business methods as a patentable category, we show that the value of firms with business method patents relative to comparable peers with no such patents to be higher by 9% after State Street. We further show that manufacturers gained a smaller 7% increase, relative to a 25% gain for firms in the trade sectors; and only firms with broad innovation scope see a significant value bump.

3 - The Effect of Routine Communication Within and Across Teams of Knowledge Workers
Fabian J. Sting, University of Cologne, C/O Wiso-Sekretariat Universitaetsstrasse Albertus, Köln, 50931, Germany, Matthias Heinz, Johannes Schleef

How does routine communication within and across teams of knowledge workers affect their problem solving quality? Our study is based on a randomized controlled trial at a kitchen manufacturer, that is, in the context of complex, mass customized products. Here, knowledge workers virtually meet and discuss quality improvements with frontline colleagues of their team or with other teams in online quality circles. We measure effects on individual quality performance.

4 - Product Development in Crowdfunding: Theoretical and Empirical Analysis
Sidika Tunc Candogan, UCL School of Management, London, United Kingdom, Philipp Benjamin Cornelius, Bilal Gokpinar, Ersin Korpeoglu, Christopher S. Tang

Crowdfunding goes beyond raising funds. Entrepreneurs often use crowdfunding to solicit feedback from customers to improve their products. We show, both theoretically and empirically, that as the initial development level increases, the likelihood of product improvement during a campaign at first increases and then decreases. Also, while our theoretical model intuitively predicts that the likelihood of campaign success will always increase with the initial development level, our empirical analysis shows that there is first an increase but then an unexpected decrease. We find that this discrepancy can be explained by feature fatigue, and incorporate this effect into our theoretical model to generate prescriptions. While crowdfunding experts believe that products should be as developed as possible before a campaign, we show that this is not always the best strategy.

■ MD26

CC Room 206A

In Person: Submodularity in Mixed-Integer Nonlinear Optimization

General Session

Chair: Qimeng Yu, Northwestern University, Evanston, IL, 60201, United States

1 - Unifying Submodularity And Sequence Submodularity
Alexander Stewart Estes, University of Minnesota, Shoreview, MN, 55126-4807, United States

In this work, we unify two results regarding greedy algorithms for maximizing submodular functions. For non-decreasing submodular functions defined on sets, it has been shown that the greedy algorithm achieves a solution whose objective is within 1-1/e of the optimal objective. More recent work has defined a new type of submodularity called sequence submodularity, and shown that greedy algorithm likewise achieves 1-1/e of the optimal objective for this type of problem. In our work, we provide a framework that generalizes the concepts of submodularity and sequence submodularity, and show that greedy algorithms achieve 1-1/e of the optimal objective for any optimization problem within this framework.

2 - An Exact Cutting Plane Method for k-submodular Function Maximization
Qimeng Yu, Northwestern University, IEM S. C210, Evanston, IL, 60201, United States, Simge Küçükyavuz

A natural generalization of submodularity—k-submodularity—applies to set functions with k arguments and appears in a wide range of applications, such as infrastructure design, machine learning, and healthcare. We propose valid linear inequalities for the hypograph of any k-submodular function, and show that maximizing a k-submodular function is equivalent to solving a mixed-integer linear program with exponentially many such inequalities. We design the first exact algorithm to solve general k-submodular maximization problems that is not complete enumeration. Our computational experiments on coupled sensor placement demonstrate the efficacy of our method in constrained nonlinear k-submodular maximization problems which admit no compact mixed-integer linear formulations. Our method also significantly outperforms exhaustive search.

■ MD27

CC Room 206B

In Person: Recent Advances in Vector Optimization

General Session

Chair: Ozlem Karsu, Bilkent University, Ankara, 6800, Turkey

1 - A Decision Support System for Surgery Rescheduling Problem (SRP)
Sajia Afrin Ema, Graduate Student, New Mexico State University, Las Cruces, NM, United States, Sayed Kaes Maruf Hossain, Hansuk Sohn

In this research, we have proposed a multiobjective multi-stage mixed-integer linear program (MILP) mathematical model for the surgery rescheduling problem (SRP). To test the model, five (5) instances of the SRP were randomly generated. FICO Xpress Optimizer was used to solve the MILP model using the data instances. However, the solver was unable to provide an optimal solution for all five (5) instances within a reasonable timeframe. To overcome the issue, we have implemented three (3) variants of the Ant colony optimization (ACO) algorithm. All three ACO algorithms were able to provide optimal/near-optimal solutions for all five (5) instances of the SRP with a reasonable timeframe.

2 - Interactive Algorithms to Solve Biobjective and Triobjective Decision Making Problems
Ozlem Karsu, Bilkent University, Bilkent University, Ankara, 6800, Turkey, Tugba Denktas, Firdevs Ulus

We propose interactive algorithms to find the most preferred solution of biobjective and triobjective integer programming problems. The algorithms can be used in any setting where the decision-maker (DM) has a general monotone utility function. They divide the image space into boxes and search them by solving Pascoletti-Serafini scalarizations, asking questions to the DM to eliminate boxes whenever possible. We also propose a cone based approach that can be incorporated into both algorithms if the DM has a nondecreasing quasiconcave utility function. We demonstrate the performances of the algorithms and their cone based extensions with computational experiments. The results show that interactive algorithms are useful in terms of solution time compared to algorithms that find the whole Pareto set and that the cone based approach leads to less interaction with the DM.

■ MD28

CC Room 207B

Technology Tutorial: Your Guide to Financial Portfolio Optimization with Excel/What'sBest!

Technology Tutorial

1 - Your Guide to Financial Portfolio Optimization with Excel/What's Best!
Linus Schrage, LINDO Systems, Inc., Chicago, IL, United States

There has been an array of risk management optimization models proposed since Harry Markowitz first introduced the mean-variance model. Learn how easy it is to optimize with different risk metrics in Excel with the help of the What'sBest! add-in. In addition to mean-variance, we will cover:

Semi-variance
Mean Absolute Deviation (MAD)
Sharpe Ratio
Omega Ratio
Sortino Ratio
Information Ratio
Value-at-Risk
Conditional Value-at-Risk
Power Utility Function
Log Utility/Kelly criterion

and a variety of other benchmark tracking methodsBy the end of the session, you will understand when each method should be applied, the common pitfalls of each approach, and the data preparation issues to be concerned with.

2 - A Stochastic Variance-reduced Accelerated Primal-dualmethod For Finite-sum Saddle-point Problems

Erfan Yazdandoost Hamedani, University of Arizona, State College, PA, 16801-4415, United States, Afrooz Jalilzadeh

In this talk, we propose a variance-reduced primal-dual algorithm for solving convex-concave saddle-point problems with finite-sum structure and nonbilinear coupling function. This type of problem typically arises in machine learning and game theory. Compared with existing methods, our framework yields a significant improvement over the number of required primal-dual gradient samples to achieve an epsilon-accuracy of the primal-dual gap. We implemented our method for solving a distributionally robust optimization problem to show the effectiveness of the proposed algorithm.

3 - Using Deep Reinforcement Learning for Solving the Stochastic Capacitated Lot Sizing Problem

Lotte van Hezewijk, Eindhoven University of Technology, Eindhoven, 3526 WD, Netherlands, Lotte van Hezewijk, ORTEC, Zoetermeer, Netherlands, Nico P. Dellaert, Noud Gademann

We study a multi-item stochastic capacitated lot sizing problem. Inspired by industrial cases, we consider a limited production capacity, stochastic demand, and setup times. The objective is to determine the production quantities, while minimizing the costs of inventory, backorders and production. We use a Deep Reinforcement Learning (DRL) methodology to find solutions. Larger problem instances encounter some challenges, which we resolve by utilizing domain knowledge to support the DRL algorithm.

■ MD29

CC Room 207C

In Person: Distributionally Robust Optimization

General Session

Chair: Soroosh Shafieezadeh Abadeh, EPFL, Ecublens, 1024, Switzerland

1 - Two-stage Data-driven Distributionally Robust Optimization With Random Recourse

Xiangyi Fan, U T-Austin, Austin, TX, United States

We study two-stage data-driven stochastic optimization problems with random recourse where the adaptive decisions are multiplied with the uncertain parameters in both the objective and the constraints. We propose a scalable approximation scheme via piecewise linear and piecewise quadratic decision rules. The emerging decision rule problems can be reformulated as exact copositive programs, which admit tractable approximations in semidefinite programming. To address the inefficiency of solving large-size semidefinite programs, we design a decomposition algorithm where smaller-size subproblems can be solved in parallel. We further establish the performance guarantees of the proposed scheme and demonstrate its effectiveness through numerical examples.

2 - First-order Methods for Distributionally-Robust MDPs

Christian Kroer, Columbia University, New York, NY, 10027-6623, United States, Julien Grand-Clement

Markov decision processes (MDPs) are known to be sensitive to parameter specification. Distributionally robust MDPs alleviate this issue by allowing for ambiguity sets which give a set of possible distributions over parameter sets. The goal is to find an optimal policy with respect to the worst-case parameter distribution. We propose a framework for solving Distributionally robust MDPs via first-order methods and instantiate it for several types of Wasserstein ambiguity sets. By developing efficient proximal updates, our algorithms achieve convergence rates that are significantly better than existing value iteration methods. Numerical experiments show that our algorithm is significantly more scalable than state-of-the-art approaches across several domains.

3 - Optimal Transport Based Distributionally Robust Optimization

Soroosh Shafieezadeh-Abadeh, ETH Zurich, Zurich, Switzerland, Liviu Aolaritei, Daniel Kuhn, John Lygeros, Florian Dorfler

We show that the ordinary use of the Wassersyein type-p distance in DRO problems is not suitable even for simple loss functions. We then propose an optimal transport based DRO approach with a general transportation cost. In this general setting, the new DRO problem can be viewed as a zero-sum game. We prove that this zero-sum game admits a Nash equilibrium. We then proceed and explore the relationship between the distributional robustness and its regularization effect. In particular, we establish a link between the DRO setting and the use of high-order variation regularization, and then, we propose a simple dual formulation of the DRO problem for the class of generalized linear models using techniques in nonconvex optimization. This formulation enables us to both analyze the equivalency between the distributional robustness and its implicit/explicit regularization effect.

■ MD30

CC Room 207D

In Person: Advanced Maintenance Models

General Session

Chair: Yisha Xiang, Texas Tech University, Lubbock, TX, 79409, United States

Co-Chair: Ying Liao, Texas Tech University, Lubbock, TX

1 - Optimal Condition-based Maintenance for Assets Dispersed on a Graph

Shadi Sanoubar, University of Pittsburgh, Pittsburgh, PA, 15207-1176, United States, Bram de Jonge, Lisa M. Maillart, Oleg A. Prokopyev

This talk is concerned with providing condition-based maintenance via a single maintenance resource to a set of geographically distributed assets. We use graph representation to model possible geographical locations, including idling and asset locations and the links between them. We formulate a Markov Decision Process to dynamically obtain the optimal positioning of the maintenance resource and the optimal timing of the interventions that the resource performs. We explore how the underlying graph structure impacts the maintenance thresholds and the locations most used for idling under the optimal policy, as well as the performance metrics such as resource utilization and asset downtime.

2 - Risk And Resilience-based Optimal Post-disruption Repair for Critical Infrastructures under Uncertainty

Haitao Liao, University of Arkansas, Fayetteville, AR, 72703-9301, United States, Basem Alkhaleel, Kelly Sullivan

Post-disruption restoration of critical infrastructures (CIs) often faces uncertainties associated with the required repair tasks and the related transportation network. In this paper, two-stage risk-averse and risk-neutral stochastic optimization models are proposed to schedule repair activities for a disrupted CI network with the objective of maximizing system resilience. Both models are developed based on a scenario-based optimization technique that accounts for the uncertainties of the repair time and the travel time spent on the underlying transportation network. An improved fast forward algorithm based on a wait-and-see solution methodology is provided to reduce the number of chosen scenarios. To assess the risks associated with post-disruption scheduling plans, a conditional value-at-risk metric is incorporated into the optimization models.

3 - Maintenance Optimization of an Offshore Wind Turbine Subject to Weather Conditions

Morteza Soltani, Clemson University, Clemson, SC, United States, Jeffrey P. Kharoufeh, Amin Khademi

We consider the maintenance optimization of an offshore wind turbine, where the feasibility of performing maintenance depends on the weather condition. The turbine's degradation evolves as a Markov chain, and the objective is to minimize the sum of the expected total setup, replacement and downtime costs over a finite horizon. We devise a Markov decision process model and establish the existence of a threshold policy, as well as monotonicity of the value function and optimal policy. A novel approach for theoretical sensitivity analyses of key model parameters is also presented.

4 - Prognosis Analysis of Breast Cancer Based on Dirichlet Process Mixture Models

Ying Liao, Texas Tech University, Lubbock, TX, 79415-5119, United States, Yisha Xiang, Di Ai, Ning Dong

Breast cancer patients in a particular subgroup often have common disease progression pattern that leads to similar survival outcomes. It is of great importance to identify such subgroups because effective treatments can be developed for the patients based on their corresponding prognostic information. In clinical practices, the number of subgroups is generally unknown and it is also challenging to model the relationships between the group labels and various prognostic factors, such as age at diagnosis, estrogen and progesterone receptors status. In this work, we propose a novel clustering framework to probabilistically label the patients based on the Dirichlet process mixture models. Given the labels, we identify significant prognostic factors using advanced machine learning algorithms and provide some insights for clinical practitioners.

■ MD31

CC Room 208A

In Person: Data-driven Methods for Systems Engineering

General Session

Chair: Luis Javier Segura, Buffalo, NY, 14228, United States

1 - An Adaptive Data-driven Kernel for Blind Image Deblurring
Sajjad Amrollahi Biyouki, The University of Tennessee, Knoxville, TN, United States, Hoon Hwangbo

Blind Image deblurring tries to estimate blurriness and recover a latent image out of a blurred image. This process, as being an ill-posed problem, requires imposing restrictions either on the latent image or a blur kernel representing blurriness. Different from recent studies that impose some priors on the latent image, this research explicitly formulates the structure of the underlying kernel where the structure itself is adaptive to data, which enables modeling nearly non-parametric shape of blurriness. When applied to the recovery of satellite images, the recovered images show the superiority of the proposed method to other state-of-the-art approaches.

2 - Surface Temperature Monitoring in Liver Procurement via Time-vertex Signal Processing
Sahand Hajifar, University at Buffalo, Buffalo, NY, United States, Hongyue Sun

Accurate evaluation of liver viability during its procurement is a challenging issue. Recently, people have started to investigate the non-invasive evaluation of liver viability during its procurement using the liver surface thermal images. However, existing works attempt to evaluate quality of the liver by extracting either temporal temperature variation or spatial temperature variation. The objective of this study is to jointly extract spatiotemporal (belonging to both space and time) variations to evaluate quality of the liver. To achieve this objective, we use techniques from time-vertex signal processing. In particular, we use joint Fourier transform (JFT) to extract features that contain information from both time and space domains. Then, we use a high-dimensional control chart to monitor the features and estimate the change point.

3 - Inkjet Printing Droplet Evolution Prediction via Tensor Time Series
Luis Javier Segura, University at Buffalo, Buffalo, NY, United States, Zebin Li, Luis Javier Segura, Hongyur Sun

Droplet behaviors substantially determine the quality of the produced products in the Inkjet Printing (IJP). The droplet formation mechanism (i.e., droplet evolution) understanding is fundamental for the process performance. This work investigates droplet evolution prediction via Tensor Time Series analysis. The method learns the spatial-temporal relationships by joining the force of Tensor Graph Convolutional Network (TGCN) and Tensor Recurrent Neural Network (TRNN). The method is tested in experimental and simulated droplet evolution data in the IJP process.

4 - Challenging Research Problems in the Automotive Industry
Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, United States

Novel challenges in the automotive industry have led to fundamentally new research opportunities in quality, statistics, and reliability. The panelists in this session will discuss the new research problems that they are investigating in their work in the automotive industry.

■ MD32

CC Room 208B

In Person: New Challenges in Pricing and Revenue Management

General Session

Chair: Adam Elmachtoub, Columbia University, New York, NY, 10027-3241, United States

Co-Chair: Xiao Lei,

1 - Menu Design of a Bipartite Matching Queueing System With Strategic Users
Lisa Hillas, University of Chicago, Chicago, IL, United States, Rene A. Caldentey, Varun Gupta

In this talk, we explore the optimal design of matching topologies for a multi-class multi-server queueing system under a FCFS-ALIS service discipline. We investigate the performance of the system from the perspective of a central planner who must design a menu of service classes, which are defined by the subset of servers that can serve each class. Customers are heterogeneous on their preferences over servers and self-select the service class to join.

2 - Loot Box Pricing and Design
Xiao Lei, Columbia University, New York, NY, 10027-6601, United States, Ningyuan Chen, Adam Elmachtoub, Michael L. Hamilton

Online games garner annual revenues in the billions, more than half of which is from purchases of virtual items to be used by the player in the game. One popular way to sell in-game items are via loot boxes, which are random bundles of virtual items, the contents of which are revealed after purchase. We consider how to design loot boxes selling strategies, and compare them with bundle selling and separate selling. We show that in an asymptotic regime, carefully designed loot box strategies can garner as much revenue as bundle selling while inheriting many nice properties of separate selling. Our result and discussion give insights to customers, sellers and regulators.

■ MD33

CC Room 209A

In Person: Resilient Infrastructure and Community Networks

General Session

Chair: Alexander Gilgur, Stevens Institute of Technology, Sunnyvale, CA, 94087-2939, United States

1 - Efficient Solution Approaches to the Isolated Community Evacuation Problem
Klaas Fiete Krutein, University of Washington, Seattle, WA, 98117, United States, Anne Goodchild

The Isolated Community Evacuation Problem (ICEP) is a recently introduced route optimization model that aims at minimizing the evacuation time for communities that have no road-based evacuation routes and rely on alternative transportation resources for evacuation. The stochastic version of the problem allows for making planning decisions for such events considering demand uncertainty through a set of disaster scenarios. However, since this adds additional complexity and computational effort, we present different approximate solution approaches to the ICEP that reduce the solution time and allow for better use in practice for evacuation planning and show the effect on example problems of varying sizes.

2 - Equitable and Sustainable Energy Transitions
Destenie S. Nock, Carnegie Mellon University, Pittsburgh, PA, 15207-1120, United States

In the fight against climate change countries have set strong electricity sector decarbonization targets. However, there is uncertainty regarding whether these policies will exacerbate social inequities, and how they will impact environmental sustainability across different income groups. Currently, most electricity planning models determine the least cost option, without considering how the recommended pathways impact distributional equity. This research will explore the sustainability and equity trade-offs between different energy transition pathways for the US. Specifically we tie a national least cost optimization model with and equity analysis. We show how decarbonization targets impact energy equity objectives.

3 - Social Cohesion and Emotion Analysis of News and Tweets During 2020 Wildfires: A Case Study
Alexander Gilgur, Stevens Institute of Technology, Sunnyvale, CA, 94087-2939, United States, Jose E. Ramirez-Marquez

Wildfires are a fact of life in California, from San Diego to Mount Shasta. We used social and public media to analyze emotions, social cohesion, and resilience in the cities of the San Francisco Bay Area, CA before, during, and immediately after California wildfires of 2020. The effects of interactions with COVID and protests of 2020 have been analyzed as well.

■ MD34

CC Room 209B

In Person: Service Science Best Cluster Paper Competition (III)

Award Session

Chair: Pnina Feldman, Boston University, Boston, MA, 02215, United States

1 - Tax-Induced Inequalities in the Sharing Economy
Yao Cui, Cornell University, Ithaca, NY, 14853-6201, United States

We use a machine learning (causal forest) method to empirically study the heterogeneous treatment effects of the occupancy tax policy on Airbnb. We find that the tax adversely affects residential listings more than commercial listings, suggesting that the current tax policy may over-penalize the wrong type of listings. We further show that this unintended consequence is caused by customers' discriminatory tax aversion. We then conduct prescriptive analytics regarding how hosts should optimally adjust prices in response to the tax and

how policy makers should set more appropriate tax rates.

2 - Dynamic Batch Learning with High-Dimensional Covariates: Theory, Algorithm and Application
Zhimei Ren, United States

We study the problem of dynamic batch learning in high-dimensional sparse linear contextual bandits. We characterize the fundamental learning limit in this problem and provide a simple, exploration-free algorithm that uses the LASSO estimator and achieves the minimax optimal performance (up to log factors). To our best knowledge, our work provides the first inroad into a rigorous understanding of dynamic batch learning with high-dimensional covariates. We also demonstrate the efficacy of our algorithm on both synthetic data and the Warfarin medical dosing data.

3 - The Important Role of Time Limits when Consumers Choose their Time in Service
Pnina Feldman, Boston University, Boston, MA, 02215, United States

We examine ways to manage congestion in services where customers choose their service time. Time limits that restrict time spent in service are very attractive levers to regulate congestion. When combined with simple pricing schemes (e.g., per-use fees and price rates), they maximize revenue and social welfare. To maximize consumer surplus, service should be provided for free, but time limits should be set to regulate congestion. Time limits don't only work well when combined with simple price mechanisms, but they are in fact optimal when congestion is high. Service providers can achieve the first-best outcome and extract all customer surplus by coupling a time limit with an optimal price mechanism.

■ MD35

CC Room 210A

In Person: Emerging Topics in Facility Logistics

General Session

Chair: Leily Farrokhvar, California State University Northridge, Porter Ranch, CA, 91326, United States

1 - Impact Of Route Planning On Workforce Scheduling In Distribution Centers
Arpan Rijal, University of Groningen, Groningen, Netherlands, Marco Bijvank, René De Koster

When the distribution of ordered items from a warehouse to customers is scheduled, the transportation planning is generally done first and this serves as input for the planning of warehouse operations. However, when the deliveries to customers have time window restrictions and the availability of order picking or staging capacities at the warehouse is limited, the sequential approach of transportation-first-warehousing-second is not only sub-optimal but the routes can also be infeasible for warehouse managers to implement. This paper studies the routing decisions of vehicles to customer locations with hard time windows while considering scheduling of order pickers determining batch size of orders and their sequencing with limited staging. We propose a mathematical model for the integrated problem and propose solution approaches.

2 - Maximum-stability Dispatch Policy for Shared Autonomous Vehicles Based on Zone-based Dynamic Queueing Models
TE XU, University of Minnesota, Minneapolis, MN, United States

Shared autonomous vehicles (SAVs) are a fleet of autonomous taxis that provide point-to-point services for travelers. But the number of waiting passengers could become arbitrarily large when the fleet size is too small for travel demand, which causes an unstable network. To overcome this, we design a zone-based dynamic queueing model for waiting passengers and a maximum stability dispatch policy for SAVs that when the average number of waiting passengers is bounded in expectation, which is proven by the Lyapunov drift techniques. Then we expand the proof to the existence of exiting passengers. Simulation results show that our dispatch policy can ensure the waiting queues are bounded in expectation.

3 - Maximal Coverage Problem for a Naval Task Group with Random Threat
Zeyu Wang, George Washington University, Washington, DC, United States, Miguel Lejeune

We present a stochastic programming model with decision-dependent probabilities for air defense coverage and the formation of a naval task group. The problem maximizes the probabilistic coverage level of a naval group. We introduce a load-discounted function to describe the impact of allocation decisions on coverage efficiency. The joint chance constraint optimizes defense coverage under uncertainty of missile attack directions. We use the Boolean framework to obtain a deterministic reformulation of the chance constraint. We derive several valid inequalities to improve computational efficiency.

4 - Increasing Shelving Density in a Robotic Mobile Fulfillment Warehouse Using Overhead Lifting System
Leily Farrokhvar, California State University Northridge, 16322 Benjamin Ct, Granada Hills, CA, 91344, United States, Vy Nguyen, Kenneth Currie

A robotic mobile fulfillment (RMF) system is proven to be a solution for the fast-growing, rapid, and dynamic demand of e-commerce. With many advantages on pick time, efficiency, and accuracy, an RMF system is often limited to a one-dimension operation on the floor coupling with heavy utilization of robots. We propose implementing an overhead lifting system to take advantage of the vertical space, increase warehouse density, improve robot utilization, and save space costs. We simulate restricted environments and analyze pick time, picker utilization, and throughput times.

■ MD36

CC Room 210B

In Person: Sustainable Urban Logistics/ Urban Freight Operations

General Session

Chair: Vikrant Vaze, Dartmouth College, Hanover, NH, 03755-3560, United States

1 - Prohibiting Cherry-picking: Regulating Ride-hailing Services Who Choose Service Region, Availability and Fleet Size
Layla Martin, Eindhoven University of Technology, Arcisstr. 21, Eindhoven, 80333, Netherlands, Wu Hao

Ridehailing is frequently positively attributed, but may also increase congestion and emissions, may negatively impact existing markets, and the service quality of ridehailing may differ within a city. We study different regulations on fleet size, service region, service availability, and rebalancing. We formulate the problem of setting fleet size, service region, and availability jointly with the operational rebalancing decision as a Mixed Integer Second-Order Cone Program. Numerical experiments on artificial and case study instances point towards surprising interdependencies. For example in the case study, requiring equal availability at all locations decreases the fleet size by up to 15.8%, and also decreases the rebalancing activities.

2 - Presenter
Ricardo Giesen, Pontificia Universidad Catolica de Chile, 486 Av Vicuna Mackenna, Casilla 306 Cod 105, Trans, Santiago, CP 7820436, Chile

Abstract not available

■ MD37

CC Room 210C

In Person: New Business Models for Sustainable Operations

General Session

Chair: Somya Singhvi, USC Marshall School of Business, Los Angeles, CA, 90007, United States

1 - The Impact of Animal Welfare Regulations on Firms
Yen-Ting (Daniel) Lin, University of San Diego, Olin Hall, School Of Business Administration Univ, San Diego, CA, 92110, United States, Yingping Mu, Wenli Xiao, Zhiping Lin

Factory farming generates pollution and animals are raised in an inhumane environment. Many countries introduce animal welfare regulations to prohibit factory farming. Under these regulations, companies can choose to offer a humane product or an organic product that vary in animal living conditions. We study how such regulations affect firms' product offering and pricing decisions under competition. We also study the effectiveness of various subsidy policies to support regulatory compliance.

2 - Improving Cash Constrained Smallholder Farmer Welfare: Role Of Government Interventions
Somya Singhvi, University of Southern California, Los Angeles, CA, 02139-4230, United States, Kenneth Pay, Yanchong Zheng

The need for immediate cash inhibits smallholder farmers from maximizing their revenue by forcing them to sell their produce at suboptimal times. This paper develops a model to examine how cash constraints influence farmers' sales decisions, as well as to analyze the efficacy of loan programs in improving revenue outcomes.

3 - Detours in Shared Rides
Sebastien Martin, Northwestern University, Evanston, IL, United States, Ilan Lobel

Detours are considered key for the efficient operation of a shared rides service, but are also the major pain point for consumers of such services. This paper studies the relationship between the value generated by shared rides and the detours they create for riders. We establish a fundamental limit on the sum of value and detour, and prove this leads to a tight bound on the Pareto frontier of

values and detours in a general setting with an arbitrary number requests. We explicitly compute the Pareto frontier for one family of city topologies, and construct it via simulation for several more networks, including one based on ridesharing data from commute hours in Manhattan. We then use these results to provide management insights and propose a two-product version of a shared rides service.

■ MD38

CC Room 210D

In Person: Fintech and OM-Finance Interface

General Session

Chair: Andrew Wu, Ross School of Business, University of Michigan, United States

1 - The Tokenvendor Problem: Tokenizing Cargo Reservations under Overbooking And No-shows

Yunzhe Qiu, Washington University in St. Louis, St. Louis, MO, 63130, United States

The container shipping industry suffers from the chronic losses caused by mismatching between the supply of liners and the demand of shippers overbooking and no-shows. We develop a model of the blockchain-based cargo reservation system, where the token is designed to be used as a booking deposit to compensate the contractual party if the other side fails to honor the booking. We propose a dynamic model for the booking deposit acceptance problem faced by the carrier with a single service slot over a fixed time horizon and characterize the optimal token reservation acceptance strategy as a downward threshold policy. Shippers with token deposits lower than a dynamic threshold should be accepted by the container liner. We propose an approximate dynamic programming algorithm, to solve the liner's acceptance problem with computational efficiency and guaranteed performance.

2 - Measuring Utility and Speculation in Blockchain Tokens

Andrew Wu, Ross School of Business, University of Michigan, Ann Arbor, MI, United States, John Silberholz

Abstract not available

■ MD39

CC Room 211A

In Person: Analytical and Empirical Approaches to Healthcare Operations

General Session

Chair: Jayashankar M Swaminathan, University of North Carolina Chapel Hill, Chapel Hill, NC, 27599-3490, United States

1 - The Effect of Standardization On Hospital Performance

Anand Bhatia, University of North Carolina Chapel Hill, UNC-CH KFBS, Chapel Hill, NC, 27599, United States, Jayashankar M. Swaminathan

Healthcare services provided to patients with similar health conditions is known to vary. Evidence-based standardized protocols can be used to address such variation in care. We examine the impact of process standardization within a hospital on its performance. Our empirical analysis finds that standardization positively impacts cost of discharge, quality of outcome, and variation in outcome across departments.

2 - Self-selecting No-pay Service Delivery Strategies: A Rising Tide That Lifts All Boats?

Vikrant Vaze, Dartmouth College, Hanover, NH, 03755-3560, United States, Omkar D. Palsule-Desai, Srinagesh Gavirneni, Gang Li

Rapidly increasing cost structure and income inequality are major impediments in making essential services universally accessible and affordable. Service organizations are offering self-selecting no-pay options that are well-known to significantly enhance service provider profit, consumer surplus, and social welfare. Their effects on competitors have not yet been documented. We analyze a duopoly setting in which one service provider offers this strategy while the competitor does not and tabulate conditions under which these strategies increase competitor profit as well. Thus, these strategies are proving to be win-win-win-win.

3 - Oh, The Places You'll Go! Impact Of COVID-19 Vaccination on Demand for Public Transport

Huaiyang Zhong, Harvard University, Boston, MA, United States, Guihua Wang, Tinglong Dai

Public transit ridership tumbled amid the COVID-19 pandemic, fueling enormous budget shortfalls and prompting slashed or eliminated services across the U.S. In this paper, we estimate the effect of COVID-19 vaccination process on the demand for public transport. Despite well-documented empirical challenges related to causal inference of vaccination campaigns, we leverage unique features of the COVID-19 vaccine rollout to develop an instrumental variables (IV) approach. We estimate that a 1% increase in vaccination rate led to a 2.6% increase in the relative mobility in public transit centers. Our findings demonstrate the significant effect of vaccination in accelerating the recovery of public transit and provides strong support for restoring and strengthening public transit infrastructure as vaccination progresses.

4 - Collaborative Care for Diabetes And Depression

Jayashankar M. Swaminathan, University of North Carolina Chapel Hill, Kenan-Flagler Business School, Operations, Chapel Hill, NC, 27599-3490, United States, Sandeep Rath

Multiple clinical trials have demonstrated the benefits of a collaborative care program that integrates patients' mental and physical healthcare within primary care. However, the financial sustainability of such collaborative care models outside trial settings has not been demonstrated. The principal challenges are: allocation of managers' time and uncertainty over future insurance payment models. We formulate a mathematical optimization model for collaborative care for the treatment of patients with diabetes and depression towards improving clinic profits and patient QALYs. We characterize the optimal allocation of the care manager's time. We also analyze the impact of different insurance payment models.

■ MD40

CC Room 211B

In Person: Big Data Finance and Machine Learning in Finance

General Session

Chair: Renyuan Xu, University of Southern California, OR Department, Los Angeles, CA ""Fx" "Chair: Zhengyuan Zhou,

1 - Presenter

Tarun Chitra, Gauntlet Networks, Inc., New York, NY, United States

Constant function market makers (CFMMs) such as Uniswap, Balancer, and Curve make up some of the largest decentralized exchanges on Ethereum and other blockchains. These protocols provide computational benefits for automated market makers in compute constrained environments such as blockchains. As the amount of capital and trading volume in these protocols grows past tens of billions of dollars, improving the efficiency of these systems has becomes more important. To describe what efficiency means in this context, we start with the theory of CFMMs and describe how it is closely tied to convex duality. This relationship is then related to classic payoff replications (e.g. Carr-Lee, El Karoui), which can be realized by optimized trading functions. We will describe how payoffs replicated by CFMMs can be designed to optimize capital efficiency and minimize fees.

2 - Infinitely Imbalanced Linear Classifiers with Applications To Credit Risk

Mike Li, Columbia University, New York, NY, United States, Paul Glasserman

In two-group linear discriminant analysis such as classifying credit risk, it is common for the data to be imbalanced: the default class is rare compared to the non-default class. Here we consider the infinitely imbalanced case where the sample size of the default class is finite and that of the non-default class grows infinitely. Under mild conditions, the regression coefficients converge to a useful limit: the exponential tilt that brings the mean of the non-default class to an exponentially weighted mean of the default class, extending a result of Owen (2007). For polynomially bounded objectives, this limit defines a distribution that is the hardest to distinguish from the non-default class; for exponential objectives with varying exponents, the linear classification based on this limit balances the trade-offs between Type 1 and Type 2 errors.

3 - Scaling Properties Of Deep Residual Networks

Renyuan Xu, University of Southern California, O R. Department, Los Angeles, CA, 94720, United States, Alain-Sam Cohen, Rama Cont, Alain Rossier

Residual networks (ResNets) have displayed impressive results in pattern recognition and have garnered considerable theoretical interest due to a perceived link with neural ODEs. This link relies on the convergence of network weights to a smooth function as the number of layers increases. We investigate the properties of weights trained by SGD and their scaling with network depth through detailed experiments. We observe the existence of scaling regimes markedly different from those assumed in neural ODE literature. Depending on certain features of the network architecture, we prove the existence of an alternative ODE limit, an SDE limit, or neither of these. These findings cast doubts on the validity of the neural ODE model as an adequate asymptotic description of deep ResNets and point to an alternative class of differential equations as a better description of the limit.

■ MD41

CC Room 212A

In Person: Electrical Grid Analysis/Transmission Planning

General Session

Chair: Afzal Siddiqui, Stockholm University, Stockholm, Sweden

1 - Integration of Optimization and Machine Learning for Improving Electrical Grid Operation

Carl Laird, Professor, Carnegie Mellon University, Pittsburgh, PA, 87123-3453, United States, Jordan Jalving, Logan Blakely, Fani Boukouvala, Zachary Kilwein, Michael Eydenberg

Reliable, optimal operation of the electrical grid requires consideration of generator costs and operating feasibility. Machine learning can be a valuable tool to approximate complex operating constraints. There has been an increase in research focused on the ability to optimize models that include neural network constraints with general nonlinear or piecewise linear activation functions. In this presentation, we demonstrate the use of machine learning to replace challenging constraints in electrical grid optimization problems.

2 - Sustainable Transmission Planning

Afzal Siddiqui, Stockholm University, Stockholm, Sweden, Makoto Tanaka, Yihsu Chen

Increased penetration of intermittent variable renewable energy sources (VRES) requires variability management, which often refers to storage and transmission investment. However, the cost of damage from emissions is overlooked in favour of VRES targets. We use a bi-level framework to devise transmission plans that directly include the cost of damage from emissions. Our upper level comprises a welfare-maximising transmission planner who internalises the damage cost. At the lower level, profit-maximising firms invest in VRES capacity and operate their fleet of assets. We implement problem instances for a Western European test network in order to examine how storage and transmission are complements or substitutes in integrating VRES.

■ MD42

CC Room 212B

In Person: Deep Learning/Machine Learning II

Contributed Session

Chair: Sepehr Fathizadan, ASU, Tempe, AZ, 85281, United States

1 - Learning a Continuous Search Space for Discrete Routing Problems Using Autoencoders

Kevin Tierney, Bielefeld University, Bielefeld, 33615, Germany, André Hottung, Bhanu Bhandari

Methods for automatically learning to solve routing problems are rapidly improving. However, most methods are unable to effectively utilize longer run times because they lack a sophisticated search component. We present a learning-based optimization approach that learns to map instance-specific routing problem solutions to points in a continuous space, thus turning a discrete search space into a continuous search space that can be explored using any unconstrained continuous optimization method (e.g., differential evolution). Our approach outperforms existing machine learning based approaches for the traveling salesperson problem and the capacitated vehicle routing problem.

2 - Deep Learning-based Disease Diagnostic Biomarker Detection With Metabolomics Data

Seonyoung Kim, Chungnam National University, Daejeon, Korea, Republic of, Taewon Go, Dongil Kim

Biomarkers play important roles in the early diagnosis of disease to improve the survival rate of patients. To determine the type and stage of diseases and the corresponding treatment options, the target biomarkers should be identified. Metabolomics provides information on cellular metabolic processes that drive tumorigenesis and tumor progression. In this study, we propose deep learning methods to detect disease diagnostic biomarkers with metabolomics. Through experiments, we compare the performance of the proposed method and other machine learning methods.

3 - Interpretable Trees

Zheng Zhang, University of Tennessee, Knoxville, Knoxville, TN, United States

Tree- and rule-based models have been known to have good interpretability, as the trained predictive models form a set of decision rules that are easy to understand in practice. Existing methods select the best model by minimizing the prediction errors on both child nodes (i.e., too much or too little) and predict values as the average of all observations in each terminal node. In this paper, we propose a split criterion based on rank concordance and a rule by fitting each terminal node with a linear function. The proposed method rather than the traditional performed better in accuracy and interpretability (e.g., capture the variations and associations between target variable and predictors).

4 - Deep Spatio-temporal Anomaly Detection in Laser Powder Bed Fusion

Sepehr Fathizadan, Arizona State University, Tempe, AZ, United States, Feng Ju, Yan Lu, Zhuo Yang

Parametric and regression-based anomaly detection methods often fall short when faced with high-dimensional data containing rich spatio-temporal correlations. The multitude of unrealistic assumptions renders the decisions made by such methods unreliable and prone to large errors. It has been shown that relying on a single melt pool image to detect anomalies in the process is usually misleading and can result in significant inflation of false alarm rates. In this study, we propose a configuration of convolutional long short-term memory auto-encoders to learn a deep spatio-temporal representation from the sequence of melt pool images and perform anomaly detection.

■ MD43

CC Room 213A

In Person: Neural Networks

Contributed Session

Chair: Angela Avila, San Antonio, TX, 78240, United States

1 - Analysis for the Continuous Version of the Alternative Fuel Refueling Station Location Problem

Sara F. Abu Aridah, PhD Student, Pennsylvania State University, University park, PA, United States, Omar Abbaas, Jose Antonio Ventura

We address the deviation-flow refueling station location problem. We start with a continuous network where any point is considered as a candidate station location. Then the network is discretized by rounding distances and the driving range to the closest integer multiple of a common divisor value. This reduces the required computational effort to solve the problem. In this network, we prove that given any feasible solution with refueling stations located at non-integer distances from network vertices, it is always possible to find an equivalent integer solution. These results are used to discretize the network and propose an efficient polynomial time algorithm to locate a set of refueling stations.

2 - Predicting Utility Power Line Risk From Tree Failure via an Interpretable Convolutional Neural Network

Nasko Apostolov, Graduate Research Associate, University of Massachusetts Amherst, Amherst, MA, United States, Ryan Suttle, Jimi Oke, Sanjay Arwade, Brian Kane

Automating tree risk assessments, which are critical to the integrity of utility power lines, could potentially yield significant cost savings while boosting community resilience. We train a novel convolutional neural network to predict tree failure likelihood categories using augmented inputs from expert-assessed tree images. Via cross-validation and hyperparameter optimization, we obtain a binary classifier with an accuracy of 0.94 (SD = 0.1). We assess the visual interpretability of the classifier using techniques such as gradient-weighted class activation maps. Our framework demonstrates the potential of artificial intelligence for sustainable infrastructure management.

3 - Classifying Soil Moisture Levels of Grazeland Using UAV Imagery Data Based on a Convolutional Neural Network Method

Angela Avila, University of Texas at Arlington, Arlington, TX, United States, Jianzhong Su, Heidi Taboada, Huihui Zhang

In field management, soil moisture is a key predictor in yield success. With acres of fields and mindfulness of water conservation, our goal is to maximize crop production at minimal cost. Unmanned Aerial Vehicles can be used to take images and provide information on ground moisture. We can then derive vegetation indices and use Convolutional Neural Network to distinguish well maintained areas from areas that are in water deficit. With imaging data collected in Fort Collins ARS, we will train the CNN system to successfully reach about 89% accuracy in predicting an image class correctly. With UAV data and CNN method we can precisely predict soil moisture levels and tend to areas with more irrigation needs.

■ MD44

CC Room 213B

In Person: Economic Modeling

Contributed Session

Chair: Ankita Srivastava, Oklahoma State University, Tulsa, OK, 74137, United States

1 - Optimal Price Subsidy for Plant-based Meat Toward a Differential Game Model

Jie Qu, University of Wisconsin Milwaukee, Milwaukee, WI, United States

Dealing with environment and food crisis, popularize the fake meat is a possible solution. However, the high production cost made fake meat lack of competitiveness. High cost will be overcome by technology advancement and economics of scale if it, in early market, received subsidy and help from government to become economically competitive. This paper deals with the determination of optimal pricing policy for the firm and optimal subsidy for the government in the monopoly and oligopoly market using differential game.

2 - Digital Borders, Spatial Trade Spillovers, and Development

Gabriel Bahr, Oklahoma State University, Stillwater, OK, United States, Bryan Hammer, Andy Luse

The purpose of this paper is to expand ICT4D literature by investigating the associations between international trade of technology merchandise and development across countries. Using a spatial autoregression model and data on 45 upper-middle and high income countries from 2009 to 2018, we examine the effects of imports and exports of technology driven trade on two measures of development (GDP and HDI). Additionally, we define spatial borders through a trade partner network and discover spillover effects of trade-development on neighboring countries.

3 - HIT Spillovers and Sustained Cooperation

Ankita Srivastava, Oklahoma State University, Tulsa, OK, United States, Chenzhang Bao, Dursun Delen

Based on the proposed referral network model we study IT spillover effects from ambulatory facilities to hospitals. Using a panel of 13 years with 2,768 US hospitals matched with approximately 30,000 ambulatory facilities, we find a 1% increase in the average EMR adoption of the regional ambulatory clinics can reduce the inpatient cost of the focal hospital by 0.031% (savings of $51,000) in one year and by 0.059% (savings of $98,000) in four years. Our model is robust to endogeneity issues. We also find support for mechanisms where spillover effects are expected to be stronger. The referral network model and empirical evidence can propagate a culture of sustained cooperation among healthcare providers.

4 - Sequential Price Negotiations for Big-ticket Items: Empirical Discovery and Estimation of Predetermined Strategies

Abdullah Gokcinar, PhD Candidate, The University of Texas at Dallas, Richardson, TX, United States, Metin Cakanyildirim, Suleyman Karabuk

We empirically analyze negotiations between the seller and buyer over the price of a big-ticket item. In a negotiation, the seller and buyer take turns to accept the other's offer, make a concession from the previous offer, or exit. Empirical results suggest that a player makes concessions following a predetermined negotiation strategy towards a price, and he/she may accept or exit based on the other player's offers. Following these, we analytically model negotiations to estimate negotiation strategies along with acceptance and exit probabilities. These estimations can help us in revealing latent negotiation characteristics in different player subpopulations.

■ MD45

CC Room 213C

In Person: Vehicle Routing I

Contributed Session

Chair: Bahar Cavdar, Texas A&M University, College Station, TX, 77843, United States

1 - Ground Vehicle and Unmanned Aerial Vehicle Cooperative Delivery with Mothership Charging

Hyung Joo Cha, Korea University, Seoul, Korea, Republic of, DongKyun Kim, Joonyup Eun, Taesu Cheong

This research proposes a vehicle routing problem using an electric drone (VRP-ED). The traditional vehicle routing problems with drones, in general, assume that drone batteries are replaced by a ground vehicle driver at a rendezvous point. However, in this talk, we propose a new cooperative vehicle routing model, where the drone acquires its electric power from the mothership on board and consumes its electric power during flight. A mathematical formulation for VRP-ED is presented. Due to the complexity of VRP-ED, a heuristic algorithm is also developed and tested.

2 - Comparing 2-phase and 3-phase Algorithm for Handling Vehicle Routing Problem

Jihyun Jo, Pennsylvania State University, University Park, PA, United States, Soundar Kumara

In our previous studies, we found out that node density can affect the solution quality of the vehicle routing problem when we use genetic algorithm-based Route-First, Partition-Second method. This method works fine when the node density is high, however, it is not good for the cases with relatively low node density with thousands of visiting nodes in a network. To overcome this problem, we proposed to solve the problem with the nearest neighborhood search algorithm-based Route-First, Partition-Second method and add re-optimization process with genetic algorithm. In this study, we set the different node densities in the same region and investigate the solution qualities of each method.

3 - A Generalization of the Pickup and Delivery Problem with Transshipment and Occasional Drivers

Zefeng Lyu, The University of Tennessee at Knoxville, Knoxville, TN, United States, Andrew Junfang Yu

A pickup and delivery problem with transshipment, occasional drivers, and predefined origins and destinations is presented. The occasional drivers are getting increasingly common but have yet been fully studied, especially when associated with predefined origin-destination pairs. Although some studies have retained the possibility of distinguishing starting and ending points, they have not evaluated it in experiments. We prove that it is more beneficial of allowing transshipment for the pickup and delivery problem when the drivers have different origins and destinations. A MIP model and a heuristic for large-scale instances are presented, which is a generalization of the existing model.

4 - A Parallel Large Neighborhood Search Algorithm for Vehicle Routing Problems with Asymmetric Costs

Keyju Lee, Korea Aerospace University, Goyang-City, Korea, Republic of, Junjae Chae, Younshik Chung

This study aims to solve capacitated vehicle routing problem with asymmetric costs. A Large Neighborhood Search (LNS) based algorithm is proposed. A nosing method that efficiently alters the closest customer node from each customer node is developed in the algorithm. The performance of the algorithm outperforms most open source VRP solvers in solving time and quality of solution.

5 - A Decision Making Tool for the Last Mile Delivery Strategy

Raghavan Srinivasan, North Dakota State University, Fargo, ND, United States, Joseph Gerard Szmerekovsky, Satpal Singh Wadhwa

Last mile delivery has experienced growing interest in utilizing the available capacity from logistics services offered by local people of a region, i.e. crowd logistics. The objective here is to provide a decision-making tool, to determine the optimal balance of deliveries by full time employees, part time employees, and crowd sourcing. A newsvendor type solution is derived for a stylized model incorporating seasonal demand, available capacity, and delivery cost to determine the optimal cost of last mile delivery using full time, part time and crowd sourcing logistics. A heuristic approach based on the stylized model is then provided to determine the optimal last-mile delivery strategy.

6 - Repair Crew Routing on Power Network Restoration

Bahar Cavdar, Texas A&M University, College Station, TX, United States, Qie He, Feng Qiu

We consider a power distribution network under disruption and study how to efficiently restore the power network where faults occur in some locations and result in outage over the network. Considering the dependencies between the power network and the road network, we develop a bi-directional dynamic programming-based solution method to minimize the total service disruption time for all customers.

■ MD46

CC Room 213D

In Person: Recent Advances in Optimization Software I

General Session

Chair: Hans Mittelmann, Arizona State University, Tempe, AZ, 85287-1804, United States

1 - Latest Developments in the Artelys Knitro Optimization Solver

Richard Waltz, Artelys, Los Angeles, CA, 90045-2603, United States

Artelys Knitro is the premier solver for nonlinear optimization problems. Knitro offers both interior-point and active-set algorithms for continuous models, as well as tools for handling problems with integer variables and other discrete structure. This talk will highlight the latest developments in Knitro, focusing on some of the recent advances in solving mixed-integer nonlinear problems. We will also present some Knitro results on large-scale models from various applications. In particular, we will highlight Knitro performance on a selection of large logistic regression models, and on large-scale optimal power flow models from the recent ARPA-E Grid Optimization 2 Competition.

2 - Latest Benchmark Results
Hans Mittelmann
Selected results from our optimization software benchmarks will be reported.

Monday, 4:30PM 6:00PM

■ ME01

CC Ballroom A / Virtual Theater 1

Hybrid QSR Best Refereed Paper Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Fugee Tsung, HKUST, Kowloon, Hong Kong

Chair: Kamran Paynabar, ISyE Georgia Tech, Atlanta, GA, 30332-0205, United States

1 - An Approach for Group and Individual Fairness in Federated Learning
Xubo Yue, University of Michigan, Ann Arbor, Ann Arbor, MI, 48105-2179, United States, Raed Al Kontar, Maher Nouiehed

2 - Partitioned Active Learning for Heterogeneous Systems
Cheolhei Lee, Virginia Tech, Blacksburg, VA, 24060, United States, Kaiwen Wang, Jianguo Wu, Wenjun Cai, Xiaowei Yue

3 - GPS: Gaussian Process Subspace Regression for Model Reduction
Ruda Zhang, The Statistical and Applied Mathematical Sciences Institute, Cary, NC, 27519, United States, Simon Mak, David Dunson

Subspace-valued functions arise in a wide range of problems, including parametric reduced order modeling (PROM). In PROM, each parameter point can be associated with a subspace, which is used for Petrov-Galerkin projections of large system matrices. Previous efforts to approximate such functions use interpolations on manifolds, which can be inaccurate and slow. To tackle this, we propose a novel Bayesian nonparametric model for subspace prediction: the Gaussian Process Subspace regression (GPS) model. This method is extrinsic and intrinsic at the same time: with multivariate Gaussian distributions on the Euclidean space, it induces a joint probability model on the Grassmann manifold, the set of fixed-dimensional subspaces. The GPS adopts a simple yet general correlation structure, and a principled approach for model selection. Its predictive distribution admits an analytical form, which allows for efficient subspace prediction over the parameter space. For PROM, the GPS provides a probabilistic prediction at a new parameter point that retains the accuracy of local reduced models, at a computational complexity that does not depend on system dimension, and thus is suitable for online computation. We give four numerical examples to compare our method to subspace interpolation, as well as two methods that interpolate local reduced models. Overall, GPS is the most data efficient, more computationally efficient than subspace interpolation, and gives smooth predictions with uncertainty quantification.

4 - Data-driven Pathwise Sampling Approaches for Online Anomaly Detection
Dongmin Li, University of Florida, Gainesville, FL, United States, Miao Bai, Xiaochen Xian

We propose a data-driven strategy for quick anomaly detection with Moving Vehicle-based sensors. We integrate statistical process control and mathematicaloptimization to monitor the system and adaptively sample from suspicious locations based on real-time data. We provide theoretical investigations and present its performance in a numerical study on wildfire detection.

■ ME02

CC Ballroom B / Virtual Theater 2

Hybrid Decision analytics in Electricity Markets

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Bruno Fanzeres,

Co-Chair: Nuran Cihangir, Pontifical Catholic University of Rio de Janeiro

1 - Approximation and Decomposition Techniques for Stochastic Energy and Reserve Scheduling: Algorithmic Efficiency and Pricing
Nuran Cihangir Martin, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil, Bruno Fanzeres dos Santos

This work evaluates the computational performance, solution quality, convergence features and pricing under Sample Average Approximation as well as Benders decomposition and Lagrangian-based relaxations applied to an energy and reserve scheduling problem. Characterized by non-convex unit commitment decisions, this stochastic mixed-integer programming problem entails a large number of scenarios and technical parameters inducing a high computational burden. Decomposition and approximation techniques increase solution efficiency and convex relaxations enable the derivation of marginal cost of energy and reserve, with each method depicting varied solution quality and convergence.

2 - Hydropower Scheduling by Use of SDDP Treatment of State-dependent Constraints
Arild Helseth, SINTEF Energy Research, Trondheim, Norway

We study a specific and challenging type of state-dependency within the framework of stochastic dual dynamic programming (SDDP) applied to hydropower scheduling. For environmental purposes, the maximum allowed discharge from hydropower stations may be limited depending on the state variables (reservoir level and inflow), reducing the hydropower flexibility. From a mathematical point of view, such state-dependent limits introduce a discontinuity that is not straightforward to embed in the SDDP algorithm. We report on the results from numerically testing a set of possible solution strategies.

3 - Multi-Stage Modeling with Recourse for Solving Stochastic Complementarity Problems with an Application In Energy
Pattanun Chanpiwat, Graduate Student, University of Maryland, College Park, MD, United States, Steven A. Gabriel

The intermittency of the variable renewable energy in power generation could be mitigated using energy storage systems. This project concerns utilizing battery storage for the implementation of renewable energy technologies in the electricity market from multiple perspectives of uncertainty. We have developed multi-stage modeling with recourse decisions for solving stochastic complementarity problems with an application in energy. The model is based on a Nash-Cournot formulation of imperfect competition among power producers. This energy system optimization modeling, based on game theory and energy market equilibria, is expected to provide great insights for energy market planners.

4 - Contextual Merit-order Dispatch under Uncertain Supply
Miguel Ángel Muñoz Diaz, PhD Student, University of Malaga, Malaga, Spain, Juan Miguel Morales, Salvador Pineda

We consider a forward (e.g., day-ahead) electricity market with uncertain supply, where production quantities are dispatched following a merit order based on marginal production costs. Unlike the traditional practice of using the forecast value of the supply to clear the market, in this talk, we introduce a procedure to find the estimate of the supply (generally different from its expected value) that leads to the most cost-efficient dispatch taking into account the subsequent real-time operation of the power system. This procedure utilizes the forecast supply as the context and exploits a novel bilevel framework for decision-making under uncertainty with contextual information.

■ ME03

CC Ballroom C / Virtual Theater 3

Hybrid Matching Markets

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Thayer Morrill, North Carolina State University, Raleigh, NC, 27695, United States, United States

1 - Matching and Money
Ravi Jagadeesan, Stanford University, Stanford, CA, United States, Alexander Teytelboym

We study the implications of budget constraints for matching with contracts. We assume preferences satisfy net substitutability: i.e, if a price of a good increases, then buyers (resp. sellers) who minimize the cost of obtaining a given level of utility will buy (resp. sell) more (resp. less) of other goods. Net substitutability coincides with gross substitutability for quasilinear preferences, but is strictly weaker otherwise. If agents have sufficient incomes for hard budget constraints not to bind, stable outcomes exist and coincide with competitive equilibrium outcomes. Otherwise, competitive equilibria can fail to exist, but stable outcomes exist and coincide with quasiequilibrium outcomes. Stable outcomes are weakly Pareto-efficient, but do not form a lattice or satisfy a Lone Wolf Theorem. Our results suggest a new scope for matching with budget constraints.

2 - Ranking Objects That Rank Back
Thayer Morrill, North Carolina State University, Raleigh, NC, 27695, United States

We consider ranking alternatives that are outcomes of a competitive process. Examples include students ranking colleges, doctors ranking residency programs, and academics ranking journals. We introduce a new approach based on desire. An object is desired if an agent prefers it to her outcome. We characterize the class of desirable rankings and argue that these rankings are superior to rankings based on revealed preference.

3 - Interview Hoarding
Vikram Manjunath, Thayer Morrill

Many centralized matching markets are preceded by interviews between the participants. We study the impact on the final match of an increase in the number of interviews for one side of the market. Our motivation is the match between residents and hospitals where, due to the COVID-19 pandemic, interviews for the 2020-21 season of the National Residency Matching Program were switched to a virtual format. This drastically reduced the cost to applicants of accepting interview invitations. However, the reduction in cost was not symmetric since applicants, not programs, previously bore most of the costs of in-person interviews. We show that, starting from a situation where the final matching is stable, if doctors can accept more interviews, but the hospitals do not increase the number of interviews they offer, then no doctor is better off and many doctors are potentially harmed. This adverse consequence is the result of what we call interview hoarding. We prove this analytically and characterize optimal mitigation strategies for special cases. We use simulations to extend these insights to more general settings.

4 - The College Portfolio Problem
Ran Shorrer, Penn State University, State College, PA, 16802, United Statesm, S. Nageeb Ali

A college applicant faces the following risky choice: she applies to a portfolio of colleges while being uncertain about which school would admit her. Admissions decisions are correlated insofar as being rejected by a lower ranked school may imply that she is rejected by a higher ranked school. We show that solutions to this decision problem involve applying to a combination of reach, match, and safety schools. When application costs decrease, a college applicant broadens the range of schools to which she applies by including both those that are more selective and those that are safer options.

■ ME04

CC Ballroom D / Virtual Theater 4

Hybrid JFIG Paper Competition

Sponsored: Junior Faculty Interest Group

Sponsored Session

Chair: Alice E. Smith, Auburn University, Auburn, AL, 36849, United States

Co-Chair: Dorit Simona Hochbaum, University of California-Berkeley, Berkeley, CA, 94720-1777, United States

Co-Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24061-1019, United States

■ ME05

CC Ballroom E / Virtual Theater 5

Hybrid PSOR Best Paper Award

Sponsored: Public Sector OR

Sponsored Session

Chair: Justin J. Boutilier, University of Wisconsin-Madison, Madison, WI, 53706-1603, United States

Co-Chair: Somya Singhvi, Massachusetts Institue of Technology, Cambridge, MA, 02139, United States

Co-Chair: Yanchong (Karen) Zheng, Massachusetts Institute of Technology, Cambridge, MA, 02142-1508, United States

1 - Off-Grid Lighting Business Models to Serve the Poor: Evidence From a Structural Model and Field Experiments in Rwanda
Serguei Netessine, The Wharton School, Philadelphia, PA, United States, Bhavani Shanker Uppari, Ioana Popescu, Rowan P. Clarke

A significant proportion of the world's population does not have access to grid-based electricity. Rechargeable lamp-based technology is becoming prominent as an alternative off-grid lighting model in developing countries. We explore, in close collaboration with Nuru Energy in Rwanda, the consumer behavior and the operational inefficiencies that result under this model. Specifically, we are interested in measuring the impact of inconvenience along with the impact of liquidity constraints on lamp usage, and evaluating the efficacy of strategies that address these factors. Our undertaking has implications for both firm-level operational decisions and government-level policy decisions.

2 - Deploying a Reinforcement Learning System for COVID-19 Testing at the Greek Border
Kimon Drakopoulos, University of Southern California, Los Angeles, CA, 90305-1028, United States

Abstract not available

3 - COVID-19: Prediction, Prevalence and the Operations of Vaccine Allocation
Georgia Perakis, Massachusetts Institute of Technology, Belmont, MA, 02478-1706, United States

Abstract not available

4 - Unmasking Human Trafficking Risk in Commercial Sex Supply Chains with Machine Learning
Pia Ramchandani, University of Pennsylvania, Philadelphia, PA, 19104, United States, Hamsa Bastani, Emily Wyatt

Abstract not available

■ ME06

CC Room 303A

In Person: Operations Research & Vulnerable Populations

General Session

Chair: Jiayi Lin, College Station, TX, 77845, United States

1 - Designing Policies for Allocating Housing to Persons Experiencing Homelessness
Bill Tang, University of Southern California, Los Angeles, CA, United States, Phebe Vayanos, Cagil Kocyigit

We study the problem of allocating scarce housing resources of different types to individuals experiencing homelessness based on their observed covariates. Our goal is to leverage administrative data collected in deployment to design an online policy that maximizes mean outcomes while satisfying budget requirements. We propose a policy in which an individual receives the resource maximizing the difference between their mean treatment outcomes and the resource bid price, or roughly the opportunity cost of using a resource. Our approach has nice asymptotic guarantees and is easily interpretable. We evaluate it on synthetic and real-world Homeless Management Information System data to illustrate practical usage of our methodology.

2 - Client-Volunteer Relationships and Satisfaction in a Non-Profit Organization: The Case of Meals on Wheels Atlanta
Shikha Safaya, Georgia Institute of Technology, Atlanta, GA, United States, Basak Kalkanci, Ravi Subramanian

We partner with Meals on Wheels Atlanta, a non-profit organization providing meals and personal interactions to seniors who have limited mobility and are food insecure. We examine how key factors related to service design, including service frequency and duration, contribute to satisfaction of seniors and volunteers and ensure high service quality and sustained volunteer engagement.

3 - Targeted Mass Screening under Limited Testing Capacity with Application to Covid-19
Jiayi Lin, Texas A&M University, College Station, TX, United States, Hrayer Aprahamian

Mass screening is an essential tool that arises in various settings, e.g., the ongoing COVID-19 pandemic. The objective is to classify subjects as positive or negative for an infectious disease as efficiently and accurately as possible. Under limited testing capacity, administrators must target those among the population who need to be screened the most. This work aims to address this decision problem by taking advantage of population-level risk information in order to identify the optimal subset of subjects to screen. We consider two models: (i) individual testing, and (ii) group testing. We solve the resulting optimization problems to global optimality through a parameterized reformulation scheme. Our case study on real COVID-19 risk data reveals substantial benefits over conventional methods, highlighting the importance of data-driven informed policies.

4 - Designing School Choice for Diversity in the San Francisco Unified School District
Katherine L. Mentzer, Stanford University, Stanford, CA, 94305, United States, Irene Yuan Lo, Itai Ashlagi, Maxwell Allman

Prompted by a redesign of the San Francisco Unified School District (SFUSD) school choice system, we explore how choice mechanisms affect tradeoffs between choice, diversity, and other school district goals. We used simulations combining zone optimization with choice to propose new assignment policies. We found that zones must be designed with choice, as choice can lead to resegregation of diverse zones. However, well-designed zones combined with minority reserves could attain SFUSD diversity goals, as well as other district objectives such as predictability and proximity. In SFUSD, traditional school choice tools such as priorities can also attain diversity goals and provide choice, at the expense of predictability and proximity. Based on our findings, we recommended a policy of medium zones and reserves that was approved by the SFUSD Board of Education.

■ ME07

CC Room 303B

In Person: Emerging Topics in Supply Chain

General Session

Chair: Woonam Hwang, University of Utah, Salt Lake City, UT, 84112-8939, United States

Co-Chair: Anyan Qi, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

Co-Chair: Andre Du Pin Calmon, Scheller College of Business, Georgia Institute of Technology, Atlanta, GA, 30308, United States

1 - Strategic Overcapacity in Live-streaming Platformselling

Anyan Qi, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Suresh P. Sethi, Liqun Wei, Jianxiong Zhang

We study the capacity investment strategy of a manufacturer who sells his product on a live-streaming shopping platform. The manufacturer first decides the production capacity, then the platform decides her commission, and finally the manufacturer sets the retail price. The platform has an informational advantage about the product demand due to proximity to the market and accessibility to the sales data of similar products. The manufacturer without a direct access to the demand information tries to infer it from the commission decision of the platform, which results in a signaling game. Interestingly, the manufacturer may strategically install a strictly higher capacity than any demand to be realized. The overcapacity also benefits the manufacturer by driving down the commission charged by the platform when observing a small market potential due to the signaling effect.

2 - Competition and Innovation

Zhibin (Ben) Yang, Universtiy of Oregon, Eugene, OR, 97403-1205, United States, Jie Ning

We study strategic interaction between an innovation-leader firm and a follower firm that both sell to and compete in the same market. The follower firm is less innovative and has the option to source from the leader firm. We analyze a multi-stage game and characterize the Sub-game Perfect Nash Equilibrium.

3 - Ambulance Platforms to Improve Response Times for Emergency Calls In Developing Countries

Pieter van den Berg, Rotterdam School of Management, Erasmus University, Rotterdam, 3062 PA, Netherlands

Many developing countries lack the infrastructure for emergency response of the developed world. Often, the problem is not the lack of capacity, but the lack of coordination. To solve this coordination problem, multiple companies, for example Flare in Kenia and StanPlus in India, have started ambulance platforms to bring together demand and supply for emergency care. We study how the operational process of these platform services differs from traditional EMS providers and help to improve the service level of these companies.

■ ME08

CC Room 303C

In Person: SpORts IV

General Session

Chair: Nils Rudi, Yale School of Management, New Haven, CT, 06511, United States

1 - Determining Expected Win Percentage in the Indian Premier League

Aaron Bradley Hoskins, California State University, Fresno, CA, 93710, United States

The Indian Premier League (IPL) is the most lucrative professional cricket league in the world. This research investigates determining the expected winning percentage of a team in the league based on underlying team performance measures.

2 - Predicting Postseason Success in Major League Baseball using Data Envelopment Analysis

Christopher Gaffney, Associate Clinical Professor, Drexel University, Philadelphia, PA, United States

Translating in-season performance to post-season success is a well-known issue in professional sports. While there are several well-known methods to predict regular season performance in Major League Baseball, postseason prediction is made more difficult by the increased variability that comes with a compressed schedule. In this paper we use data envelopment analysis to study the impact of efficient resource utilization on postseason performance.

3 - Optimal Character Selection in DND

Michael A. Perry, Fresno State University, Fresno, CA, United States, Aaron Bradley Hoskins

The research uses a Monte Carlo simulation to determine character survival rate in a typical one day of adventuring in Dungeons and Dragons. The Duelist Algorithm is used as an outer loop to optimize the survival rate of the adventuring party. Comparisons to other metaheuristics are also provided.

4 - Soccer Penalty Shootouts: Network Analysis and Performance Mechanisms

Nils Rudi, Yale School of Management, New Haven, CT, 06511, United States

Modeling soccer penalty shootouts as a probability network facilitates analysis of several questions, including the impact of alternative sequences such as ABBA. I prove several properties of this model that justify the underlying markov assumption. Using a large dataset of penalty shootouts, I study potential performance drivers and mechanisms combining the markov model and traditional econometrics.

■ ME10

CC Room 304B

In Person: Management of Service Systems

General Session

Chair: Wei Liu, University of North Carolina at Chapel Hill, United States

1 - Optimal Scheduling of Proactive Care with Patient Deterioration

Jing Dong, Columbia University, New York, NY, 10027-6945, United States, Yue Hu, Carri Chan

Healthcare systems are limited resource environment where scarce capacity is often reserved for the most critical patients. However, there has been a growing interest in the use of proactive care when a less urgent patient may become urgent while waiting. On one hand, providing service for patients when they are less urgent could mean that fewer resources are needed to serve them. On the other hand, utilizing limited capacity for patients who may never need the level of care in the future takes the resource away from the more urgent patients. To understand this tension, we propose a queueing model with two patient classes: moderate and urgent, and allow patients to change classes while waiting. We characterize how moderate and urgent patients should be prioritized for service when proactive care for moderate patients is an option.

1 - Joint Staffing and Admission Control Problem under Different Levels of Information

Wei Liu, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, Vidyadhar Kulkarni

We consider a joint staffing and admission control problem in a multi-server queueing system under three different levels of information, namely minimal, partial and full information about the state of the queueing system. Our major contribution lies in the combination of the admission control, staffing problem, and information levels. The system earns a unit reward from serving a customer if her queueing time is no more than a fixed threshold and each server costs a fixed amount per unit time. Under each information case, we derive the optimal admission policy and optimal staffing level by maximizing the profit. We also study the criterion of maximizing the revenue rate per server and show the connection between these two criteria in determining the optimal staffing level. Finally, we compare the system performance under different levels of information.

■ ME11

CC Room 304C

In Person: Market Design and Advances in Auction Design

General Session

Chair: Sasa Pekec, Duke University, Durham, NC, United States

1 - Revenue-Sharing Allocation Strategies for Two-Sided Media Platforms: Pro-Rata versus User-Centric

Sasa Pekec, Duke University, Durham, NC, United States

We consider a two-sided streaming service platform which generates revenues by charging users a subscription fee for unlimited access to the content, and compensates content providers (artists) through a revenue-sharing allocation rule. Platform users are heterogeneous in both their overall consumption and the distribution of their consumption over different artists. In addition to determining the platform optimal revenue allocation rule, we study two primary revenue allocation rules used by market-leading music streaming platforms — pro-rata and user centric. In the pro-rata rule artists are paid proportionally to their share in the overall streaming volume, while in the user-centric rule each user's subscription fee is divided proportionally among artists based on the consumption of that user. We characterize when these two allocation rules can sustain a set of artists on the platform and compare them from both the platform and artists perspectives. In particular, we show that, despite the cross-subsidization between low and high streaming volume users, pro-rata rule can be preferred by both the platform and the artists. We further show that the platform's problem of selecting an optimal portfolio of artists is NP-complete. However, building on duality theory, we develop a polynomial time algorithm which outputs a set of artists so that the platform profit is within a single artist revenue from the optimal profit. Furthermore, for a platform that uses pro-rata or user-centric rules, by establishing connections to Knapsack problem, we develop a Polynomial Time Approximation Scheme (PTAS) for the optimal platform profit.

2 - A Smarter Market to End Global Warming and How to Implement it

John F. Raffensperger, RAND Corp., Santa Monica, CA, 90405, United States

Existing emissions trading systems inhibit emissions but not warming per se. They give poor price signals, and require laws for implementation. To solve these problems, I propose (1) a single global double-sided "smart market" with constraints on warming for the next 150 years. Each auction gives prices for this range. Further, I propose (2) this market be started by a coalition of firms, with jurisdictions joining as they are ready. Firms must require their suppliers to join. The proposed rules and implementation path appear to incentivize a rush to join. This design appears to be closer to "first best," with a lower cost of mitigation, than any in the literature, while lowering the chance of catastrophe. A market simulation shows the error of static prices and "global warming potential" used in existing ETSs. An implementation simulation supports the participation analysis.

■ ME12

CC Room 304D

In Person: Forecasting/Accounting and Nonlinear Programming

Contributed Session

Chair: Kaizhao Sun, Georgia Institute of Technology, Atlanta, GA, 30318, United States

1 - New Product Life-cycle Forecasting With Temporal Hierarchies

Oliver Schaer, University of Virginia, Charlottesville, VA, United States, Nikolaos Kourentzes, Douglas Thomas

Extending life-cycle curves to capture seasonality can substantially increase model complexity and complicate the estimation of model parameters. To address these issues, we suggest using temporal hierarchies that use optimal suited time-series models at each aggregation level to extract model structure and subsequently combine it to increase predictive accuracy. For example, fitting a diffusion model at the quarterly level, with a long term focus, and a seasonal exponential smoothing model at the weekly level, with a short term focus. Combining these hierarchically results in a prediction that retains both aspects. We evaluate our approach on life-cycle data from a computer manufacturer.

2 - Time Series Forecasting for Equity Valuation Using Accounting Data

Lukas Benjamin Heidbrink, Bielefeld University, Bielefeld, Germany

Companies and investors need to forecast accounting data in a variety of cases, such as equity valuation and cash flow forecasting, or due to regulators requirements. I evaluate modeling alternatives in equity valuation and profitability forecasting given the nonstationary nature of many variables, focusing on the value relevance of accrual and cash basis accounting measures. Thus, I utilize classic multivariate time series models, error correction models and different artificial neural networks to test their predictive performance empirically and improve valuations.

3 - Polyhedral Relaxations for Nonlinear Univariate Functions

Kaarthik Sundar, Los Alamos National Laboratory, Los Alamos, NM, United States

This talk will present linear programming and mixed-integer linear programming relaxations for the graph of a univariate, bounded, nonlinear function f(x) that converge to its convex hull and the its graph, respectively. Theoretical convergence guarantees and rates of convergence will be discussed. Efficacy of utilizing these relaxations in global optimization algorithms to solve Mixed Integer Non-Linear Programs (MINLPs) will be shown. Furthermore, we will also show techniques to use these relaxations to build convex relaxations for non-linear on-off constraints.

4 - Algorithms for Difference-of-Convex Programs Based on Difference-of-Moreau-Envelopes Smoothing

Kaizhao Sun, Georgia Institute of Technology, Atlanta, GA, United States, Xu Andy Sun

We consider minimization of a difference-of-convex (DC) function with and without linear constraints. We first study a smooth approximation of a DC function termed difference of Moreau envelopes (DME), which captures geometric properties of the original function and enjoys some growth conditions. Then we show that the gradient descent method and an inexact variant converge on the DME and deliver a stationary solution of the original DC function. Furthermore, when the minimization is constrained in an affine subspace, we proposed two variants of the augmented Lagrangian method based on DME, which allow a nonsmooth concave component in the objective compared to the literature.

■ ME13

CC Room 201A

In Person: Multi-agent Learning in Games

General Session

Chair: Chamsi Hssaine, Cornell University, Los Angeles, CA, 90025-5692, United States

1 - Finite-time Last-iterate Convergence for Multi-agent Learning in Games

Tianyi Lin, University of California, Berkeley, Berkeley, CA, 94720-2502, United States, Zhengyuan Zhou, Panayotis Mertikopoulos, Michael Jordan

We consider multiagent learning via online gradient descent in a class of games called cocoercive games, a fairly broad class of games that admits many Nash equilibria and that properly includes unconstrained strongly monotone games. We characterize the finite-time lastiterate convergence rate for joint OGD learning; further, building on this result, we develop a fully adaptive OGD learning algorithm that does not require any knowledge of problem parameter and show, via a novel double-stopping time technique, that this adaptive algorithm achieves same finite-time last-iterate convergence rate as non-adaptive counterpart. We extend OGD learning to the noisy gradient feedback case and establish last-iterate convergence results first qualitative almost sure convergence, then quantitative finite-time convergence rates all under nondecreasing step-sizes.

2 - Algorithmic Collusion: Supra-competitive Prices via Independent Algorithms

Mallesh Pai, University of Pennsylvania, Philadelphia, PA, 19104, United States

We study outcomes when competing sellers use machine learning algorithms to set prices while ignoring competitors' prices. We show that the long-run prices depend on the informational value of price experiments: if low, these prices are consistent with the static Nash equilibrium of the full information setting. If high, these prices are supra-competitive—-the joint-monopoly outcome is possible. We show a novel channel: competitors' algorithms end up running correlated experiments. Therefore, sellers' misspecified models overestimate own price sensitivity, resulting in higher prices.

■ ME14

CC Room 201B

In Person: Data-Driven Smart Transportation and Shared Mobility

General Session

Chair: Amirmahdi Tafreshian, University of Michigan, Ann Arbor, MI, 48109-2125, United States

Co-Chair: Hao Yan, Tempe, AZ, 85281-3673, United States

1 - A Generalized Fluid Model of Ride-Hailing Systems

Zhengtian Xu, The George Washington University, Washington, DC, 48105-2540, United States, Yafeng Yin, Xiuli Chao, Hongtu Zhu, Jieping Ye

This study proposes a macroscopic fluid modeling framework to assist with strategic decision making of a platform for operating a large-scale on-demand app-based ride-hailing system. The framework captures the spatiotemporal characteristics of a ride-hailing system, and is flexible in representing control policies that a platform is implementing. It thus enables the analysis of a large-scale ride-hailing system with observable market responses and facilitates the optimization of the control polices. As a demonstration of the proposed framework, we customize it for a ride-hailing system operated by Didi Chuxing in a large city of China, and conduct an empirical study of the system. To our best knowledge, the proposed model is the first of its kind that offers a tractable way to support the analysis and optimization of large-scale ride-hailing systems.

2 - A Truthful Subsidy Scheme for Peer-to-peer Ridesharing Markets with Incomplete Information

Amirmahdi Tafreshian, University of Michigan, Ann Arbor, MI, 48109-2125, United States, Neda Masoud

Traffic congestion during peak periods has become a serious issue around the world, which is mainly due to the high number of single-occupancy commuter trips. Ridesharing platforms can present a suitable alternative for serving commuter trips. However, they face a major obstacle that prevents them from being a viable mode of transportation in practice; The users often provide tight time windows, which ultimately leads to a low matching rate. This study addresses this issue by introducing a subsidy scheme that allocates incentives to encourage a few carefully selected set of travelers to change their travel behavior. In order to implement this scheme for a ridesharing platform in the existence of private information, we propose an auction-based mechanism that guarantees truthfulness, individual rationality, budget-balance and computational efficiency.

3 - Network-level Impacts of Connected and Autonomous Vehicles on Traffic Congestion and Emission in a Mixed Traffic Environment

Ehsan Kamjoo, Michigan State University, East Lansing, MI, United States, Fatemeh Fakhrmoosavi

While many studies in the literature have investigated the impacts of connected vehicles (CV) and autonomous vehicles (AV) on traffic congestion and emission at the facility level, little is known about these impacts at large scales. Furthermore, there are uncertainties in the values of different parameters associated with these impacts, such as the extra vehicle-miles of traveled induced by AVs, technology cost of these vehicles, and possible reductions in the value of time of AV users, which have not been explored. Therefore, this study develops a stochastic framework and an algorithm to find the optimum market shares of CVs and AVs in a mixed traffic environment, consisting of human-driven vehicles without connectivity, CVs, and AVs, minimizing the system cost. Emission, travel time, and technology costs are considered as components of the system cost.

4 - Graph Based Approach to Real Time Metro Passenger Anomaly Detection

Weiqi Zhang, Hong Kong University of Science and Technology, Hong Kong, Hong Kong

Real-time anomaly detection of passenger flows in the metro system is very important to maintain the metro system's normal operation and ensure passengers' safety. We propose a novel abnormal passenger flow detection method based on smart card data. The method constructs a graphic model whose topological structure can capture the spatial distribution of anomalous passenger flow. It further incorporates external information (e.g. geographical information) to depict the latent passenger flow's spatial dependence. A detection statistic is constructed by using graph community detection, which can be used for further signal selection and noise filter. It can be efficiently solved via a Min-Cut-based algorithm and can provide real-time solutions to anomaly detection and diagnosis. Preliminary experimental results demonstrate the efficiency of our method.

5 - Public Transportation Analysis via Tensor Decomposition and Spectral Clustering

Nurettin Dorukhan Sergin, Arizona State University, Tempe, AZ, 85282-5544, United States, Hao Yan

Automated fare collection systems record millions of transactions every day in major cities. These transactions, when analyzed, yield tremendous insight to public transportation decision-makers. We propose a model that undertakes two important analyses: discovering station similarities and detecting rare events in terms of hourly passenger inflow into stations. Our method combines tensor decomposition with spectral clustering and trains on a spatiotemporal tensor. We present our findings on smart card data collected over several months from Hong Kong's subway system.

6 - A Macroscopic Model of Dockless Bike Sharing Systems

Hongyu Zheng, Northwestern University, Evanston, IL, United States, Kenan Zhang, Yu (Marco) Nie

This paper studies the design of a dockless bike sharing (DBS) system in a city using a parsimonious spatial model, in which the DBS service competes with walking and a generic motorized mode. Travelers choose one of the three modes according to their utility, which may depend on trip duration, access time and monetary cost. We show the access time to DBS is determined by the number of unique bike locations in the city, which is a function of the bike fleet size. The model defines a supply-demand equilibrium that may be controlled by choosing the service price and the fleet size of the DBS system. We calibrate the model against empirical data collected in Chengdu, China, and test three counterfactual strategies: (i) profit maximization; (ii) market share maximization with non-negative profit; and (iii) social optimum.

■ ME15

CC Room 201C

In Person: Advances in Reinforcement Learning and Applications

General Session

Chair: Sadjad Anzabi Zadeh, University of Iowa, Coralville, IA, 52241-2536, United States

1 - Optimal Dosing Protocol for Warfarin Using Deep Reinforcement Learning

Sadjad Anzabi Zadeh, University of Iowa, Coralville, IA, 52241-2536, United States

Warfarin is a widely used anti-coagulant with narrow therapeutic range that makes it hard to optimally determine the daily dose. We show that deep Q-learning method can solve this problem and find the optimal dose for different patients with varying responses to the medication. Since the method requires a large volume of data, we employ a PK/PD model to simulate patients' response to warfarin.

2 - Simple Agent, Complex Environment: Efficient Reinforcement Learning with Agent States

Shi Dong, Stanford University, Stanford, CA, United States

We design a simple reinforcement learning agent that, with a specification only of suitable internal state dynamics and a reward function, can operate with some degree of competence in any environment. We establish a regret bound demonstrating convergence to near-optimal per-period performance, where the time taken to achieve near-optimality is polynomial in the number of internal states and actions, as well as the reward averaging time of the best policy within the reference policy class, which is comprised of those that depend on history only through the agent's internal state. Notably, there is no further dependence on the number of environment states or mixing times associated with other policies or statistics of history.

■ ME16

CC Room 201D

In Person: Participatory Specification of Trustworthy Machine Learning

General Session

Chair: Katia Guerra, University of North Texas, Flowermound, TX, 75028, United States

1 - Paving an Intentional Path Towards Inclusive Practices in AI Development

Tina M. Park, Research Fellow (Methods for Inclusion), Partnership on AI, San Francisco, CA, United States

Partnership on AI believes that working with communities affected by the deployment of AI/ML technologies is integral to their responsible development and mitigation of harm. To deepen our understanding of how inclusive public engagement approaches can help developers and researchers, PAI launched the Methods for Inclusion project. Multidisciplinary in nature, Methods for Inclusion draws from fields outside of computer science and technology, such as public planning & policy, education, public health, sociology, and community organizing which have grappled with questions of participation and inclusion for many decades. Drawing on semi-structured interviews with developers, data scientists, and researchers, as well as community advocates, the project explores the challenges present in conducting participatory design processes inclusively and equitably.

2 - Fair Performance Metric Elicitation

Gaurush Hiranandani, Student, UIUC, Urbana, IL, United States, Narasimhan Harikrishna, Oluwasanmi Koyejo

What is a fair performance metric? We consider the choice of fairness metrics through the lens of metric elicitation — a principled framework for selecting performance metrics that best reflect implicit preferences. The use of metric elicitation enables a practitioner to tune the performance and fairness metrics to the task, context, and population at hand. Specifically, we propose a novel strategy to elicit group-fair performance metrics for multiclass classification problems with multiple sensitive groups that also includes selecting the trade-off between predictive performance and fairness violation. The proposed elicitation strategy requires only relative preference feedback and is robust to both finite sample and feedback noise.

3 - Stochastic Optimization of Area under Precision-Recall Curve with Provable Convergence
Qi Qi, The University of Iowa, Iowa City, IA, United States, Tianbao Yang

In this work, we propose a principled technical method to optimize area under Precision-Recall Curve (AUPRC) for deep learning. Our approach is based on maximizing the averaged precision (AP), which is an unbiased point estimator of AUPRC. We cast the objective into a sum of dependent compositional functions with inner functions dependent on random variables of the outer level. We propose efficient adaptive and non-adaptive stochastic algorithms with provable convergence guarantee under mild conditions by using recent advances in stochastic compositional optimization. Extensive experimental results on graphs and image datasets demonstrate that our proposed method outperforms prior methods on imbalanced problems. To the best of our knowledge, our work represents the first attempt to optimize AUPRC with provable convergence.

4 - Safeguarding Data Privacy in the Era of Artificial Intelligence
Kwan-Yuet Ho, United States

Because knowing individuals' preferences is a lucrative business, personalization has become a common task among data science teams in various commercial and government sectors. The inevitable use of personal data puts people's privacy at risk. Some hackers might simply steal the data illegally. Some employees who are working on the data and machine learning models might make inappropriate use of the data for their own purpose. Sometimes even if the data are turned "anonymous," the use of artificial intelligence can sometimes reveal the identity of the individuals represented by the data. In this talk, I will talk about how to protect the privacy of everyone in three aspects: 1) the system architecture design; 2) the rule-based removal of the sensitive information; and 3) the use of machine learning models to further eliminate information about the individuals.

5 - Customers Privacy Protection Behaviors in E-commerce Transactions: The Role Of Privacy Concerns, Privacy Risks, and Privacy Policies.
Katia Guerra, University of North Texas, Denton, TX, United States, Vess Johnson

This research investigates the impact of information privacy concerns on the awareness of privacy risks and on the awareness of organizational privacy policies toward the adoption of customers' privacy protection behaviors in the context of e-commerce transactions. We develop a research model and we test it by employing a Qualtrics online survey questionnaire. We use crowdsourcing through Mechanical Turk to collect data. The contribution of this study is to shed the light on the mechanisms that lead consumers to take privacy protection behaviors rather than to interrupt e-commerce transactions in the light of privacy risks, on one side, and organizational privacy policies, on the other side.

■ ME17

CC Room 202A

In Person: Decision Models for Resilient Network Operations

General Session

Chair: Mathieu Dahan, ISyE Georgia Tech, Atlanta, GA, 30309, United States

1 - Network Inspection Against Strategic Attacks Using Heterogeneous Detectors
Bobak McCann, Georgia Institute of Technology, Atlanta, GA, United States, Mathieu Dahan

We consider a network inspection game, in which a defender positions heterogeneous detectors according to a probability distribution in order to detect multiple attacks caused by a strategic attacker. We assume the defender has access to multiple types of detectors that can potentially differ in their accuracy and cost. The objective of the defender (resp. attacker) is to minimize (resp. maximize) the expected number of undetected attacks. We provide a full analytical characterization of the Nash equilibria for this game under the assumption that each component in the network can be monitored from a unique detector location. Then, we determine the optimal detector investment for the defender that guarantees a target detection level in the worst case.

2 - Resilient Hyperconnected Intercity Parcel Delivery Network Design
Onkar Kulkarni, ISyE Georgia Tech, Atlanta, GA, United States, Yaarit Cohen, Mathieu Dahan, Benoit Montreuil

In this work, we study a tri-level optimization model to design a hyperconnected intercity parcel delivery network that is capable to withstand coordinated disruptions. In the first stage, hubs are positioned, and service routes are set up. Then, a fictitious adversary disrupts one or more routes. Finally, the flow of parcels is selected as to avoid the disruptions. The overall aim is to design a network that minimizes the total distance travelled by parcels after worst-case disruptions. We propose an approach to approximately solve this challenging problem by decoupling the first stage from the others. We validate our approach by designing networks across China, analyze their efficiency and resilience under various worst-case scenarios.

3 - A Study of Projection-free Gradient-based Algorithms for Zero-sum Linear Quadratic Games
Arnesh Sujanani, Georgia Institute of Technology, Atlanta, GA, United States, Vidya Muthukumar, Mathieu Dahan

Zero-sum linear quadratic games can be formulated as nonconvex-nonconcave min-max problems. Recent work has established that under certain conditions, stationary points of the objective are Nash equilibria. Furthermore, such work has established that projected nested gradient methods, under such assumptions, achieve global sublinear convergence to Nash equilibria. We build upon this work and study the landscape of gradient based algorithms for linear quadratic games. In particular, we study the convergence, or lack thereof, of projection-free gradient-based algorithms for linear quadratic games. Our analysis primarily relies on establishing conditions under which the updates of gradient-based algorithms remain stable.

4 - Operations Planning and Risk Management in Covid-19 Surveillance Testing Programs
Hannah Wilborn Lagerman, ISyE Georgia Tech, Atlanta, GA, United States, Mathieu Dahan, Pinar Keskinocak

The success of a surveillance testing program relies on managing risks which threaten to disrupt its operations. In this work, we aim to identify and mitigate such risks for Covid-19 testing laboratories that conduct pooled as well as diagnostic testing. Using machine learning and simulation, we quantify the laboratory's testing capacity, evaluate bottleneck improvements, and analyze laboratory's sensitivity to variability in supply chain conditions. We apply this approach to Georgia Tech's Covid-19 testing laboratory to improve its operations and inventory management as a function of disease positivity rate, pool size, and predicted testing demand.

■ ME18

CC Room 202B

In Person: Environmental Sustainability Analysis and Strategies

General Session

Chair: Xichen Sun, College Station, TX, 77845, United States

1 - Searching for the Synergy Between Environmental Sustainability and Economic Sustainability
Sidi Deng, Research Assistant, Purdue University, West Lafayette, IN, United States, Yuehwern Yih, John W. Sutherland

This presentation concentrates on the synergy between environmental sustainability and economic sustainability. The presenter will provide an overview of some innovative methodologies that incorporate environmental factors into the framework of economic evaluation. These methods fall into three categories, which will be introduced in three sections:(1) Integrating techno-economic assessment (TEA) and life cycle analysis (LCA) framework. An overview of a TEA template adopted by Purdue and The University of Arizona will be given.(2) Including external cost factors into the cost-benefit analysis. This section highlights a dynamic price model that analyzes the impact of environmental regulation/policies on the associated market.(3) A discussion on the relationship between economic growth and environmental sustainability.

2 - Process Optimization for Bioleaching Lithium-ion Batteries
Majid Alipanah, University of Arizona, Tucson, AZ, United States, Hongyue Jin, Qiang Zhou, Caitlin McNamara, Vicki Thompson, Yoshiko Fujita, David Reed

By 2040, end-of-life lithium-ion batteries (LIBs) are expected to reach approximately 8 million tonnes per year. Several critical materials found in LIBs, such as lithium, cobalt, and nickel, have limited resources and are mined in only a few countries. Bioleaching technology has the potential to recycle EOL LIBs in a cost-effective and environmentally friendly manner. This study tried to optimize the bioleaching process for value recovery from EOL LIBs through integrating techno-economic assessment and response surface methodology. The result of the optimization showed the economic feasibility of the process and the life cycle assessment showed its sustainability by the lower environmental footprint compared to other leaching methods

3 - On the Complementarity Between Servicizing and Remanufacturing: Economic and Environmental Implications
Xichen Sun, Texas A&M University, College Station, TX, United States, Rogelio Oliva, Tharanga Rajapakshe

The recent shift in customer demand from product ownership to other alternatives has motivated manufacturers to offer servicizing a business strategy that sells a product's functionality as a service. This trend is observed in the industries where remanufacturing is prevalent. Offering servicizing facilitates remanufacturing by providing a stable flow of high-quality returns, thus reducing remanufacturing-related costs. Further, servicizing can satisfy customer demand with reduced production, reinforcing remanufacturing's positive effect on the environment. To investigate these complementarities, we consider a profit-maximizing manufacturer who markets new and remanufactured products and explores the possibility of introducing servicizing. We develop stylized models that capture the main product attributes for remanufacturing and servicizing.

■ ME19

CC Room 203A

In Person: Deep Learning and Mechanism Design

General Session

Chair: Michael Albert, Assistant Professor, University of Virginia, Charlottesville, VA

1 - Auction Learning as a Two Player Game

Jad Rahme, Princeton University, Princeton, NJ, United States, Sami Jelassi, S. Matthew Weinberg

Designing an incentive compatible auction that maximizes expected revenue is a central problem in Auction Design. While theoretical approaches have hit some limits, a recent research direction initiated by Duetting et al. (2019) consists in building neural network architectures to find optimal auctions. We propose two conceptual deviations from their approach. First, we introduce a time-independent Lagrangian inspired by recent results in auction design theory. Second, we amortize the optimization procedure used in previous work to compute optimal misreports with the introduction of an additional neural network. We show the effectiveness of our approach by learning competitive or strictly improved auctions compared to prior work. Both results together further imply a novel formulation of Auction Design as a two-player game with stationary utility functions.

2 - Deep Learning for the Automated Design of Two-sided Matching Markets

Sai Srivatsa Ravindranath, Harvard University, Cambridge, MA, United States, Zhe Feng, Shira Li, Jonathan Ma, Scott Kominers, David C. Parkes

Economic theory provides the celebrated deferred acceptance mechanism for the design of a stable, two-sided matching mechanism that is also strategy-proof on one side of the market. At the same time, it is provably impossible to achieve both stability and strategy-proofness simultaneously. But there is little understanding in regard to how to navigate the necessary tradeoffs between these two properties. In this talk, we demonstrate how deep neural networks can be used for the automated, data-driven design of matching mechanisms that strike new tradeoffs between stability and incentive alignment, expanding the efficient frontier and suggesting new targets for economic theory.

3 - Certifying Strategyproof Auction Networks

Michael J. Curry, University of Maryland, College Park, MD, United States

The design of strategyproof, revenue-maximizing auctions is a classic goal of mechanism design, but in multi-agent, multi-item settings, progress has been very limited. This has motivated attempts to train deep neural networks to approximate optimal auctions. These approaches work well empirically. However, there is no way to be completely sure that they are actually strategyproof. By drawing connections between strategyproofness and adversarially robust machine learning, we devise a modified auction architecture for which it is possible to compute exact, tight certificates on the degree to which strategyproofness is violated for a given bid profile. We find that our approach is effective, though scalability could be improved, and that gradient-based approximations do underestimate the extent of violations.

4 - Provable Lower Bounds for Black Box Mechanism Design

Michael Albert, Assistant Professor, University of Virginia, Charlottesville, VA, 22903-1416, United States, Minbiao Han

The field of mechanism design has had significant success in constructing optimal mechanisms to allocate resources when there are information asymmetries. However, there are many situations under which no optimal mechanism is known, leading to the adoption of black box optimizers, such as deep neural networks, to learn good mechanisms. However, these learned mechanisms only approximately satisfy traditional mechanism design guarantees, such as incentive compatibility. Given that these mechanisms fail traditional mechanism design guarantees, they cannot guarantee any lower bound on their performance. In this work, we present a procedure where by having sample access to a mechanism we can prove a lower bound on the performance. Moreover, we develop new techniques to construct mechanisms using deep neural networks that provide good lower bounds on the performance.

■ ME20

CC Room 203B

In Person: OR for Equity in Health and Society

General Session

Chair: Caleb Bugg, University of California-Berkeley, Berkeley, CA, 94704, United States

1 - Applications Of Nonnegative Tensor Completion Via Integer Optimization

Caleb Bugg, University of California-Berkeley, Berkeley, CA, 94720, United States

There is an unresolved tension in the literature on tensor completion. One set of approaches has polynomial-time computation but requires exponentially more samples than the information-theoretic rate, whereas another set of approaches achieves the information-theoretic rate but requires solving NP-hard problems for which there are no known numerical algorithms to compute global minima. This paper resolves this tension for nonnegative tensors by developing a numerical algorithm that provably converges to a global minima in a linear (in numerical tolerance) number of oracle steps while achieving the information-theoretic rate. We then show the usefulness of our algorithm on health-related data.

2 - Persistent Inequities and Systemic Racism

Jonathan W. Welburn, RAND Corporation, Santa Monica, CA, 90401, United States

Persistent inequities and systemic racism have resulted in the current American disparity where Black households hold a tenth the wealth of their white peers. Calls for reparations from have regained significant attention as a solution for addressing the harms of slavery and of the de jure segregation and institutionalized discrimination that followed. We introduce a microsimulation model of intergenerational wealth to analyze the potential impact of policy interventions, from reparations to baby bonds, and their affect on the Black-white wealth gap.

■ ME21

CC Room 204A

In Person: Valuing External and Collaborative Innovation

General Session

Chair: Zeya Wang, PhD Student, Atlanta, GA, 30308-1192, United States

1 - Leveraging the Potential of Outsourcing and Offshoring in Complex Product Development

Ole Frauen, Volkswagen AG, Wolfsburg, 38100, Germany, Arnd H. Huchzermeier, Jurgen Mihm

Leveraging the potential of outsourcing and offshoring remains a major challenge in complex product development. It is a question about effectively decomposing and distributing work across geographical and organizational boundaries while providing high quality products. The decisions must clearly depend on the product's characteristics and the emerging collaborative network. The conducted study is based on an extensive data set involving all development projects of one of the largest car manufacturers worldwide. We demonstrate that a precise distinction between outsourcing and offshoring, as well as the introduction of a network perspective, are crucial to evaluate the effects in more detail.

2 - An Entrepreneur's Innovation Dilemma: Learning-financing Tradeoff at Lean Startups

Onesun Steve Yoo, University College London, London, United Kingdom, K Sudhir

Using a Bayesian learning model of lean startup and a Nash bargaining game between the investor and entrepreneur, this paper examines entrepreneur's trade-off between optimizing learning for the startup's success relative to the need to convey market potential by producing observable success signal for early-stage investors. We find that depending on the entrepreneur's relative bargaining position, the entrepreneur may distort product development downwards or upwards to sacrifice learning relative to the one prescribed in the Lean startup method. The two types of distortions differently impact the innovation efficiency and innovation output. We examine how they could be mitigated and collectively improve the innovation economy.

3 - Optimal Presentation of Alternatives

Zeya Wang, Georgia Institute of Technology, Atlanta, GA, United States, Morvarid Rahmani, Karthik Ramachandran

In many contexts such as healthcare, knowledge outsourcing, or product design and development, a provider may have multiple alternatives that could potentially solve the client's problem. A key decision for the provider is: how to present these alternatives to a client? In this paper, we develop a game-theoretic model where the provider chooses which alternative to present and in what sequence, and the client chooses which alternative to implement. We characterize the optimal strategies for the provider in equilibrium to determine which alternative the provider should offer and when to offer it. We study the effects of implementation ability, asymmetric implementation cost and correlation between options on these strategies.

■ ME22

CC Room 204B

In Person: Healthcare Analytics in Action: Using Data-driven Models to Effect Change

General Session

Chair: Retsef Levi, MIT, Cambridge, MA, 02142-1320, United States

Co-Chair: Taghi Khaniyev, MIT Sloan School of Management, Cambridge, MA, 02142-1508, United States

1 - Optimal Resource Pooling for Effective Use of Future Operating Room Capacity

Seung-Yup Lee, Vanderbilt University Medical Center, Nashville, TN, 37212, United States, Vikram Tiwari

We investigate the optimal timing for release of unfilled operating room (OR) block capacity to improve the efficiency and effectiveness of OR use. A Markov decision process structure is designed that incorporates not only the number of remaining days until the day of surgery but also the remaining capacity of the OR block as well as historical demand for the block. In this presentation, we propose the decision-making modeling structures for both the single- and multi-OR block cases and discuss the applicability of the resulting polices in practice and expected improvements. Our results provide insights into pursuing proactive management of pooling limited resources in the healthcare setting where both system-wide efficiency and specialty-specific characteristics of resources should be considered.

2 - A Prescriptive Approach to Surgical Inpatient Discharges

Taghi Khaniyev, MI T. Sloan School of Management, Cambridge, MA, 02142-1508, United States, Kyan Safavi, Martin Copenhaver, A. Cecilia Zenteno, Bethany Daily, Peter Dunn, Retsef Levi

We first trained a neural network model to accurately predict next-day's inpatient discharges using structured EHR data which was represented based on whether it indicated a clinical or administrative barrier to discharge which was defined as an event that may postpone the patient's discharge. Discharge predictions were categorized as NO/MAYBE/YES. An optimization model was developed to select the minimal subset of barriers for each patient that need to be resolved in order to move a patient to YES category. This minimal list was intended to serve as a prioritized action list for each patient. When we augmented the prediction model with free-text clinical notes using a recurrent neural network, the prediction accuracy was improved by up to 20%.

■ ME24

CC Room 205A

In Person: Emerging Topics in Sustainable Operations

General Session

Chair: Adem Orsdemir, University of California-Riverside, Riverside, CA, 92521-9800, United States

1 - Is Adopting Mass Customization a Path to Environmentally Sustainable Fashion?

Adem Orsdemir, University of California-Riverside, Anderson Riverside, CA, 92521-9800, United States, Aydin Alptekinoglu

In high-product-variety businesses like fashion, mass production systems create environmental waste in the form of overproduction on a colossal scale. Mass customization has been proposed — without solid evidence — as a solution. In this paper, we analyze whether mass customization can indeed offer a win-win solution that helps both the bottom line and the environment. We also study the impact of three real policy options: promoting mass customization, charging a disposal fee for overproduction, and recycling.

2 - How Does Physical Access Affect Emergency Department Utilization? Evidence From Insurance Coverage Expansion

Eric Xu, University of Minnesota, Minneapolis, MN, 55455-0438, United States, Anant Mishra, Kevin Linderman

The Patient Protection and Affordable Care Act was an attempt to provide widespread insurance coverage. While the law's Medicaid Expansion provided individuals with a financial means, we find that the impact of physical accessibility, e.g. spatiotemporal characteristics, has a non-trivial impact on emergency department use. We also find that congestion at the nearest primary care clinic due to a post-enforcement increase in Medicaid managed care encounters represents an underlying mechanism affecting annual emergency department use.

3 - Empirical Investigation of Locational Demographics and Facility Emissions

Abhinav Shubham, PhD Student, Georgia Institute of Technology, Atlanta, GA, United States, Ravi Subramanian

Environmental Justice encapsulates the idea of fairness in protection for communities from environmental and health hazards, regardless of race, color, national origin, or income. It is relevant to the practice of OM in the form of inequities that result from disparate operational decisions or policies. The research question that we aim to address is: How disparate are facility-level emissions across communities with different racial makeups? To address this question, we draw data multiple sources. we address the confounding effects of pre-treatment factors through various methods to assess how facilities may differ in their emissions (outcome) between locations that differ in racial makeup. Our findings offer evidence for regulatory intervention and opportunities for firms to reconsider their ESG objectives with local considerations of fairness and equity.

■ ME25

CC Room 205B

In Person: Julia Packages for the Modeling and Solution of Optimization Problems

General Session

Chair: Joshua Pulsipher, University of Wisconsin Madison, United States

1 - Strengths of Approximations for Bipartite Bilinear Programs

Akshay Gupte, University of Edinburgh, Edinburgh, United Kingdom

We present theoretical analyses of some inner and outer approximations of a bipartite bilinear program. The outer approximations we consider are from standard methods such as Reformulation Linearisation Technique and Lagrange Duality. In particular, we give a combinatorial upper bound on the relative gap of the RLT to the optimum by showing that this gap is bounded by the chromatic number of a certain graph that is obtained from the co-occurrence graph of the problem. Secondly, we give a sufficient condition for the RLT or a lifting of it to be exact (i.e., relative gap of 1). Thirdly, we show that convexifying all the bilinear terms simultaneously over the domains of the variables is equivalent to taking a certain semi-Lagrangian of the problem. The combinatorial bound from the first result on RLT also allows us to bound the gap from a MIP inner approximation of the problem.

2 - InfiniteOpt.jl: A Unifying Abstraction for Infinite-Dimensional Optimization

Joshua Pulsipher, University of Wisconsin-Madison, Madison, WI, United States, Weiqi Zhang, Victor M. Zavala

Infinite-dimensional optimization problems are a challenging problem class that cover a wide breadth of optimization areas and embed complex modeling elements such as infinite-dimensional variables, measures, and derivatives. Typical modeling approaches (e.g., those behind Gekko and Pyomo.dae) often only consider discretized formulations and do not provide a unified paradigm across the various disciplines. We present InfiniteOpt.jl which facilitates a coherent unifying abstraction for characterizing these problems rigorously through a common lens. This decouples models from discretized forms and promotes the use of novel transformations. This new perspective encourages new theoretical crossover and novel problem formulations (creating new disciplines like random field optimization).

■ ME26

CC Room 206A

In Person: Packing and Scheduling

General Session

Chair: Christopher Muir, Georgia Institute of Technology, Atlanta, GA, United States

1 - Incremental Packing Problems
Lingyi Zhang, Columbia University, New York, NY, 10027-6702, United States, Yuri Faenza, Danny Segev

Incremental packing problems extend classical packing problems (like knapsack, stable set, generalized assignment, etc.) to a multi-period setting. In each period, we are allowed to pack a previously unpacked item (if there is enough capacity available), but are not allowed to unpack a previously packed item. In this talk, we present formulations and approximation algorithms for incremental packing problems via a reduction to a multi-machine scheduling problem, and we moreover investigate limits of using single-period techniques in the multi-period setting.

2 - Capacity Expansion in the College Admission Problem
Federico Bobbio, PhD Candidate, University of Montreal, Montreal, QC, Canada, Margarida Carvalho, Alfredo Torrico, Andrea Lodi

The college admission problem plays an important role in several real-world allocation mechanisms. In particular, the student-oriented deferred acceptance algorithm is known to produce a stable matching that is weakly preferred by every student. However, if an extra position is available in a single university, then a subset of the students would improve their allocations. This raises a natural question: To which universities should we allocate B extra positions in order to produce the best possible allocation for all the students? In this work, we study the expansion of the capacities in the college admission problem with strict and complete preferences. Our main contribution is twofold: First, we provide a theoretical understanding of the underlying mathematical structure of the problem; second, we propose an algorithmic approach to solve the problem.

3 - Submodular Interval Scheduling
Christopher Muir, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Alejandro Toriello

Given a set of jobs with fixed start/end times, fixed interval scheduling asks the decision maker to group the jobs into schedules such that jobs within a schedule do not overlap in time. The decision maker wants to minimize the sum of schedule costs. Submodular cost functions are commonly used as they model economies of scale; however, interval scheduling with submodular costs is NP-Hard. We propose a branch-and-price approach for submodular fixed interval scheduling. For some specific cost functions, we present efficient algorithms for solving the linear relaxation of the underlying column-generation model. We evaluate our approach using random instances and instances derived from cloud services applications. We show that branch-and-price is able to efficiently solve large instances, outperforming standard integer programming models when available.

■ ME28

CC Room 207B

In Person: Data Science and Stochastic Optimization

General Session

Chair: Suvrajeet Sen, Univ. of Southern California, Santa Monica, CA, 90403, United States

1 - Nonparametric Stochastic Decomposition
Shuotao Diao, University of Southern California, Los Angeles, CA, 90007-2490, United States, Suvrajeet Sen

We study the mathematical fusion of non-parametric estimation and stochastic decomposition (SD) algorithms which we refer to as Non-parametric SD. This permits simultaneous updates of the expected value objective, as well as first-stage decisions using k nearest neighbor (kNN) estimation to calculate a new minorant of the current kNN benchmark function. Both convergence and computational results will be presented.

2 - Primal-dual Incremental Gradient Method Fornonsmooth and Convex Optimization Problems
Afrooz Jalilzadeh, The University of Arizona, State College, PA, 16801-4415, United States

n this talk, we consider a nonsmooth convex finite-sum problemwith a conic constraint. To overcome the challenge of projecting onto the con-straint set and computing the full (sub)gradient, we introduce a primal-dualincremental gradient scheme where only a component function and two con-straints are used to update each primal-dual sub-iteration in a cyclic order.We demonstrate an asymptotic sublinear rate of convergence in terms of sub-optimality and infeasibility which is an improvement over the state-of-the-artincremental gradient schemes in this setting.

3 - An Overview of Learning Enabled Stochastic Optimization
Suvrajeet Sen, Univ. of Southern California, Santa Monica, CA, 90403, United States

The combination of learning and optimization provides the scientific basis for analytics, allowing rapid and defensible data driven decisions. We outline a broad agenda which allows new modeling and algorithmic tools to be integrated in one framework.

■ ME29

CC Room 207C

In Person: OR/ML Practice at Amazon

General Session

Chair: Kaiyue (Kay) Zheng, Amazon, Bellevue, WA, 98004, United States

1 - Optimal Trailer Management Using a Multi-Period Multi-Location Variant on the Newsvendor Model
Dmitriy Belyi, Amazon.com, Austin, TX, 78750-4024, United States

We consider the trailer management problem in Amazon's transportation network, where we must allocate available trailers to accommodate all transportation needs at the lowest cost. This problem is fraught with uncertainty and high dimensionality, and is difficult to model and solve using standard approaches. In this talk, we consider a novel modeling approach for this problem, reminiscent of the classic newsvendor. We also present an efficient parallelized solution methodology based on marginal costs.

2 - Sortation Optimization and Allocation Planning in Amazon Middle Mile Network
Kay Zheng, Research Scientist, Amazon, Bellevue, WA, 98004, United States

Middle mile network involves the transportation and sortation of goods from warehouses to the last mile carriers that provides final-mile delivery services. Amazon middle mile transportation paths can include one or more sortation processes along the way and span hundreds or even thousands of miles. Sortation resource optimization and allocation at the middle mile network plans for where, when and how to sort packages along their shipment paths so as to achieve cost, speed or other goals given limited resources at warehouses and on the road. In this work, we present a mixed-integer programming based planning approach to model the trade-offs in the network and discuss the complexities due to the interconnectedness of network structure.

■ ME30

CC Room 207D

In Person: Applying for SBIR/STTR Grants/Data Analytics for Structured Data from Advanced Sensing Systems

General Session

Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, United States

Co-Chair: Andi Wang, Georgia Institute of Technology, Atlanta, GA, 30318-5546, United States

1 - Applying for SBIR/STTR Grants
Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, United States

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs provide exciting opportunities for researchers who have created domestic small businesses to engage in federal research/research and development, with the potential for commercialization. The panelists in this session will discuss SBIR/STTR programs and share information about applying to these programs.

2 - Wavelet Basis Function for Meltpool Monitoring in AM
Siqi Zhang, The Pennsylvania State University, State College, PA, United States

The characteristics of melt pools are critical for process monitoring and control in AM process. However, there are practical issues pertinent to in-situ monitoring of melt-pool characteristics (e.g., a large volume of time-varying melt-pool imaging data, sensitivity to many process parameters (i.e., laser power)). Hence, this paper presents a parametric approach of wavelet basis function to model and monitor melt-pool variations in AM. Specifically, we designed a sparse kernel-weighted regression model to represent the high-dimension imaging data. Experimental results on real-world data demonstrated the effectiveness of wavelet basis functions to represent and monitor the melt-pool imaging data in AM.

■ ME32

CC Room 208B

In Person: Revenue Management

General Session

Chair: Rene A. Caldentey, The University of Chicago, Chicago, IL, 60637-1656, United States

1 - Tight Guarantees for Multi-unit Prophet Inequalities and Online Knapsack

Jiawei Zhang, New York University, New York, NY, 10012-1106, United States, Jiashuo Jiang, Will Ma

Prophet inequalities are a fundamental tool for comparing the performance of online vs. offline algorithms. In the basic setting of k-unit prophet inequalities, the celebrated algorithm of Alaei (2011) with a performance guarantee of 1-1/sqrt{k+3} has been applied in online advertising, healthcare scheduling, and revenue management. Despite its wide applicability for rounding an LP solution, the tightness of this guarantee for a given k has remained unknown. In this paper we resolve this question, characterizing the tight bound using differential equations and deriving the best-known guarantee for k-unit prophet inequalities. In the generalization of the online knapsack problem, we also derive an improved and tight guarantee of 1/(3+1/e^2)~0.319, by bypassing the splitting of large vs. small items in our analysis.

2 - Posted Price Versus Auction Mechanisms in Freight Transportation Marketplaces

Sungwoo Kim, Georgia Tech, Atlanta, GA, United States, He Wang, Xuan Wang

We consider a truckload transportation marketplace in which a platform serves an intermediary to match shippers, who make payment to the platform for transportation services, with carriers, who book loads and get compensation from the platform for transporting the loads. The objective of the platform is to design a policy that specifies how to set prices for shippers and payments to carriers, as well as how carriers and loads should be matched, in order to maximize its long-run average profit. This research analyzes theoretical performances of posted price, auction, and hybrid mechanisms which combine posted price and auction mechanisms.

■ ME33

CC Room 209A

In Person: Experimental Design for Marketplaces

General Session

Chair: Chen Chen, Booth School of Business, The University of Chicago, Durham, NC, 27708-9972, United States

Chair: Rad Niazadeh, Chicago Booth School of Business, Stanford, CA, 94305-5008, United States

1 - Balancing Covariates in Randomized Experiments with the Gram-schmidt Walk Design

Christopher Harshaw, Yale University, New Haven, CT, United States, Fredrik Sävje, Daniel Spielman, Peng Zhang

In the design and analysis of Randomized Control Trials, it is widely accepted that balancing pre-treatment covariates between the treatment groups may lead to improved precision of treatment effect estimates when the covariates are correlated with outcomes. However, we argue that there is a fundamental trade-off between efficiency gained by covariate balance and robustness of these estimates.We present the Gram-Schmidt Walk Design, which allows experimenters to optimally navigate this trade-off. The design utilizes recent advances in algorithmic discrepancy theory [Bansal et al 2019]. We provide a tight analysis of the design, including non-asymptotic bounds on the variance and tails of the Horvitz-Thompson estimator. Based on these results, we develop estimators for non-asymptotic confidence intervals.

2 - Near-optimal Experimental Design for Networks: Independent Block Randomization

Chen Chen, Booth School of Business, The University of Chicago, Chicago, IL, 27708-9972, United States, Ozan Candogan, Rad Niazadeh

We consider the problem of designing a randomized experiment for a network of users. A decision-maker uses an unbiased Horvitz-Thompson estimator to estimate the total market effect of the treatment and chooses an optimal joint distribution of randomized assignments to minimize the worst-case variance of this estimator. For networks that can be partitioned into densely connected communities by ignoring only a small number of connections, it is near-optimal to assign all users in the same community to the same variant. We develop a family of independent block randomization (IBR) experiments, and we show these policies are asymptotically optimal when the number of communities grows large and no community size dominates the rest. Beyond the asymptotic regime, the IBR experiment is 7/3-approximation for any problem instance.

■ ME34

CC Room 209B

In Person: Trust in the Digital Economy and Social Media

General Session

Chair: Yangyan Shi, Auckland, New Zealand

1 - Reverse Logistics Capability for Sustainable Development

Olivia Lee, Macquarie University, Sydney, Australia

The purpose of this paper is to present a conceptual framework of reverse logistics capability in the pharmaceutical industry. Today, sustainability is becoming increasingly important for all companies, across all industries including the pharmaceutical industry. In addition, reverse logistics plays a vital role in recycled material flows and waste management in supporting sustainable

2 - Risk Factor Analysis of the Time to Progression for Alzheimer's Disease Patients

Robin Qiu, Penn State (The Pennsylvania State University), Malvern, PA, United States

In this talk, we show a predictive model for probable Alzheimer's disease (AD) patients to enable risk factor analyses, aimed at providing medical professionals and caregivers a tool so that personalized care becomes possible. As AD patients' time to progression generally accelerates over time, a predictive model should account for a patient staging status to determine his/her personalized and precise care. The Global Staging Clinical Dementia Rating score is used to define AD patients' progression stages. Hence, we present cluster-based predictive models, enabling supporting decision-making on the guidance of personalized care and disease management on an individual patient basis.

3 - Improving Social Media Presence of Firms under Budget Constraints: A Multi-method Approach

Mayukh Majumdar, PhD Candidate, Mays Business School, College Station, TX, United States, Subodha Kumar, Chelliah Sriskandarajah

The use of social media platforms by firms to promote their products among the public has received major attention among researchers and practitioners, especially the image-based content given the widespread availability of multimedia-based platforms. In this study, we examine the role of post features in driving user engagement and the operational value in the analysis of social media content. We use a combination of deep learning method, econometric approach, and optimization framework to offer relevant managerial insights under budget constraints.

4 - Artificial Intelligence-as-a-service in Healthcare

Youakim Badr, Associate Professor, The Pennsylvenia State University, Malvern, PA, United States, Robin Qiu

Artificial Intelligence-as-a-Service typically refers to off-the-shelf software packages that are offered by third party vendors to implement AI solutions with minimal investment. Healthcare is likely to be the one market where AIaaS can truly have impacts that affect human lives with a large spectrum of applications, ranging from drug discovery, personalized medicine, personal health virtual assistants, survival analysis, and surgery robots, etc.In this study, we survey the current status of AIaaS in healthcare and identify common setbacks, including a lack of data exchange, data privacy and security, regulatory compliance, ethic and fairness, patient and provider adoption.

■ ME36

CC Room 210B

In Person: Emerging Transportaion and Transportation-Enabled Services

General Session

Chair: Neda Mirzaeian, Carnegie Mellon University, Pittsburgh, PA, 15217-1249, United States

1 - Multimodal Transportation Alliance Design with Endogenous Demand: Large-scale Optimization for Rapid Welfare Gains

Kayla Spring Cummings, Massachusetts Institute of Technology, Cambridge, MA, 02134-1506, United States, Vikrant Vaze, Ozlem Ergun, Cynthia Barnhart

We present an incentive-aligned collaborative pricing structure for competing urban transportation operators to jointly maximize system welfare. The alliance requires no change in infrastructure and captures behavior of all strategic agents in the system. We demonstrate the alliance's utility on a full-scale case study of the Greater Boston Area which integrates 10 different datasets.

2 - Can Autonomous Vehicles Solve the Commuter Parking Problem?
Neda Mirzaeian, Carnegie Mellon University, 5738 Wilkins Ave Apt 1a, Pittsburgh, PA, 15217-1249, United States, Soo-Haeng Cho, Sean Z. Qian

We investigate the effect of autonomous vehicles (AVs) on the morning commute. We characterize a user equilibrium for commuters by developing a continuous-time traffic model that takes into account parking fees and traffic congestion as two key economic deterrents to driving. In addition, we consider the case of a social planner who aims to minimize the total system cost by controlling the commuters' decisions. We illustrate our results using data from Pittsburgh, and show that AVs reduce the need for downtown parking. We also show that, in the short run, adjusting downtown parking fees and imposing tolls on downtown congestion can reduce the total system cost significantly (e.g., a 51% reduction for Pittsburgh), and that adjusting the road and parking capacities as a long-term plan may reduce the total cost even further (e.g., an additional 70% reduction for Pittsburgh).

■ ME37

CC Room 210C

In Person: Managerial Issues in the Platform Economy

General Session

Chair: Koushiki Sarkar, Northwestern University, Evanston, IL, 60201-4434, United States

1 - Why Harry Wouldn't Meet Sally: An Empirical Analysis of Gender Disparity in Online Learning Forums
Zhihan (Helen) Wang, Ross School of Business, University of Michigan, Ann Arbor, MI, United States, Jun Li, Andrew Wu

On most Massive Open Online Courses (MOOC) platforms, the discussion forum is the primary source of interaction among learners. Using a large-scale data set of forum posts on a world-leading MOOC platform, we demonstrate the existence of gender bias in discussion behavior among learners, and examine the sources of this bias and its potential impact on engagement and learning outcomes.

2 - Strategic Considerations in the Presence of Social Influencers
Gad Allon, University of Pennsylvania, Philadelphia, PA, 19104-3615, United States, Koushiki Sarkar, Achal Bassamboo

The use of social information for decision-making is of great practical importance in various settings, amongst which online shopping holds a special place. Customers frequently base their purchase decisions on reviews of prominent users, typically known as influencers. We address the following questions: what features promote a particular user to the level of an influencer? How should firms incentivize influential reviewers to structure their reviews? When customers have a limited search budget, we show that they do not necessarily follow the most precise or most open influencer. Further, the firm does not always benefit from disclosing accurate quality information. The firm may profit significantly by appropriately controlling the social information displayed to the agents, either by targeting influencers to post more or providing better quality information

■ ME39

CC Room 211A

In Person: New Directions in Operations Management

General Session

Chair: Maria R. Ibanez, Kellogg School of Management at Northwestern University, Evanston, IL, 60208-0898, United States

1 - The Power of Analytics in Epidemiology for the COVID-19; Prediction, Prevalence and Vaccine Allocation
David A. Nze-Ndong, Massachusetts Institute of Technology, Cambridge, MA, United States, Mohammed Amine Bennouna, Georgia Perakis, Omar Skali Lami, Ioannis Spantidakis, Leann Thayaparan, Asterios Tsiourvas

Mitigating the COVID19 pandemic poses many challenges. Those include predicting new cases and deaths, understanding true prevalence, and allocating vaccines. We present a novel predictive ML-based aggregation method (MIT-Cassandra) also used by the CDC that is consistently among the top 10 models in terms of accuracy. We then predict the true prevalence of COVID19 and incorporate it into an optimization model for fair vaccine allocation. We obtain interesting insights on how prevalence affects the vaccine distribution for a heterogeneous population. Our work has been part of a collaboration with MIT's Quest for Intelligence and as part of CDC's model ensemble.

2 - Supply Chain Characters as Predictors of Cyber Risk: A Machine-learning Assessment
Retsef Levi, MIT, Sloan School of Man., Cambridge, MA, 02142-1320, United States

The presentation provides the first empirical evidence that certain supply-chain attributes are significant predictors of cyber risk for enterprises, in addition to their internal characteristics and level of cybersecurity management. It leverages outside-in cyber risk scores that represent quality of cyber security management, and augment these with supply chain features that are inspired by network science research, to develop a more comprehensive risk assessment. The main result is to develop a model that shows that supply chain network features add significant detection power relative to merely internal enterprise attributes in predicting risk of cyber data breach incidents. Additionally, the model highlights several cybersecurity risk insights related to third party data breach mechanisms that have seen significant increase over the last several years.

3 - An Empirical Study of Time Allotment and Delays in E-commerce Delivery
Natalie Epstein, Harvard Business School, Cambridge, MA, 02138, United States, Maya Balakrishnan, MoonSoo Choi

Time allotment comes with an inherent tradeoff between delays and duration, so managers need to carefully evaluate such tradeoff. We explore the relationship between time allotment and delivery outcomes in an e-commerce delivery context and further seek to identify relevant features for predicting order delays and study how real-time information of the delivery process can improve prediction accuracy. We use the JD.com transaction dataset provided by Shen et al. (2020) and find that (i) increasing the allotted time for an order increases the duration of its delivery process, (ii) more allotted time reduces the likelihood of an order being late or delayed, (iii) our delay prediction models exhibit accuracy levels higher than no-information rate, and (iv) adding information from early parts of the delivery significantly increases accuracy when predicting future delays.

■ ME40

CC Room 211B

In Person: Machine Learning in Finance

General Session

Chair: Renyuan Xu, University of Southern California, Los Angeles, CA, 94720, United States

Co-Chair: Zhengyuan Zhou

1 - Scaling Properties of Deep Residual Networks
Renyuan Xu, University of Southern California, Los Angeles, CA, 94720, United States, Alain-Sam Cohen, Rama Cont, Alain Rossier

Residual networks (ResNets) have displayed impressive results in pattern recognition and have garnered considerable theoretical interest due to a perceived link with neural ODEs. This link relies on the convergence of network weights to a smooth function as the number of layers increases. We investigate the properties of weights trained by SGD and their scaling with network depth through detailed experiments. We observe the existence of scaling regimes markedly different from those assumed in neural ODE literature. Depending on certain features of the network architecture, we prove the existence of an alternative ODE limit, an SDE limit, or neither of these. These findings cast doubts on the validity of the neural ODE model as an adequate asymptotic description of deep ResNets and point to an alternative class of differential equations as a better description of the limit.

■ ME41

CC Room 212A

In Person: ARPA-E Grid Optimization Competition 2

General Session

Chair: Constance Crozier, University of Colorado, Boulder, CO, United States

1 - Algorithmic Development for Solving Large-Scale Security Constrained AC-OPF with Switching
Andy Sun, Georgia Tech, Atlanta, GA, United States

2 - On Solving Large-Scale Mixed-Integer Nonlinear Programs
Hassan Hijazi

The talk will cover recent work on solving large-scale Mixed-Integer NonLinear Programs (MINLPs). We will discuss ideas such as automatic projection of auxiliary variables, building convex outer relaxations as well as convex inner restrictions, and showcasing how they both play an important role in providing feasible solutions and optimality guarantees for challenging MINLPs. Numerical results on the ARPA-e Grid Optimization Competition Challenge 2 will be presented.

3 - Approximations and Heuristics For Fast Security Constrained Optimal Power Flow

Constance Crozier, Univ, of Colorado,

Security constrained optimal power flow (SCOPF) extends the traditional optimal power flow problem to a two-stage stochastic optimization model. The problem seeks to find the lowest cost way to deliver power to consumers, while considering a set of pre-defined contingencies (such as a component outage). For large networks, with many contingencies, the resulting problem contains millions of variables. Given that the power flow constraints are non-convex, it may not be possible to reach a solution in the required timescale. In this talk, we will discuss the approximations and heuristics used by the CU Boulder team in the ARPA-E GO competition to reduce the complexity of the problem.

■ ME42

CC Room 212B

In Person: Deep Learning/Machine Learning I

Contributed Session

Chair: Meghna Maity, Kansas State University, Manhattan, KS, 66502, United States

1 - Optimal Policy Trees

Jack Dunn, Interpretable AI, Cambridge, MA, United States, Maxime Amram, Ying Zhuo

We propose an approach for learning optimal tree-based prescription policies directly from data, combining methods for counterfactual estimation from the causal inference literature with recent advances in training globally-optimal decision trees. The resulting method, Optimal Policy Trees, yields interpretable prescription policies, is highly scalable, and handles both discrete and continuous treatments. We conduct extensive experiments on both synthetic and real-world datasets and demonstrate that these trees offer best-in-class performance across a wide variety of problems.

2 - A Theoretical Framework for Data Science

Brian Wright, Assistant Professor/Director Undergraduate Program, University of Virginia, Charlottesville, VA, United States

As the first School of Data Science in the country, University of Virginia faculty in the School have created a framework for Data Science that will drive research activity and shape academic programs. This session will discuss this framework in detail.

3 - Can a Joint Model Assist Target Label Prediction? Conditions and Approaches

Jaeyoung Park, University of Florida, Gainesville, FL, United States, Muxuan Liang, Xiang Zhong

Multi-label datasets are common in many practical problems. In order to borrow information from auxiliary labels, classical approaches build a joint model to predict multiple labels simultaneously. However, a joint model may not necessarily lead to better prediction for the target label. In this work, we propose a framework to effectively utilize the hidden structure such as the hidden layers learned in the joint model to aid the prediction of the target label, even when the joint model is misspecified. Further, we propose a conditional-independence-targeted Neural Network (CITNN) aiming at efficient learning of predictive hidden structure.

4 - An Interpretable Deep Learning Model to Predict Symptomatic Knee Osteoarthritis Using Radiographs

Maryam Zokaeinikoo, Cleveland Clinic, Cleveland, OH, United States, Xiaojuan Li, Mingrui Yang

Early prediction of knee osteoarthritis (OA) may help initiate potential interventions or treatments sooner, which can result in preventing or delaying knee OA development. This study aims to develop a deep learning (DL) model to predict the incident symptomatic radiographic knee OA over the next 78 months using radiographs at baseline. The proposed model combines clinical variables, along with the attention and probability scores from our trained DL model to predict the knee osteoarthritis incident. The developed multi-modal model demonstrated an AUC of 0.76. Moreover, our model is interpretable, which can detect the potential abnormalities using the learned attention scores.

5 - A Holistic Approach to Mitigating Contamination in Food Supply Chain under Uncertainty

Meghna Maity, Kansas State University, Manhattan, KS, United States

Our work involves a holistic approach to make a perishable food supply chain resilient by identifying and optimizing the relevant factors that lead to bacterial contamination in food. Data-driven technologies such as machine learning are employed to filter the relevant parameters impacting food quality through various supply chains. Next, by integrating the Bayesian Network in Markov decision process models, we determine the optimal parameter settings to mitigate such contamination. We also use emerging blockchain technology to track the contamination and improve transparency throughout the supply chain.

■ ME44

CC Room 213B

In Person: Pricing and Revenue Management

Contributed Session

Chair: Wei Sun, IBM T. J. Watson Research Center, Yorktown Heights, NY, 10598, United States

1 - The Impact of Order Fulfilment Services Provided by Online Marketplace Operators on Third-party Seller's Performance

Hao Su, University of Maryland-College Park, College Park, MD, United States, Martin E. Dresner

This paper examines the impact of order fulfilment services provided by marketplace operators on third-party sellers' competitiveness and product performance. We also examine factors that may moderate the relationship between using order fulfilment services provided by marketplace operators and a third-party seller's competitiveness: the cost of services, the shipment size/weight, and the product value.

2 - The Impact of Uncertainty on a Broker's Optimal Bidding Decisions in B2B Markets

Ozden Engin Cakici, American University, Washington, DC, United States, Itir Z. Karaesmen

We study a broker's problem of matching a buyer with stochastic suppliers. The broker bids at each supplier. After the suppliers evaluate the bids, the broker learns the procurement quantity and then ships the items from each supplier to the buyer. When there is a single supplier the problem reduces to a new type of newsvendor problem. We study the impact of uncertainty on the optimal bids. We prove that the broker may or may not increase the bid when faced with uncertainty compared to a case with no uncertainty. We provide conditions under which it is optimal for the broker to bid at multiple suppliers. We numerically find that the broker's expected profit decreases in the correlation between suppliers.

3 - Assortment Optimization for Online Multiplayer Video Games

Fan You, PhD Candidate, University of Colorado-Boulder, Boulder, CO, United States, Thomas Vossen

We consider the assortment optimization problem for a class of online multiplayer video games, where the in-game store has a unique structure with two sections, Featured and Just For You (JFY). All customers are offered the same Featured assortment whereas JFY is used for personalized recommendations. We model the choice of customers under the constrained mixture of nested logit model, and design a MILP formulation, as well as a FPTAS. We also propose a Lagrangian upper bound and a fast heuristic. We provide theoretical guarantees of the MILP formulation, the FPTAS as well as the heuristic algorithm. Numerical experiments show that our approaches perform well across a variety of settings.

4 - Ticket Pricing via Prescriptive Model Distillation

Wei Sun, Researcher, IBM Research, Yorktown Heights, NY, United States, Max R. Biggs, Shivaram Subramanian, Youssef Drissi, Markus Ettl

Powerful blackbox machine learning models often lead to complex policies which are difficult to verify and manage. Biggs et. al 2021 proposed a decision tree approach to extract revenue-maximizing pricing policies which are also interpretable by separating the counterfactual estimation and policy learning steps. We implement and test this method on airline ticket sales data. Results show that this method is capable of achieving significant improvement over current pricing policies with just a few rules.

■ ME46

CC Room 213D

In Person: Project Management

Contributed Session

Chair: Mohsen Mohammadi, University of Louisville, Chicopee, MA, 01020, United States

1 - Interrelationships Among Project Attributes and Time-phased Resource Patterns in a Project Portfolio

Vishwanath Hegde, Professor, California State University-East Bay, Hayward, CA, United States, Zinovy Radovilsky

We analyze the interrelationships among project attributes, durations, and time-phased resource allocation patterns in a portfolio of engineering projects. We estimate parametric models that capture unique duration/resource usage patterns from a longitudinal dataset spanning eleven years and analyze the link between the patterns and project attributes. Our research enhances the macro estimation of duration and resource requirements for incoming projects.

2 - A Continuous-time Linear Programming Formulation for Resource-constrained Project Scheduling with Multiple Sites
Norbert Trautmann, Professor, University of Bern, Bern, Switzerland, Mario Gnaegi

We present a continuous-time mixed-integer linear programming formulation for scheduling the activities of a multi-site project subject to precedence and renewable-resource constraints. As a consequence of the distribution of the renewable-resource units among the multiple sites, transportation times must be considered for moving some mobile resource units or the output of some precedence-related activities.

3 - A Revised PERT Model Using Log-Normal Activity Times
Eric Logan Huggins, Professor of Management, Fort Lewis College, Durango, CO, United States, Ivan G. Guardiola

The standard PERT model assumes that activity times follow Beta distributions and that completion time for the entire project is Normally distributed. We consider several revisions to this model; specifically, we assume that the activity times follow Log-Normal distributions instead which we believe may improve the model. While the Log-Normal can be similarly skewed like the Beta, it has an infinite right tail which puts no limit on how long an activity can be delayed; further, our model allows estimating the worst case scenario with a given confidence level.

4 - Linear Relaxations for Mixed Integer Nonlinear Programs in Natural Gas Transportation Networks
Sai Krishna Kanth Hari, Los Alamos National Laboratory, Los Alamos, NM, United States

Efficient and profitable transportation of natural gas along pipeline networks requires solving challenging Mixed Integer Nonlinear Programs (MINLPs) as the gas flow is governed by nonlinear, non-convex physics. Obtaining tight bounds on the objective value of these MINLPs using convex relaxations is of significant interest in the research community. Here, we utilize the recent advancements in the literature of polyhedral relaxations for univariate and bilinear functions to develop Linear Programming and Mixed Integer Linear Programming relaxations for the MINLP.

5 - How To Quantify Outcome Functions of Linear Programs with Interval Right-hand Sides
Mohsen Mohammadi, University of Louisville, Louisville, KY, United States, Monica Gentili, Milan Hladik, Raffaele Cerulli

An outcome function is an extra function of interest associated with the set of optimal solutions of an optimization problem. In this talk, we consider the problem of finding the range of a given outcome function over the set of all possible optimal solutions of a linear program with interval right-hand sides. We show the relevance of the problem in practice, address its computational complexity, and discuss some of its theoretical properties. Moreover, we propose several heuristics to solve the problem and analyze their quality and efficiency."

Tuesday, 7:45AM-9:15AM

■ TB01

CC Ballroom A / Virtual Theater 1

Hybrid Dynamic Data Driven Application Systems

Sponsored: Simulation Society

Sponsored Session

Chair: Kevin Jin,

1 - Social Media Networks as Dynamic Data Driven Applications Systems
Conrad Tucker, Carnegie Mellon University, Pittsburgh, PA, United States, Sakthi Prakash

This research aims to transform large-scale social media networks (SMNs) into dynamic data-driven application systems (DDDAS) that model and predict real world events/national security threats. The conventional wisdom has been that complex, high fidelity sensors are needed to accurately model real-world events. The concept of large-scale SMNs serving as dynamic sensing systems is a departure from traditional perceptions of SMNs simply being platforms for disseminating content and connecting individuals. However, the advent of AI that are capable of generating hyper-realistic data, threatens to significantly degrade the veracity of SMN data and hence, their ability to serve as DDDAS. This work proposes algorithms that enable SMNs to serve as DDDAS, as well as algorithms that protect SMNs against adversarial attacks seeking to degrade their veracity.

2 - Identification and Adaptive Control of Markov Jump Systems: Sample Complexity and Regret Bounds
Laura Balzano, University of Michigan, Ann Arbor, MI, 48109, United States

Learning how to effectively control unknown dynamical systems is crucial for intelligent autonomous systems. This task becomes a significant challenge when the underlying dynamics are changing with time. Motivated by this challenge, this work considers the problem of controlling an unknown Markov jump linear system (MJS) to optimize a quadratic objective. By taking a model-based perspective, we consider identification-based adaptive control for MJSs. We first provide a system identification algorithm for MJS to learn the dynamics in each mode as well as the Markov transition matrix, underlying the evolution of the mode switches, from a single trajectory of the system states, inputs, and modes. Through mixing-time arguments, sample complexity of this algorithm is shown to be O(1/sqrt(T). We then propose an adaptive control scheme that performs system identification together with certainty equivalent control to adapt the controllers in an episodic fashion. Combining our sample complexity results with recent perturbation results for certainty equivalent control, we prove that when the episode lengths are appropriately chosen, the proposed adaptive control scheme achieves O(sqrt(T)) regret which can be improved to O(log(T)) with partial knowledge of the system. This is work with Yahya Sattar, Zhe Du, Davoud Ataee Tarzanagh, Samet Oymak, and Necmiye Ozay.

3 - Using Saliency Map to Interpret EO and Passive RF Sensor Fusion
Asad Vakil, Oakland University, Rochester, MI, United States, Robert Ewing, Erik Blasch, Jia Li

This study applies saliency map to find the impact of individual modalities in EO and P-RF sensor fusion using the AFRL's ESCAPE dataset. When saliency maps are applied to P-RF data alone, the resulting maps are mostly blank due to insignificant changes. To prevent the AI models from focusing solely on the EO input, where dense optical flow (DOF) makes the presence of vehicle targets obvious, the P-RF histogram was overlayed on top of DOF-EO to generate a single input. The experimental results reveal three broad categories of heatmaps, heatmaps focused on vehicles when the target is visible, heatmaps focused on the P-RF histogram when the target is out of sight, and heatmaps focused on both which occur when multiple targets are moving. While the insights provided by heatmaps are more intuitive than quantitative, they highlight and confirm the impact of P-RF data in various scenes.

4 - Physics-informed Statistical Learning of Scientific and Engineering Processes
Xiao Liu, University of Arkansas, Fayetteville, AR, 72701, United States, Xinchao Liu, Guanzhou Wei, Mohammadmahdi Hajiha

This talk will focus on a physics-informed statistical learning framework for engineering processes governed by fundamental physical laws. Two examples will be discussed. The first example is related to the modeling and prediction of natural processes (smoke, sea surface temperature, aerosol depth, etc.), and the second example deals with how statistical learning can be used to learn the outputs from computer simulation models (such as Finite Element Analysis), and make predictions under new scenarios.

5 - Thermospheric Density Modeling Using Dynamicmode Decomposition with Control and Machine Learning
Richard Linares, MIT

Thermospheric density is the main source of uncertainties for satellites' orbit prediction in Low Earth Orbit. It is highly dynamic and driven by external drivers, such as solar and geomagnetic activity. A dynamic reduced order thermospheric density model is developed for real-time density prediction using density data from Global Ionosphere Thermosphere Model (GITM). A deep convolution autoencoder neural network is constructed to capture a high-level abstraction of the thermospheric density in a reduced order space. A linear model is then fitted onto the reduced-order states using Dynamical Mode Decomposition with Control. Data assimilation is then used to improve prediction capabilities.

6 - DDDAS for Robust Reconfiguration of Self-healing Microgrid Clusters
Abdurrahman Yavuz, University of Miami, Miami, FL, United States, Nurcin Celik, Jie Xu, Chun-Hung Chen

Cluster of microgrids are formed of loads, distributed generation units (DGs) and energy storage units that operate in coordination to supply electricity in a reliable and low-cost manner while supporting each other against the effects of prevalent faults, with or without support from the host grid. Here, we propose a reconfiguration method for such microgrid clusters using the Dynamic Data Driven Applications Systems (DDDAS) framework to manage the stochasticity of the non-dispatchable DGs and loads under different system anomalies, such as extreme weather events. Self-healing capabilities are facilitated via intelligent exploitation of real-time data and, in return, adjustment of the measurement process to guide new data collection.

■ TB02

CC Ballroom B / Virtual Theater 2

Hybrid Stochastic or Distributionally Robust Integer Programming

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Xian Yu, University of Michigan, Ann Arbor, MI, 48105-2129, United States

Co-Chair: Siqian Shen, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - Rolling Horizon Policies in Multistage Stochastic Programming

Murwan Siddig, Clemson University, Clemson, SC, United States, Yongjia Song, Amin Khademi

Multistage Stochastic Programming (MSP) is a class of models for sequential decision-making under uncertainty. MSP problems are known for their computational intractability due to the sequential nature of the decision-making structure and the uncertainty in the problem data due to the curse of dimensionality. A common approach to tackle MSP problems with a large number of stages is a rolling-horizon (RH) procedure, where one solves a sequence of MSP problems with a smaller number of stages. This leads to a delicate issue of how many stages to include in the smaller problems used in the RH procedure. This paper addresses this question for, both, finite and infinite horizon MSP problems. Our numerical experiments on a hydrothermal power generation planning problem show the effectiveness of the proposed approaches.

2 - Stochastic Routing and Wavelength Assignment Problem in WDM Networks

Maryam Daryalal, University of Toronto, Toronto, ON, Canada

In a telecommunication network, Routing and Wavelength Assignment (RWA) is the problem of finding a path and a wavelength for every incoming request. In the first part of this talk we introduce the first two-stage stochastic integer programming model for the RWA problem with incoming request uncertainty, to maximize the expected number of granted requests. We design a decomposition-based solution approach, which uses various relaxations of the problem and a newly developed cut family. Guided by the multistage nature of the provisioning decisions, in the second part of the talk we present a multistage model for the RWA problem with incremental traffic. Evaluating obtained solutions in a multistage setting in a rolling-horizon framework, we show that our methods provide high-quality solutions compared to traditionally used deterministic ones.

3 - Pragmatic Distributionally Robust Optimization for Simple Integer Recourse Models

Ruben van Beesten, MSc, University of Groningen, Groningen, Netherlands, David Morton, Ward Romeijnders

We consider simple integer recourse (SIR) models under distributional uncertainty. Distributionally robust optimization (DRO) provides a framework for dealing with the distributional uncertainty in these models. However, the integer restrictions typically cause these models to be non-convex and hence, hard to solve. To overcome this issue, we propose a pragmatic approach in which we restrict the uncertainty set in such a way that the problem becomes convex, while the uncertainty set remains structurally similar to traditional uncertainty sets. We coin this approach pragmatic DRO.In this presentation we focus on a setting where the uncertainty set is based on a set of moment conditions. We show that our pragmatic approach is equivalent to a continuous recourse problem under modified moment conditions.

4 - On Finite Adaptability in Two-stage Distributionally Robust Optimization

Eojin Han, Southern Methodist University, Dallas, TX, 75205, United States, Chaithanya Bandi, Omid Nohadani

In many applications, practitioners prefer policies that are interpretable and easy to implement. In this paper, we leverage the concept of finite adaptability to construct policies for two-stage distributionally robust optimization problems. This is done by partitioning the uncertainty space and assigning a contingent decision to each piece. We first show that the optimal partitioning can be characterized by translated orthants, which only require the problem structure. We then prove that finding the optimal partitioning is hard and propose a specific partitioning scheme with orthants, which can be obtained by solving a mixed-integer optimization problem of a moderate size. We provide performance bounds of our policies which generalize the existing bounds in the literature. We also assess suboptimality in general settings and provide techniques for lower bounds.

5 - On the Value of Multistage Stochastic Facility Location with Risk Aversion

Xian Yu, University of Michigan, Ann Arbor, MI, 48105-2129, United States, Shabbir Ahmed, Siqian Shen

We study the capacitated facility location problem over a finite time horizon under uncertain demand. We model a multistage stochastic integer program based on a scenario tree representation and compare it with a two-stage approach that decides which facilities to open for all periods upfront. Using expected conditional risk measures, we provide tight lower bounds for the gaps between optimal objective values of the risk-averse multistage and two-stage models. Moreover, two approximation algorithms are proposed to solve the programs efficiently, with the approximation ratio independent of the underlying stochastic process, structure of the scenario tree, and risk parameters. Computational studies are conducted on randomly generated and real network instances to demonstrate the tightness of the bounds and efficacy of the approximation algorithms.

■ TB03

CC Ballroom C / Virtual Theater 3

Hybrid Design and Operation of Online Platforms

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Daniela Saban, Stanford University, Aachen, United States

Co-Chair: Vahideh Manshadi, Yale University, New Haven, CT, United States

1 - Designing Service Menus for Bipartite Queueing Systems

Varun Gupta, University of Chicago Booth School of Business, Chicago, IL, 60637-1610, United States, Rene A. Caldentey, Lisa Hillas

We look at the problem of designing a matching system with queues in an environment with multiple classes of servers, and multiple types of customers with heterogeneous preferences over servers. The system designer offers a static menu of service classes, where each menu is a set of servers that can serve the service class. Customers choose which class to join upon arrival. The servers serve their adjacent service classes in First-Come-First-Served order. Customers act as rational self-interested utility maximizing agents when choosing which service class to join. We study the problem under (conventional) heavy traffic conditions, that is, in the limit as the traffic intensity of the system approaches one from below, and provide insights into the design tradeoffs of "good" service menus.

2 - In Which Random Matching Markets Does the Short Side Enjoy an Advantage?

Pengyu Qian, Purdue University, Krannert School of Management, Columbia Business School, West Lafayette, IN, 10027, United States, Yash Kanoria, Seungki Min

In this work, we study Gale-Shapley two-sided matching markets where agents on both sides have ordinal preferences over potential partners on the other side. These markets have broad applications in school choice, labor markets, etc.We investigate in which markets does being on the short side of the market allow agents to obtain better match partners relative to a similar ``balanced" market with equal numbers of agents on the two sides.We study ``partially connected" random matching markets with n+k men and n women in which agents consider a limited set of potential partners, and discover a new type of smoking gun evidence of whether a matching market exhibits a short side advantage. In particular, we sharply characterize the resulting (nearly unique) stable matching as a function of the connectivity d and the ``imbalance", overcoming significant technical challenges.

3 - Designing Approximately Optimal Search On Matching Platforms

Alexander Wei, UC Berkeley, Berkeley, CA, United States, Nicole Immorlica, Brendan Lucier, Vahideh Manshadi

We study the design of a two-sided matching market in which agents' search is guided by a platform. The platform determines the rates at which agents of different types meet, while agents strategically accept or reject the potential partners whom they meet. We focus on the platform's problem of optimal search design in a continuum matching market model where agents have symmetric pairwise preferences. The platform's objective is to find meeting rates that maximize the equilibrium social welfare of the resulting game. Incentive issues arising from congestion and cannibalization make this design problem intricate. Nonetheless, we give an efficiently computable solution that achieves 1/4 the optimal social welfare. Our solution shows the platform can substantially limit choice while maintaining approximately optimal welfare through a carefully chosen search design.

4 - The Value of Excess Supply in Spatial Matching Markets

Yeganeh Alimohammadi, Stanford University, Stanford, CA, United States, Mohammad Akbarpour, Shengwu Li, Amin Saberi

We study dynamic matching in a spatial setting. Drivers are distributed at random on some interval. Riders arrive in some (possibly adversarial) order at randomly drawn points. The platform observes the location of the drivers, and can match newly arrived riders immediately, or can wait for more riders to arrive. The cost of matching a driver to a rider is equal to the distance between them. We quantify the value of slightly increasing supply. We prove that when there are $(1+\epsilon)$ drivers per rider (for any $\epsilon > 0$), the cost of matching returned by a simple greedy algorithm which pairs each arriving rider to the closest available driver is $O(\log^3(n))$, where n is the number of riders. However, with equal number of drivers and riders, even the ex post optimal matching does not have a cost less than $\Theta(\sqrt{n})$.

■ TB04

CC Ballroom D / Virtual Theater 4

Hybrid JFIG Paper competition II

Sponsored: Junior Faculty Interest Group

Sponsored Session

Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24061-1019, United States

Co-Chair: Dorit Simona Hochbaum, University of California-Berkeley, Berkeley, CA, 94720-1777, United States

Co-Chair: Alice E Smith, Auburn University, Auburn, AL, 36849, United States

■ TB05

CC Ballroom E / Virtual Theater 5

Hybrid Getting Started in Public Sector Operations Research

Sponsored: Public Sector OR

Sponsored Session

Chair: Jessica Heier Stamm, Kansas State University, Manhattan, KS, 66503-8514, United States

1 - Getting Started in Public Sector Operations Research I
Jessica Heier Stamm, Kansas State University, Manhattan, KS, 66503-8514, United States

Public sector operations research is dedicated to decision problems with outcomes that can impact the public / society at large. Such problems often involve complex situations, uncertainty, and multiple stakeholders with differing and potentially conflicting objectives. This panel features speakers with complementary expertise in public sector operations research, who will discuss how to get started in this broad and impactful domain. Panelists will briefly describe their own research, and discussion will proceed to a moderated question and answer session. Questions from the audience are welcomed.

2 - Panelist
Austin Buchanan, Oklahoma State University, Stillwater, OK, 74078-5017, United States

3 - Panelist
Ozlem Ergun, Northeastern University, Boston, MA, 2115, United States

4 - Panelist
Benjamin D. Leibowicz, University of Texas-Austin, Austin, TX, 78712-1591, United States

■ TB06

CC Room 303A

In Person: Simulation Applications for Public Policy

General Session

Chair: Tessa Swanson, Ann Arbor, MI, 48103, United States

1 - A Customizable Agent-based Simulation Tool for Analyzing Infectious Disease Control Strategies in Metropolitan Areas
Ashkan Negahban, The Pennsylvania State University, Malvern, PA, United States

Non-pharmaceutical interventions such as social distancing, school/business closures, random testing and quarantines are crucial in controlling the spread of an infectious disease. We propose a customizable agent-based simulation and decision support tool that allows for any city to create a fine-grained simulation of the corresponding real-world population and their interactions to enable analysis of various control strategies. We illustrate the applicability and efficacy of the proposed tool for the case of Covid-19 outbreak in New York City.

2 - Simulating Covid-19 Risks Associated with Returning to In-person College Classes
Tessa Swanson, Industrial and Operations Engineering, Ann Arbor, MI, United States, Seth Guikema

As universities prepare for a school year following disruption from the COVID-19 pandemic, risk analysis can support decision-making for resuming in-person instruction. A simulation-based risk analysis approach enables scenario evaluation and comparison to guide decision making under uncertainty. We develop a simulation model to evaluate various scenarios involving in-person classes for the University of Michigan's College of Engineering. We estimate risks of infection, hospitalizations, and deaths, incorporating uncertainties in disease transmission as well as impacts of policies, such as masking and facility interventions, and population-level disease prevalence and immunity.

■ TB07

CC Room 303B

In Person: Business Analytics for Disaster Management

General Session

Chair: Alfonso Pedraza-Martinez, Indiana University, Indiana University

1 - Inventory Pre-positioning Decision Support for Humanitarian Relief in Nepal
Jason Acimovic, Penn State University, University Park, PA, United States

Humanitarian organizations typically work independently to pre-position stock in countries in preparation for a disaster. This lack of coordination leads to gaps and overlaps. Working with the Emergency Supply Prepositioning Strategy Group (ESUPS), we utilize inventory data they collected from various NGOs working in Nepal to formulate and solve an optimization problem suggesting where inventory should go. From this, we and ESUPS developed a decision support tool to help guide local NGOs working in Nepal. We will talk about the experience of implementing optimization problem solutions in actual humanitarian organizations, and the status of the project.

2 - Business Analytics for Disaster Management: Research Opportunities And Challenges
Alfonso J. Pedraza-Martinez, Indiana University, Kelley School Of Bus., Bloomington, IN, 47405-5308, United States, Lu (Lucy) Yan, Yu Kan

We discuss the state of the art of academic and practitioner business-analytics applications for disaster management. In doing so, we identify opportunities for future research in this area. Moreover, we present an empirical application that exemplifies our proposed agenda.

■ TB09

CC Room 303D

In Person: Optimization and Surrogate Methods for Black-Box Systems

General Session

Chair: Hadis Anahideh, University of Illinois at Chicago, Chicago, IL, 60654-4907, United States

1 - An Exploration-Exploitation Approach for Surrogate Optimization
Nazanin Nezami, University of Illinois at Chicago, Chicago, IL, United States, Hadis Anahideh

The exploration-exploitation trade-off has a critical role in surrogate optimization of expensive black-box functions. Despite the effort of related research in developing strategies to comply with this trade-off, they come short in providing effective guarantees. Proposing a fundamentally different approach to balance this trade-off, we introduce Determinantal Point Processes (DPP) in surrogate optimization. DPP guarantees diversity in a selected subset yet can incorporate the quality of the candidates. This makes DPP a natural choice to balance the exploration-exploitation trade-off. Incorporating the quality component, however, requires careful considerations which is a primary goal of this project. DPP can be successfully utilized for generating representative candidates as well as selecting informative subsets for expensive evaluations.

2 - Bayesian Optimization is Superior to Random Search for Machine Learning Hyperparameter Tuning: Analysis of the Black-box Optimization Challenge 2020
Ryan Turner, Twitter, San Francisco, CA, United States, David Eriksson, David Eriksson, Michael McCourt, Juha Kiili, Eero Laaksonen, Zhen Xu, Isabelle Guyon

This paper presents the results and insights from the black-box optimization (BBO) challenge at NeurIPS 2020. The challenge emphasized the importance of evaluating derivative-free optimizers for tuning the hyperparameters of machine learning models. This was the first black-box optimization challenge with a machine learning emphasis. It was based on tuning (validation set) performance of standard machine learning models on real datasets. This competition has widespread impact as black-box optimization is relevant for hyperparameter tuning in almost every machine learning project as well as many applications outside of machine learning. The final leaderboard was determined using the optimization performance on held-out (hidden) objective functions. Baselines were set using several open-source black-box optimization packages as well as random search.

3 - Smart-Replication for Black-Box Optimization under Uncertainty

Hadis Anahideh, University of Illinois at Chicago, Chicago, IL, 60654-4907, United States, Jay Michael Rosenberger, Victoria C. P. Chen

Optimizing high-dimensional expensive black-box systems under uncertainty is an extremely challenging problem. As a resolution, we develop a novel replication approach called Smart-Replication to overcome the uncertainties associated with the black-box output. The Smart-Replication approach identifies promising input points to replicate and avoids unnecessary evaluations of other data points. It is agnostic to the choice of a surrogate and can adapt itself to an unknown noise level. We demonstrate the effectiveness of the Smart-Replication approach using interpolating and non-interpolating surrogates on different complex global optimization test functions.

■ TB10

CC Room 304B

In Person: Data Analytics in Agriculture

General Session

Chair: Fatemeh Amini, Iowa State University, Ames, IA, 50014, United States

1 - Sparse Testing (ST) in Plant Breeding

Reka Howard, University of Nebraska-Lincoln, Lincoln, NE, 68583, United States

Sparse testing (ST) in plant breeding is the situation where not all genotypes of interest are grown in each environment. Using genomic prediction and genotype x environment interaction (GE), the non-observed genotype-in-environment combinations can be predicted. The accuracy of predicting the unobserved data depends on (1) how many genotypes overlap between environments, (2) in how many environments each genotype is grown, and (3) which prediction method is used. Here, we studied the predictive ability obtained when using a fixed number of plots and different ST designs. The empirical study was based on maize hybrid data collected in three environments. Three different prediction models were implemented, two main effects models, and a model including the GE term. The GE model had higher prediction accuracy than the other models for the different allocation scenarios.

2 - Agricultural Genome to Phenome Initiative: Shared Data Science Across Crop and Livestock Communities

Jennifer Clarke, University of Nebraska-Lincoln, Lincoln, NE, United States, Jack Dekkers, Carolyn Lawrence-Dill, Eric Lyons, Brenda Murdoch, Patrick Schnable, Christopher Tuggle

To achieve sustainable genetic improvements of agricultural species, the expertise of a broad community of agricultural researchers must be engaged from both crop and livestock communities. This includes integrative disciplines such as statistics and the data and engineering sciences. The objective of the Agricultural Genome to Phenome Initiative (AG2PI) is to assemble and prepare a transdisciplinary community to conduct AG2P research. To accomplish this, AG2PI seeks to engage a broad and diverse researcher community through Field Days, Conferences, Training workshops, and Seed grants. In this presentation we will provide an overview of AG2PI and highlight examples of AG2P data science research. We will provide information about AG2PI activities including seed grants to support projects that will develop and enable FAIR data science in agricultural contexts.

3 - Blockchain Technology and the Sustainable Supply Chain: Theoretically Exploring Adoption Barriers

Sara Saberi, Worcester Polytechnic Institute (WPI), Worcester, MA, 1609, United States, Mahtab Kouhizadeh, Joseph Sarkis

In this study, the technology-organization-environment framework andforce field theories are utilized to investigate blockchain adoption barriers. Using various literature streams on technology, organizational practices, and sustainability, a comprehensive overview of barriers for adopting blockchain technology to manage sustainable supply chains is provided. The barriers are explored using technology, organizational, and environmental supply chain and external framework followed by inputs from academics and industry experts and then analyzed using the Decision-Making Trial and Evaluation Laboratory (DEMATEL) tool. The results show that supply chain and technological barriers are the most critical barriers among both academics and industry experts.

4 - Nonlinear Multi-objective Optimization Selection Strategy In Multi-trait Genomic Selection

Fatemeh Amini, Iowa State University, Ames, IA, 50014-7776, United States, Guiping Hu, Lizhi Wang

Genomic Selection mostly aims at using genotypic data to identify elite breeding parents and the mating strategy to enhance only one trait at a time. Although some of the research address multi-trait genomic selection which improves multiple traits simultaneously, they mostly use linear index selection in identifying elite breeding parents. In this paper, we proposed a nonlinear selection approach that adopts a nonlinear multi-objective optimization function which can be adopted with any desired mating strategy. A simulation platform is designed to compare the optimal Pareto Frontier of performance of different selection strategies in the final generation of SAM maize dataset. The results demonstrate that the nonlinear multi-objective approach outperforms linear index selection, considering both continuous and discrete traits.

■ TB11

CC Room 304C

In Person: Economics and Computation IV

Award Session

Chair: Ali Aouad, London Business School, London, NW6 4TG, United Kingdom

1 - Fair Dynamic Rationing

Scott Rodilitz, Yale, New Haven, CT, United States, Vahideh Manshadi, Rad Niazadeh

We study the allocative challenges that governmental and nonprofit organizations face when rationing of a social good among agents whose needs (demands) realize sequentially and are possibly correlated. To better achieve equity and efficiency in such contexts, social planners intend to maximize the minimum fill rate across agents. We show that a simple adaptive policy of projected proportional allocation achieves the best possible expected minimum fill rate (ex-post fairness) and minimum expected fill rate (ex-ante fairness). Our policy is transparent and easy to implement, and we demonstrate its effectiveness with a numerical study motivated by the rationing of COVID-19 medical supplies.

2 - The Limits to Learning a Diffusion Model

Andrew Zheng, Massachusetts Institute of Technology, Cambridge, MA, United States, Vivek Farias, Jackie W. Baek, Tianyi Peng, Joshua T. Wilde, Deeksha Sinha, Retsef Levi, Andreea Georgescu

We provide the first sample complexity lower bounds for the estimation of simple diffusion models, including the Bass model (for product adoption) and the SIR model (for epidemics). For Bass models with low innovation rates, our results imply that one cannot predict the eventual number of adopting customers until one is at least two-thirds of the way to the time at which the rate of new adopters is at its peak. For the SIR model, one cannot predict the eventual number of infections until one is approximately two-thirds of the way to the time at which the infection rate has peaked. These limits are borne out in both product adoption data (Amazon), as well as epidemic data (COVID-19).

3 - Incomplete Information VCG Contracts for Common Agency

Elisheva S. Shamash, PhD student, Technion, Haifa, Israel, Tal Alon, Ron Lavi, Inbal Talgam-Cohen

We study contract design for welfare maximization in the ``common agency" model [Bernheim and Whinston,1986], coordinating multiple principals with incomplete information of agent's action. Extending complete-information VCG contracts [Lavi and Shamash, 2019] to incomplete information,we characterize ``incomplete information VCG contracts (IIVCG)", and show uniquness guaranteeing truthfulness and welfare maximization. We reveal a tradeoff between individual rationality and limited liability, which insure participation. We design a polynomial-time algorithm determining whether a setting has an IIVCG contract with both properties, and if possible, returning such a contract.

4 - Dynamic Pricing and Learning under the Bass Model

Steven Yin, Columbia University, New York, NY, United States, Shipra Agrawal, Assaf Zeevi

We consider a novel formulation of the dynamic pricing and demand learning problem, where the evolution of demand in response to posted prices is governed by a stochastic variant of the popular Bass model with parameters (α, β) representing the so-called "innovation" and "imitation" effects. In this model the posted price not only affects the demand in the current round but also the future evolution of demand. Our main contribution is the development of an algorithm that satisfies a high probability regret guarantee of order $\tilde O(m^{2/3})$; where the market size m is known a priori. Moreover, we show that no algorithm can incur smaller order of loss by deriving a matching lower bound.

5 - Online Assortment Optimization for Two-sided Matching Platforms

Ali Aouad, London Business School, London, United Kingdom, Daniela Saban

Motivated by online labor platforms, we study a two-sided online assortment optimization problem. Each customer arrives and requests to match with a supplier out of the displayed assortment; subsequently, suppliers make choice decisions over the set of requests they received. We show that myopic algorithms attain the best-possible competitive ratio for this problem under general rank-based choice models. We devise "preference-aware" balancing algorithms that achieve higher competitive ratios under logit-based choice models. Interestingly, the performance of online algorithms is tightly connected to the structure of the supplier-side choice model.

■ TB12

CC Room 304D

In Person: Railroad Maintenance

General Session

Chair: Faeze Ghofrani, Penn State Altoona, PA, United States

1 - Automatic Train Dispatching: A Real-life Application in the Greater Oslo Region

Carlo Mannino, SINTEF Digital, Oslo, Norway, Giorgio Sartor, Andreas Nakkerud, Oddvar Kloster, Christian Schulz, Bjørnutar Leberget, Giorgio Grani

Serving more than a million residents, the railway network of the Greater Oslo Region is composed of several lines incident to the large Oslo central station (Oslo S). An ongoing project with Bane NOR, the Norwegian infrastructure manager aims at developing a system to dispatch trains for the entire region. A prototype of such system is currently being tested by Bane NOR dispatchers. It uses mathematical optimization and decomposition to find optimal schedules (every few seconds) based on the real-time train positions and the network status. To our knowledge, this is the largest real-life application of automatic train dispatching in Europe.

2 - Inspection Technologies for Reliable Railway Transportation Systems

Faeze Ghofrani, Assistant Teaching Professor, Pennsylvania State University, Altoona, PA, 16803, United States

This study delivers an in-depth review of the state-of-the-art technologies relevant to inspection technologies giving emphasis to their use in railroad systems. The review not only looks at the research being carried out but also investigates the commercial products available for railroad systems inspection. It continues further to identify the methods suitable to be adopted in a moving vehicle detection system. Even though flaw detection has been a well-researched area for decades, an in-depth review summarizing all available technologies together with an assessment of their capabilities has not been provided in the recent past according to the knowledge of the authors. As such, it is believed that this study will be a good source of information for future researchers in this area.

■ TB13

CC Room 201A

In Person: Models of Learning and Experimentation in OM

General Session

Chair: Vikas Deep, Northwestern University, Evanston, IL, United States

1 - Markdown Pricing under Unknown Demand

Su Jia, Carnegie Mellon University, Pittsburgh, PA, United States

Dynamic pricing problem has been extensively studied recently. Naturally, people formulate such problems as variants of the MAB problems. Although bandits problems have been well understood from the theoretical perspective, bandit based pricing policies are rarely deployed in practice, mainly because they often overlooked some practical constraints. In this work, we consider the dynamic pricing problem under the monotonicity constraint, i.e. markdown pricing. We provide a complete settlement of the problem by providing simple, efficient markdown policies, with best possible theoretical guarantees, for each of those settings.

2 - Discriminative Learning via Adaptive Questioning

Vikas Deep, Northwestern University, Evanston, IL, United States, Sandeep Juneja, Achal Bassamboo, Assaf Zeevi

We consider the problem of designing an adaptive sequence of questions of varying degree of hardness thatoptimally classify a candidate's ability into one of several categories or discriminative grades. A candidate'sability is modeled as an unknown parameter, which, together with the difficulty of the question asked,determines the probability with which s/he is able to answer a question correctly. The learning algorithm isonly able to observe noisy responses to its queries. We consider this problem from a fixed confidence-based -correct framework, that in our setting seeks to arrive at the correct ability discrimination at the fastestpossible rate while guaranteeing that the probability of error is less than a pre-specified and small .

■ TB14

CC Room 201B

In Person: Reinforcement Learning with Engineering Applications II

General Session

Chair: Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, 02115-5005, United States

Co-Chair: Ashwin Devanga, Northeastern University, Boston, MA, 02120, United States

1 - Building Data Mining Test Environments to compare performance of different Algorithms including Reinforcement Learning

Ashwin Devanga, Northeastern University, Boston, MA, United States, Mohammad Dehghanimohammadabadi

We are working on a project called DM-Gym, an open-source python library for developing reinforcement learning (RL) algorithms to address data mining (DM) problems, and a testbed for creating multiple DM environments for RL such as regression, and classification. DM-Gym provides a new toolkit for the machine learning community to explore the capabilities of RL in solving data mining benchmarks.

2 - Reinforcement Learning Applications in Engineering using MATLAB

Mohammad Dehghanimohammadabadi, Northeastern University, Snell Engineering Center, Boston, MA, 02115-5005, United States, Sahil Belsare, Rifat Sipah

The project demonstrates RL's capabilities of providing insightful results to the Engineering problems using MATLAB Environment. Tutorials from different domains such as HVAC control, Financial Portfolio management, Cart-Pole control, and Robotics are designed to (i) teach RL concepts, (ii) provide guidelines to create and develop engineering problem environments, and (iii) apply different RL and deep RL technique to solve them.

3 - The Third-Party Logistics Provider Freight Management Problem: A Reinforcement Learning Approach

Amin Abbasi Pooya, University of Kansas, Lawrence, KS, 66045, United States, Michael Lash

Third-party logistic (3PL) providers act as external entities that provide companies with partial/full logistics services. Contracting to 3PL providers allows companies to focus on their primary business objectives, while maintaining a consistent flow of products through their supply chains. We propose a framework that captures the salient objectives involved in the so-called "freight management problem" (FMP) faced by 3PL providers. To solve the FMP, we adopt Reinforcement Learning (RL) approaches, which permit the efficient learning of policies without making restricting assumptions. We find that RL methods substantially outperform adopted heuristics on simulated and real-world data.

■ TB15

CC Room 201C

In Person: Advances in Customers Behavior Analytics and Modeling

General Session

Chair: Yichen Ding, University of Iowa, Iowa City, IA, 52246-2872, United States

Co-Chair: Amin Hosseininasab, University of Florida, Gainesville, FL, 32611-1942, United States

1 - From Favorited to Fear: An Empirical Investigation of Customer Emotions and Behavior of Online Customers After Data Breaches

John N. Angelis, University of Maine, Orono, ME, 24504, United States, Rajendran Murthy, Tanya Beaulieu, Joseph Miller

Previous empirical papers on data theft crimes often ask respondents to imagine that a well-known company has been hacked and then measures their response. We improved this design by first having respondents pick a favorite free or paid website and then presenting them with a data breach scenario involving their account or the entire site. Using automated textual analysis, we discover that only fear has a significant effect on breached customer behavior, and the customers who most likely to express positive sentiment pre-breach do not significantly differ in their post-breach behavior.

2 - Behavioral Analysis of Consumer Return Policy Decisions

Han Oh, Mays Business School, Texas A&M University, College Station, TX, United States, Huseyn Abdulla, Rogelio Oliva

We investigate consumer return policies recognized and studied by operations management scholars as an important managerial decision in a retail environment. Our research investigates, through randomized experiments, the behavioral aspects of return policy decisions and their interaction with other operational decisions.

3 - Understanding Road Users' Behavior from Egocentric Video Data
Yichen Ding, University of Iowa, Iowa City, IA, 52246-2872, United States

Based on road users' trip record data, we use deep learning methods to model and forecast their responses to the various traffic conditions and reactions in the complex road environment. Furthermore, we provide some case studies to generate insights on how to keep these road users safe and bring inspiration to facilitate the behavioral studies.

4 - Modeling Lengthy Behavioral Log Data for Customer Churn Management
Daehwan Ahn, Post Doc, University of Pennsylvania, Philadelphia, PA, 19130, United States, Dokyun Lee, Kartik Hosanagar

Churn management has benefited much from advanced feature learning techniques applied to large-scale behavioral log data. Despite its success, the current models can only address sequences of short length ranging from hundreds to thousands. In practice, however, customer log data has a very long sequence that can extend to millions in length that can only be utilized through manual and onerous feature engineering, which requires domain expertise and can be unreliable depending on the data scientist. We propose an automated log-processing approach that extends powerful feature learning approaches to extract valuable signals from lengthy log data. Our proposed framework achieves a significant improvement in customer churn prediction relative to existing manual feature engineering approaches developed by a global game company.

■ TB16

CC Room 201D

In Person: Reinforcement Learning

General Session

Chair: Zaiwei Chen, Georgia Institute of Technology, Atlanta, GA, 30318, United States

1 - Finite Sample Analysis of Off-policy Natural Actor-critic Algorithm
Sajad Khodadadian, Georgia Institute of Technology, Atlanta, GA, United States

In this paper, we provide finite-sample convergence guarantees for an off-policy variant of the natural actor-critic (NAC) algorithm based on Importance Sampling. In particular, we show that the algorithm converges to a global optimal policy with a sample complexity of O(-3log2(1/)) under an appropriate choice of stepsizes. In order to overcome the issue of large variance due to Importance Sampling, we propose the Q-trace algorithm for the critic, which is inspired by the V-trace algorithm. This enables us to explicitly control the bias and variance, and characterize the trade-off between them. As an advantage of off-policy sampling, a major feature of our result is that we do not need any additional assumptions, beyond the ergodicity of the Markov chain induced by the behavior policy.

2 - Finite-Sample Analysis Of Reinforcement Learning Algorithms: A Lyapunov Approach
Zaiwei Chen, Georgia Institute of Technology, Atlanta, GA, 30318, United States

This paper develops an unified framework to study finite-sample convergence guarantees of a large class of value-based asynchronous Reinforcement Learning (RL) algorithms. We do this by first reformulating the RL algorithms as Markovian Stochastic Approximation (SA) algorithms to solve fixed-point equations. We then develop a Lyapunov analysis and derive mean-square error bounds on the convergence of the Markovian SA. Based on this result, we establish finite-sample convergence bounds for asynchronous RL algorithms such as Q-learning, n-step TD, TD(\lambda), and off-policy V-trace. As a by-product, by analyzing the performance bounds of the TD(\lambda) (and n-step TD) algorithm for general \lambda (and n), we demonstrate a bias-variance trade-off, i.e., efficiency of bootstrapping in RL. This was first posed as an open problem in (Sutton, 1999).

■ TB17

CC Room 202A

In Person: Optimization Techniques for Airline Industry

General Session

Chair: Xiaodong Luo, Professor, Chinese University of Hong Kong, ShenZhen Campus, ShenZhen, Guangdong province, China, China

1 - Efficient Performance Bounds For Online Decisions On Large Time-space Networks
Lavanya Marla, U of Illinois at Urbana-Champaign, Urbana, IL, 61801-2925, United States

Performance evaluation frameworks for problems involving online stochastic combinatorial optimization are nearly always based on offline or omniscient bounds. While improved primal policies can be obtained using machine learning approaches, very little progress has occurred on finding dual (omniscient) bounds. We present a novel methodology to construct tighter performance bounds for dynamic resource allocation problems modeled on time-space networks.

2 - Demand Estimation for Low Cost Carriers
Xiaodong Luo, Professor, Chinese University of Hong Kong, ShenZhen Campus, ShenZhen, Guangdong Province, China, Xiaodong Luo

We present some interesting ideas for demand estimation/untruncation for low cost carriers. We will use a simplified spiked MNL model and then use advanced nonlinear programming such as majorization minimization/Frank Wolfe method to solve the underlying non-convex optimization problems. We will compare it with other MNL models and other expectation maximization methods.

■ TB18

CC Room 202B

In Person: Improving Distributed Energy Generation and Resilient Microgrid Modeling

General Session

Chair: Andrew MacMillan, Carleton University, Ottawa, ON, Canada

1 - Characterizing Wind Power Curtailment in Ercot
Kristen Schell, Assistant Professor, Carleton University, Ottawa, ON, 12180-3522, Canada

Curtailment of renewable energy occurs when the power system cannot accept the power available from the renewable generator, so this power is "spilled", or not used. Curtailment can happen in a power system for many reasons market and dispatch decision, transmission constraints, errors in forecasting as the power grid is constantly balancing supply and demand. Using data from the power system operator of Texas, ERCOT, two models are developed to: 1) characterize the extent of wind power curtailment and 2) quantify the opportunity cost of past curtailment practices.

2 - Robust and Cost-effective Microgrid Design for Equitable Climate Resilience: A Case Study of West Oakland's Resilience Hub Project
Papa Yaw Owusu-Obeng, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States

Microgrids can maintain power to critical loads in events of utility power outages caused by extreme weather. This is useful in building resilience to climate crisis—as seen in the 2020 California heat wave and 2021 Texas winter storm where vulnerable populations depended on facilities with microgrids for essential energy services. This has driven the demand for resilience hubs to provide equitable energy access to low-income communities in the event of power outage. The challenge however is that the concept of resilience hub microgrids are new and there is no blueprint for robust and cost-effective design. This work presents advancement on two fronts: 1) energy efficiency analysis to determine the optimal energy conservation measures for resilience hubs, and 2) a multi-objective optimization model for least cost microgrid design to accommodate extended power outages.

3 - Predicting Hydrokinetic Power Potential in Short Stream Reaches Via Remote Sensing Methods
Andrew MacMillan, Carleton University, Ottawa, ON, Canada

Hydrokinetic power is a promising technology to address energy security issues for rural communities. Predicting the power potential of a location via resource assessment is a crucial first step in planning new energy projects. This is important for screening out locations and determining where on-site data collection is warranted. Recent studies have used digital elevation datasets to remotely predict flow characteristics where on-site data was not available. However, the studies focused on broader watershed regions and large rivers rather than specific locations. This study seeks to apply remote sensing methods to specific stream segments and smaller rivers for hydrokinetic feasibility and to validate it against obtained ADCP data from site measurements. Results provide insights into adapting first-principles equations of river flow to shorter stream reaches.

■ TB20

CC Room 203B

In Person: Data-driven Modeling for Disease Management

General Session

Chair: Gizem Nemutlu, Brandeis University, Waltham, MA, 01803-3872, United States

1 - Determining the Optimal Covid-19 Testing Centre Locations and Capacities Considering the Disease Dynamics and Target Populations

Esma Akgun, University of Waterloo, Waterloo, ON, N2L 6P1, Canada, Sibel Alumur Alev, F. Safa Erenay

Testing individuals at risk to identify COVID-19 infections and isolating them help control and mitigate the pandemic. However, during the peaks, the existing testing capacity may need to be expanded. We develop a location and capacity allocation model integrated with an SEIR model to determine the optimal locations of new pop-up testing centers, capacities of the existing centres, and the assignments of demand regions to the testing centres considering time-variant testing demand due to ever-changing disease prevalence. The objective function is to minimize the total distance traveled subject to budget and capacity constraints. We applied the model to the case of Ontario, Canada using real data.

2 - Limits of Capacity Flexibility: Impact of Hallway Placement on Patient Flow and Quality of Care in the Emergency Department

Arshya Feizi, PhD Candidate, Boston University, Boston, MA, 02134, United States, William Baker

A common practice in busy emergency departments (EDs) is to admit patients from the waiting area to hallway beds as the regular beds fill up. Using data from a large ED, we first perform a causal analysis to quantify the impact of hallway placement on wait times and quality of care as defined by disposition time, ED length of stay (LOS) and likelihood of adverse outcomes. Next, we perform a counterfactual analysis using a data-driven simulation of the ED to find better hallway usage policies. We find that a pooling policy, where hallway beds are used only if all regular beds are full, has the greatest impact on reducing wait times, albeit at the cost of higher hallway utilization. Also, too little or too much wait tolerance for rooming patients may result in over- or under-utilization of the hallway space, both of which are detrimental to ED average throughput times and wait times.

3 - Liver Cancer Surveillance in the Era of New Hepatitis C Antiviral Treatments: A Value of Information Analysis

Gizem S. Nemutlu, Brandeis University, Waltham, MA, 01803-3872, United States, Jagpreet Chhatwal

The treatment landscape for chronic hepatitis C has changed with the use of direct-acting antivirals; 95-100% of individuals with hepatitis C can now be cured. However, the risk of liver cancer is not eliminated for individuals with advanced liver disease. The value of routine cancer surveillance in this population is widely debated; long-term data on liver cancer incidence is lacking. Our objective was to evaluate the value for future research on liver cancer surveillance in hepatitis C cured individuals using a validated microsimulation model. We estimated the cost-effectiveness of routine surveillance and performed a value of information analysis informed by the population-level expected value of perfect information to determine the value of future research. Our analysis showed that the routine surveillance was cost-effective only in individuals with cirrhosis.

■ TB22

CC Room 204B

In Person: Healthcare: Incentives and Operations

General Session

Chair: Alon Bergman, University of Pennsylvania, Wynnewood, PA, 19096, United States

1 - Scheduling Smarter: Scheduling Decision Impact on Nurse-Aide Turnover

Kevin Mayo, Indiana University, Bloomington, IN, 47408, United States, Eric Michael Webb, George Ball, Kurt M. Bretthauer

High turnover rates in long-term nursing facilities exacerbates the current and worsening shortage of caregivers. Part-time Certified Nursing Assistants (CNAs) provide a significant amount of patient care in these facilities and have high turnover rates, potentially harming health outcomes and increasing cost of care. We empirically analyze the effect of scheduling decisions on part-time CNA turnover. Using novel data for 6,221 part-time CNAs at 157 facilities over a 26-month period, we identify three scheduling levers that can reduce turnover: reducing co-worker variability, reducing variation in weekly scheduling and increasing hours worked which follows a nuanced non-linear relationship. These findings suggest that smart managers will benefit from identifying quality workers and assigning them more consistent schedules as part of a team.

2 - Designing Physician Payments for Diagnostic Accuracy under Limited Outcome Visibility

Elodie Adida, University of California-Riverside, Riverside, CA, 92521-9800, United States, Tinglong Dai

The prevailing payment system in the U.S. does not sufficiently incentivize physicians to exert diagnostic effort. Meanwhile, misdiagnosis remains frequent and hard to keep track of. In this paper, we develop a model to analyze the effect of a fee-for-service payment system on diagnostic accuracy, physician effort, and social welfare for a given condition. We consider a partially altruistic physician who may (1) exert costly but non-reimbursable effort and/or (2) order a reimbursable diagnostic test that is costly to the patient. Exerting effort generates an imperfect signal, whereas performing a test detects the patient's true condition. We also analyze a diagnosis-based payment system and study how to best approach the socially optimal outcome.

3 - The Role of Schedule Volatility in Employee Turnover: The Case of Home Health Care

Alon Bergman, Postdoctoral Scholar, University of Pennsylvania, Philadelphia, PA, United States, Guy David, Hummy Song

High rates of employee turnover increase employee search costs and training costs, and can contribute to the loss of organizational knowledge and productivity. In the case of licensed nurses, high job turnover is likely to raise healthcare costs and reduce its quality. This paper identifies schedule volatility, an operationally measurable element, to be a key determinant of nursing turnover in home health care. Using administrative data from a large home health agency, we define and document different measures of worker schedule volatility, and recover causal estimates for the effect of schedule volatility on nurses' voluntary separation (quitting) using an IV approach. We then consider several counterfactual scheduling policies. Through simulations, we calculate the counterfactual schedule volatility resulting from each policy and its effect on nursing turnover.

■ TB23

CC Room 204C

In Person: Theoretical and Empirical Models in Service Operations

General Session

Chair: Lina Wang, Arizona State University, Scottsdale, AZ, 85257, United States

1 - The Impact of Piracy on Movie Distribution

Franco Berbeglia, Professor, Purdue University, West Lafayette, IN, 15232-2962, United States, Timothy Derdenger, Michael D. Smith, Rahul Telang

We develop and estimate a dynamic discrete choice model that embeds piracy downloads as a substitute for legal distribution channels. In general, high quality pirated movies become available as soon as there is a home video released in some market, which then impacts demand in all other markets, as piracy belongs to a unique global market. The current problem in the industry is that home video releases are optimized locally, without considering the impacts created by piracy on other markets. Even though piracy may not be eliminated; it can be controlled by choosing the release timing of foreign releases more wisely. Through counterfactuals, our model can predict the impact on studio revenues of delaying piracy, which may inform business practitioners about the trade-off they face when optimizing local home video releases.

2 - Delegation with Technology Migration: An Empirical Analysis of Mobile Virtual Network Operators

Fan Zou, University of South Carolina, West Columbia, SC, 29169, United States, Yan Dong, Kejia Hu, Sriram Venkataraman

This study examines the impact of mobile virtual network operators (MVNOs) on the performance of mobile network operators (MNOs) in the presence of overlapping generations of wireless mobile technologies (2G and 3G). MVNOs distribute MNOs' mobile services to customers without owning any spectrum or network infrastructures. Some MVNOs are wholly owned by MNOs with a revenue-sharing mechanism (branded MVNOs), while others operate through wholesale agreements with MNOs (third-party MVNOs). By focusing on the impact of MVNOs on MNOs' performance, we investigate governance issues, e.g., delegation vs. ownership, in value chains with overlapping generations of technologies.

3 - An Analysis of Operating Efficiency and Public Policy Implications in Last-Mile Transportation Following Amazon's Vertical Integration

Lina Wang, Arizona State University, Tempe, AZ, 85257, United States, Elliot Rabinovich, Harish Guda

We examine how Amazon's decision to vertically integrate its retail platform and last-mile delivery operations can lead to anticompetitive outcomes as a result of a deterioration in the operating efficiency in the routes served by a last-mile transportation firm. We also expand on public policy measures that can ameliorate these outcomes. Based on an operational analysis of the last mile transportation firm, we find that Amazon's decision to vertically integrate increased significantly the mileage necessary to deliver parcels in the ZIP code areas where this integration occurred. Moreover, this increase was significantly amplified by the remoteness and proportion of fast deliveries in these areas.

■ TB24

CC Room 205A

In Person: Emerging Topics in Revenue Management

General Session

Chair: Chin-Chia Hsu, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

1 - Dynamic Pricing and Demand Learning for a Large Network of Products

Prem Talwai, MIT, Cambridge, MA, 02142, United States, N. Bora Keskin, David Simchi-Levi

We consider a seller offering a large network of N products over a time horizon of T periods. The seller does not know the products' demand model and can dynamically adjust product prices to learn the demand model based on sales observations. The seller aims to minimize its regret, i.e., the revenue loss relative to a clairvoyant who knows the underlying demand model. We consider a sparse set of demand relationships between products, and design a dynamic pricing-and-learning policy that achieves near-optimal regret performance in terms of N and T. We also show that under certain sparsity conditions, the seller's regret can be independent of N.

2 - Hotel Demand Forecasting Using a Time Varying Arrival Rate

Alexander Robinson, University of California-Irvine, Long Beach, CA, 90815-4362, United States, John G. Turner

Effective pricing is important in the hotel industry. Especially for budget hotels, price is frequently the primary point of differentiation for a customer. Estimating a function price-dependent demand function presents a number of challenges, including endogeneity and censored data. In this paper, we address these issues by modeling demand as the product of a time-varying arrival probability and purchase probability. We adapt the Expectation Maximization (EM) algorithm to estimate these probabilities separately. We also present a variant of EM that can make convergence time up to 90% faster, with little to no loss of prediction accuracy.

3 - Persuasion, News Sharing, and Cascades on Social Networks

Chin-Chia Hsu, PhD Candidate, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Amir Ajorlou, Ali Jadbabaie

We study a model of online news dissemination on a Twitter-like social network. Given a news item and its credibility, agents with heterogeneous priors strategically decide whether to share the news with their followers. An agent shares the news, if the news can persuade her followers to take an action (such as voting) in line with the agent's perspectives. We describe the agent's decision making and the conditions that lead to sharing the news with followers, and characterize the size of news spread at the equilibrium of the news-sharing game. We further identify the conditions under which the news with low credibility can spread wider than highly credible news. In particular, we show that when the network is highly-connected or the news is not a "tail event", a sharing cascade can occur even with news that is not credible.

■ TB26

CC Room 206A

In Person: Mixed-integer Optimization in Defense Applications

General Session

Chair: Robert Mark Curry, United States Naval Academy, Annapolis, MD, 21403-4616, United States

1 - Robust Minimum-Cost Flow Problems under Multiple Ripple Effect Disruptions

Mehdi Ansari, Oklahoma State University, Stillwater, OK, United States, Juan Sebastian Borrero, Leonardo Lozano

We study multi ripple effect disruptions over a network as a defender-attacker optimization problem. The defender acts on an uncertain objective function whose parameters are determined by the attacker who operates multi disruptions on the network. A cutting generation algorithm is presented to find the robust optimal solution of the bilevel programming. The attacker solves a mixed-integer programming on an uncertainty set to identify the worst realization of parameters. In this regard, two different cost functions are proposed and the formulation of the subproblem has been modified to enhance the performance of the method. The algorithm has been tested on generated grid networks and real-world datasets. The results help decision-makers to react immediately after severe disruptions like earthquakes in the populated urban areas.

2 - Integer Programming Models for Optimal Naval Placement in Contested Waters

Robert Mark Curry, United States Naval Academy, Annapolis, MD, 21403-4616, United States

Territorial claims in contested maritime settings have long been disputed. Some actors proceed by claiming previously unoccupied islands and creating massive artificial islands in order to make significant progress in expanding financial and military control over these waters. In order to halt this expansion, we assume a country's naval forces are able to fortify islands either already occupied or currently occupied by an ally force. We explore a variety of methods for determining the valuation of islands in contested waters. We next formulate and solve an integer program to build a tree of islands that maximizes the total value of occupied islands. We then analyze the sensitivity of our solutions to determine their efficacy under varying parameters. Finally, we explore a novel interdiction problem in which the adversary reacts optimally to our naval placement decision.

■ TB27

CC Room 206B

In Person: Recent Advances in Stochastic Gradient Algorithms

General Session

Chair: Lam M. Nguyen, IBM Thomas J. Watson Research Center, Ossining, NY, 10562-6037, United States

Co-Chair: Trang H Tran, Cornell University, NY, United States

1 - Shuffling Gradient-Based Methods

Trang Tran, Cornell University, Ithaca, NY, United States, Lam M. Nguyen, Quoc Tran Dinh, Katya Scheinberg

We combine two advanced ideas widely used in optimization for machine learning: shuffling strategy and momentum technique to develop a novel method with momentum for finite-sum minimization problems. We establish that our algorithm achieves a state-of-the-art convergence rate for any shuffling strategy under standard assumptions. In particular, if a random shuffling strategy is used, we can further improve our convergence rate by a fraction of the data size. When the shuffling strategy is fixed, we develop another new algorithm that is similar to existing momentum methods. We prove the same convergence rate of this algorithm under the L-smoothness and bounded gradient assumptions. We demonstrate our algorithms via numerical simulations on standard datasets and compare them with existing shuffling methods.

2 - Hogwild! Over Distributed Local Data Sets with Linearly Increasing Mini-batch Sizes
Lam M. Nguyen, IBM Thomas J. Watson Research Center, Ossining, NY, 10562-6037, United States

We consider big data analysis where training data is distributed among local data sets in a heterogeneous way and we wish to move SGD computations to local compute nodes where local data resides. The results of these local SGD computations are aggregated by a central "aggregator" which mimics Hogwild!. We show how local compute nodes can start choosing small mini-batch sizes which increase to larger ones in order to reduce communication cost. We improve state-of-the-art literature and show O(K^{0.5}) communication rounds for heterogeneous data for strongly convex problems, where K is the total number of gradient computations across all local compute nodes. For our scheme, we prove a tight and novel non-trivial convergence analysis for strongly convex problems for heterogeneous data which does not use the bounded gradient assumption as seen in many existing publications.

■ TB28

CC Room 207B

In Person: Robust Optimization for Machine Learning

General Session

Chair: Phebe Vayanos, University of Southern California, Los Angeles, CA, 90089, United States

1 - New Algorithms and Complexity Analysis for Distributionally Robust Multistage Convex Optimization
Shixuan Zhang, Georgia Institute of Technology, Atlanta, GA, United States, Andy Sun

We present a novel algorithmic study and complexity analysis of stagewise independent distributionally robust multistage convex optimization (DR-MCO). A new class of dual dynamic programming (DDP) algorithms for solving DR-MCO is proposed. The new algorithms generalize existing DDP-type algorithms by introducing the technique of regularization that enables the algorithms to handle fast growth of Lipschitz constants, and problems without relatively complete recourse. We then provide a thorough complexity analysis of the new algorithms, proving both upper complexity bounds and a matching lower bound. Numerical examples are given to show the effectiveness of the proposed algorithms.

2 - Competitive Pricing in Airline Revenue Management with Multi-agent Reinforcement Learning
Shulu Chen, George Washington University, Washington D.C, DC, United States, Syed A. Shihab, Peng Wei

We explore the application of multi-agent reinforcement learning (MARL) in airline revenue management (RM) in a competitive market. By extending our group's research of DRL in airline pricing, this research uses multi-agent reinforcement learning to observe certain competitors' information and make learning-based decisions under uncertainty. We model two competitive agents in MARL frame as two competitive airline companies. At each time step, two airline companies will choose their price points respectively, according to their own remaining seats, time to departure, and competitor's price. We expect that the competitive MARL agents would have a better performance than the previous methods because of additional information and learning-based adaptive decision making.

3 - Optimal Robust Classification Trees
Nathan Justin, University of Southern California, Los Angeles, CA, United States, Andres Gomez, Phebe Vayanos, Sina Aghaei

In many high-stakes domains, the data used to drive machine learning algorithms is noisy (due to e.g., the sensitive nature of the data being collected, limited resources available to validate the data, etc). In this paper, motivated by the need for interpretability and robustness in these domains, we present an efficient MIP-based method for learning optimal classification trees that are robust to perturbations in the data features. We evaluate the performance of our approach on numerous publicly available datasets and show significant improvements over the state-of-the-art.

■ TB30

CC Room 207D

In Person: Fundamentals of Start-Ups

Panel Session

Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, United States

1 - Fundamentals of Start-Ups
Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, United States

Researchers and faculty members are increasingly engaging start-up opportunities that involve new and challenging issues in entrepreneurship, venture capital funding, and intellectual property rights. The panelists in this session will discuss their own experiences in pursuing start-up opportunities and creating companies.

2 - Panelist
Kamran Paynabar, ISyE Georgia Tech, Georgia Tech, H. Milton Stewart School Of Isye, Atlanta, GA, 30332-0205, United States

■ TB31

CC Room 208A

In Person: Data Markets

General Session

Chair: Azarakhsh Malekian, University of Toronto, Toronto, Canada

1 - Synthetic Interventions
Anish Agarwal

Consider a setting where there are N heterogeneous units (e.g., individuals, sub-populations) and D interventions (e.g., socio-economic policies). Our goal is to learn the potential outcome associated with every intervention on every unit (i.e., N x D causal parameters). Towards this, we present a causal framework, synthetic interventions (SI), to infer these N x D causal parameters while only observing each of the N units under at most two interventions, independent of D. This can be significant as the number of interventions, i.e, level of personalization, grows. Importantly, our estimator also allows for latent confounders that determine how interventions are assigned. Theoretically, under a novel tensor factor model across units, measurements, and interventions, we formally establish an identification result for each of these N x D causal parameters, and establish finite-sample consistency and asymptotic normality of our estimator. Empirically, we validate our framework through both experimental and observational case studies; namely, a large-scale A/B test performed on an e-commerce platform, a phase 3 clinical trial data from a pharmaceutical company, and an evaluation of mobility-restricting policies on COVID-19. We believe this has important implications for program evaluation and the design of data-efficient RCTs with heterogeneous units and multiple interventions.

2 - A Model of Behavioral Manipulation
Ali Makhdoumi, Duke University, Durham, NC, 27708-9972, United States

The default position among AI researchers is that the vast amounts of data collected by online platforms ultimately benefit users by providing them with more informative advertising, better-targeted products, and more personalized services. This talk raises and explores the possibility that this informational advantage may also enable platforms to engage in behavioral manipulation, which we define as the ability of platforms to modify the behavior of users in a way that is beneficial for the platform and costly for users.

■ TB32

CC Room 208B

In Person: mpi-sppy: Asynchronous Optimization under Uncertainty

General Session

Chair: David Woodruff, University of California Davis, CA, United States

1 - Asynchronous Projective Hedging: Introduction, Implementation, and Large-scale Computational Experiments Using mpi-sppy
Jean-Paul Watson, Senior Research Scientist, Lawrence Livermore National Laboratory, Livermore, CA, United States, David L. Woodruff, Jonathan Eckstein, Bernard Knueven

We describe a scenario-based decomposition algorithm Asynchronous Projective Hedging, or APH for multistage stochastic programming that resembles the progressive hedging method of Rockafeller and Wets, but is capable of asynchronous parallel operation without sacrificing theoretical convergence in the convex case. Perhaps more importantly, each iteration of the decomposition method may process only a subset of the possible scenarios. We discuss the implementation of APH in the mpi-sppy parallel library for stochastic programming, and detail large-scale computational experiments highlighting both the effectiveness of APH and the scalability (to tens of thousands of ranks) of mpi-sppy.

2 - Bounds and Confidence Intervals in mpi-sppy
David L. Woodruff, University of California, Davis, Davis, CA, 95616, United States, Xiaotie Chen, Bernard Knueven, Jean-paul Watson

mpi-sppy (https://github.com/Pyomo/mpi-sppy) is a software package to allow for optimization of Pyomo optimization models uncertainty. In thistalk we will overview design and performance considerations related to bounds and confidence intervals. Particular attention will be paid to issuesassociated with problems that have more than two stages and scenarios that do not exhibit stage-wise independence.

■ TB33

CC Room 209A

In Person: Learning and Optimization in Decision Making

General Session

Chair: Xiaoyue Gong, MIT, Cambridge, MA, 02139-4301, United States

1 - Chasing Convex Bodies Optimally
Mark Sellke, Stanford University

I will explain our recent understanding of the chasing convex bodies problem posed by Friedman and Linial in 1993. In this problem, a player receives a request sequence K_1,...,K_T of convex sets in d dimensional space and moves online into each requested set. The player's movement cost is the length of the resulting path. Chasing convex bodies asks to find an online algorithm with cost competitive against the offline (in hindsight) optimal path. This is equivalent to a competitive analysis view on online convex optimization. Obtaining any finite competitive ratio for this problem was open until 2018. We give an optimal algorithm based on an object from classical convex geometry known as the Steiner point.

2 - Simultaneous Learning of Consumer Preference Over Different Markets.
Fabricio Previgliano, University of Chicago, Chicago, IL, United States

We study the ranking and selection problem faced by a company that wants to identify the most prefered product among a finite set of alternatives when consumer preferences are unknown over different markets that may have similar characteristics. The company is able to sequentially display a subset of products to different customers on each market and ask them to report their top preference over the displayed set. The objective of the firm is to design a display policy that minimizes the expected number of samples needed to identify a top product on each market with a fixed high probability.

3 - Dynamic Planning and Learning under Recovering Rewards
Feng Zhu, MIT. IDSS, Boston, MA, United States, David Simchi-Levi, Zeyu Zheng

Motivated by emerging applications in promotions and recommendations, we introduce a general class of multi-armed bandit problems that satisifies: (i) at most K out of N different arms are allowed to be pulled in each time period; (ii) the expected reward of an arm immediately drops after it is pulled, and then non-parametrically recovers as the idle time increases. To maximize expected cumulative rewards over T time periods, we propose and prove performance guarantees for a class of "Purely Periodic Policies". For the offline problem when all model parameters are known, our proposed policy obtains an asymptotically tight approximation ratio that is at the order of 1-O(1/K1/2). For the online problem when the model parameters are unknown and need to be learned, we design an Upper Confidence Bound (UCB) based policy that has O(NT1/2) regret against the offline benchmark.

■ TB34

CC Room 209B

In Person: Service and Technology

General Session

Chair: Yiwei Wang, University of California-Irvine, Irvine, CA, 92617, United States

1 - An Empirical Examination of Food Waste in the Food Service Industry
Yu Nu, Cornell University, Ithaca, NY, United States, Karan Girotra, Elena Belavina

Roughly one third of food produced globally for human consumption is wasted each year, which has been a major contributor to carbon emissions. This paper studies the value of Al-enabled monitoring in the food service settings. Using synthetic control method, we analyze the staggered adoption of Winnow (new measurement tech of food waste) by more than 130 food service sites in the UK, and find an average reduction of 18%-20% in daily food waste around one week post-adoption. We explain site-heterogeneity in terms of their treatment effects through covariates of interest, and further examine the mechanisms of action that lead to the effect of Winnow, with a special focus on the changes in critical fractile.

2 - Does Customer Email Engagement Improve Profitability? Evidence From a Field Experiment of a Subscription-based Service Provider
Yiwei Wang, University of California-Irvine, Paul Merage School of Business, Irvine, CA, 92617, United States, Lauren Xiaoyuan Lu, Pengcheng Shi

This paper analyzes the outcome of a field experiment conducted by a large U.S. car wash chain, which offers subscription services to consumers and employs an RFID-based technology to track subscriber service events. We find that a one-month engagement with two emails separated by a half-month interval increased the likelihood of subscriber retention by 7.4% five months after the experiment started and decreased the subscriber churn odds by 26.3%. Meanwhile, we find that the same engagement increased a subscriber's per-period service consumption by 8.8%. Our study highlights that email engagement is a double-edged sword—it increases both customer retention and service consumption, and it may decrease profitability when the increased operating cost to serve retained customers outweighs the benefit of customer retention.

■ TB35

CC Room 210A

In Person: E-commerce logistics

General Session

Chair: Reem Khir, Georgia Institute of Technology, Atlanta, GA, United States

1 - Dynamic Containerized Consolidation in Urban Parcel Logistics
Sara Kaboudvand, ISyE Georgia Tech, Atlanta, GA, 30318, United States, Benoit Montreuil

Hub-based network structures are common in urban parcel logistics for better freight consolidation and economies of scale. However, sorting every parcel at (intermediate) hubs requires significant investment in real-estate, human, and machine resources and imposes extra waiting and processing times. Such re-sorting can be bypassed by smartly encapsulating parcels that share common service features and a subsequent destination. In this study, we formally describe the problem of dynamically consolidating parcels into containers of potentially different sizes, then present and compare four highly scalable heuristic policies. We provide empirical results and a set of sensitivity analyses using an agent-oriented discrete-event megacity logistics simulator developed by Georgia Tech's Physical Internet Center.

2 - Learning-based Online Decision-making in Multi-order Picking Environments
Jana Boerger, Georgia Tech, Atlanta, GA, United States, Marlin Wolf Ulmer, Benoit Montreuil

Promising their customers fast deliveries, retail companies and logistics providers need efficient warehouse processes, especially for the resource consuming order picking. Orders are unknown and are streaming in in real-time. Pickers perform repeated picking trips throughout the day. With a picking trolley or cobot, they move through the warehouse to pick items according to a pick list of ordered items. As multiple orders can be picked concurrently, controls need to carefully balance the trade-off between consolidation and timely fulfillment. Aiming for smart balancing, we present a reinforcement learning based decision-support algorithm and evaluate it through simulations based on real world data.

3 - Dynamic Parcel Consolidation and Containerization in Hyperconnected Logistic Hubs
Nidhima Grover, Graduate Research Assistant, Georgia Institute of Technology, Atlanta, GA, United States, Benoit Montreuil

In Physical Internet-based hyperconnected logistics, parcels are consolidated into modular containers and routed through a network of logistic hubs so that they remain together for a long portion of their multi-hub journey. At hubs where the parcels' joint travel is completed, the containers are opened, and parcels are sorted for final delivery or re-consolidated for the next part of their inter-hub journey. This research focuses on the optimization of parcel consolidation at a hub, considering each parcel's sequence of hubs in the path, arrival time, target time of departure, and dimensions. We develop an optimization model that minimizes handling cost such that delivery time, consolidation target, and other operational constraints are met. We present preliminary computational results that demonstrate the increase in performance due to effective consolidation.

4 - An Optimization Model of U-Shape Kitting Cell Configuration Design
Wencang Bao, Georgia Institute of Technology, Atlanta, GA, United States

Kitting is an effective part-feeding mode to supply varied parts to highly customized assembly lines, however, there are less optimization models of kitting cell design have been investigated yet. Considering material handling and space cost, we focus on U-shape configuration, build an optimization model to determine: 1. the size of the kitting cell, 2. the storage type of each part and 3. the location of each part. To deal with the computational inefficiency, we propose an Upper-Lower-Bounds (ULB) strategy to accelerate the solving process via deciding the max and min number of parts in each storage type. Experiments show that our model can get a significantly lower cost than current benchmarks. Finally, some heuristic algorithms are discussed.

5 - The Value of Limited Adaptability for Workload Balance in Logistics Operations
Reem Khir, Georgia Institute of Technology, Atlanta, GA, United States, Alan Erera, Alejandro Toriello

This talk presents a flexible assignment balancing problem with a focus on parcel sort systems critical for modern e-commerce operations. The idea is to use simple and practical recourse strategy that allows sort systems to be reconfigured once

information about the actual demand is revealed. We introduce the stochastic k-adaptable assignment balancing problem that generates k assignment options apriori with the objective of minimizing the maximum expected workload assigned to any sorter. The goal is to enable decision makers to adapt their operations to a plan that works best under the realized demand while maintaining a good level of consistency and stability in operations desired in practice. We compare exact and heuristic solution approaches and test them on real data obtained from a large parcel carrier.

■ TB36

CC Room 210B

In Person: Emerging Logistics Models

General Session

Chair: Mohammad Moshref-Javadi, Northeastern University, Boston, MA, 02115-5005, United States

1 - Fleet Resupply by Drones for Last-mile Delivery

Juan C. Pina-Pardo, Pontificia Universidad Catolica de Valparaiso, Avenida Brasil 2241, Valparaiso, 2340000, Chile, Daniel F. Silva, Alice E. Smith, Ricardo Gatica

This presentation introduces the Vehicle Routing Problem with Drone Resupply, which consists of finding a set of routes for a fleet of vehicles to deliver orders that become available throughout the day. Once the vehicles start their delivery routes, they do not need to return to the depot to collect newly released orders, as these orders are sent to them via drones. Assuming that the orders' release times are known at the beginning of the day, we present a MILP formulation and an efficient two-stage heuristic approach for solving realistic-sized instances. The effects of depot location, customer distribution, drone capacity, and spread of orders' release dates are investigated.

2 - Locational Pricing of Metro Mobility Services

Yanchao Liu, Wayne State University, Detroit, MI, 48201 United States

Mobility supply and demand are unevenly distributed across time and space, and they often do not match in quantity. Dynamic pricing has been used to restore the balance, but are also challenged by equity concerns. In this talk, we present a novel mathematical model to characterize the market dynamics and propose algorithms to compute the market equilibria and the fair fares.

3 - Drone Logistics for Uncertain Demands of Disaster-impacted Populations

Zabih Ghelichi, University of Louisville, Louisville, KY, United States, Monica Gentili, Pitu B. Mirchandani

In this study, we present a stochastic optimization model to address the challenges associated with timely delivery of aid packages to disaster-affected regions via a fleet of drones while considering the set of demand locations is unknown. The main problem is to locate a set of drone platforms such that with a given probability, the maximum total cost (or disutility) under all realizations of the set of demand locations is minimized. We formulate and solve a time-space drone scheduling model for a set of scenarios to build up the total disutility distribution. We also propose an algorithmic solution approach which decomposes the problem into three tractable subproblems.

■ TB37

CC Room 210C

In Person: Technology, Innovation Management and Entrepreneurship

General Session

Chair: Sreekumar R. Bhaskaran, Southern Methodist University, Dallas, TX, 75275-0333, United States

1 - Where to Pop-up? Channel Operation Strategies under Price Harmonization

Arunima Chhikara, University of Kansas, Lawrence, KS, United States, Avinash Geda, Nazli Turken, Janice E. Carrillo

Price harmonization across different channels is a widely practiced marketing strategy. Contrary to the intuition that dual-channel firms utilize both channels under channel-specific pricing strategy, we find conditions when a single (online/offline) channel dominates the dual-channel policy under the price harmonization strategy. We find that for the price harmonization strategy, the optimal channel selection, and the optimal prices depend on market sizes, on-hand inventory, and salvage value. Our results are important to channel managers' coordinated decisions when offering a product in their respective channels to optimize the overall profits at the retailer level.

2 - Entrepreneurial Mindset and Behavior for Product I ntroduction Decisions

Sinan Erzurumlu, Babson College, Babson Park, MA, 02457, United States, Sreekumar R. Bhaskaran, Karthik Ramachandran

Firms often face a choice between developing a risky, advanced, product and launching an on-hand product. While launching the on-hand product might bring much needed revenues, it could affect the profitability of the advanced product under development depending on the consumer experience with the launched on-hand product. We present evidence from behavioral studies that study how product managers in established and startup firms make these decisions. We particularly examine the impact of cash constraint, available options and trade-off; our findings reveal insights on how to position project continuation with respect to cash on hand, value of the project and the leanness of development process.

■ TB40

CC Room 211B

In Person: Recent Developments in Semidefinite Programming

General Session

Chair: Alex Wang, Carnegie Mellon University, Pittsburgh, United States

1 - Approximating Sparse Semidefinite Programs

Kevin Shu, Georgia Institute of Technology, Atlanta, GA, United States

It is well understood how to solve sparse semidefinite programs when the sparsity pattern corresponds to a chordal graph. We extend these results by analyzing a relaxation of the PSD cone defined for any graph, which we call the locally-PSD cone. We introduce a numerical invariant of a graph, which we call the additive distance, measuring how well the locally-PSD relaxation approximates the PSD cone. We then give bounds on the additive distance for a wide range of graphs, and show that in many cases, the approximation ratio for the relaxed program is bounded from above by 1+n/g^3, where n is the number of vertices, and g is the length of the shortest cycle in the graph with at least 4 vertices.

2 - Convex Hull Results for Quadratic Programs with Non-Intersecting Constraints

Alexander Joyce, Clemson University, Clemson, SC, United States

Let F be a set defined by quadratic constraints. Understanding the structure of the lifted closed convex hull of C(F) is crucial to solve quadratically constrained quadratic programs related to F. In this talk, we discuss the relationship between C(F) and C(G), where G results by adding non-intersecting quadratic constraints to F. We prove that C(G) can be represented as the intersection of C(F) and some half spaces defined by the added constraints. The proof relies on a complete description of the asymptotic cones of sets defined by a single quadratic equality and a partial characterization of the recession cone of C(F). Our proof generalizes an existing result for bounded F with non-intersecting quadratic hollows.

3 - On the Central Path of Semidefinite Optimization: Degree And Worst-case Convergence Rate

Ali Mohammad Nezhad, PhD, Purdue University, West Lafayette, IN, United States, Saugata Basu

We investigate the complexity of the central path of semidefinite optimization through the lens of real algebraic geometry. To that end, we propose an algorithm to compute real univariate representations describing the central path and its limit point, where the limit point is described by taking the limit of central solutions, as bounded points in the field of algebraic Puiseux series. As a result, we derive an upper bound on the degree of the Zariski closure of the central path and a complexity bound for describing the limit point. Furthermore, by the application of the quantifier elimination to the real univariate representations, we provide an upper bound on the worst-case convergence rate of the central path.

4 - Restricted Simultaneous Diagonalizability with Applications to Quadratic Programming

Alex Wang, Carnegie Mellon University, Pittsburgh, 15213, United States

Quadratically constrained quadratic programs (QCQPs) are a fundamental class of NP-hard optimization problems that ask us to minimize a quadratic objective function subject to a number of quadratic constraints. In this talk, we introduce and investigate an extension of the simultaneously-diagonalizable-via-congruence (SDC) property—namely, the d-restricted SDC (d-RSDC) property—that will provide us with a tool for simplifying general QCQPs. Informally, a general QCQP can be "lifted" into a diagonal QCQP with only d-many additional variables if and only if it satisfies the d-RSDC property. We will present a number of sufficient conditions for this property to hold and complement our theoretical results with preliminary numerical experiments applying this property to QCQPs with a single quadratic constraint and additional linear constraints.Based on joint work with Rujun Jiang. https://arxiv.org/abs/2101.12141

■ TB41

CC Room 212A

In Person: Power System Resilient Design and Optimization

General Session

Chair: Beheshteh Raouf, Clarkson University, Potsdam, NY, United States

Co-Chair: Seyedamirabbas Mousavian,

1 - Load Frequency Control of Interconnected Power System Based On Kharitonov's Theorem

Beheshteh Raouf, Clarkson University, Potsdam, NY, United States

Frequency deviations from the acceptable range can hurt the system's stability and reliability. These deviations may even cause the power grid to collapse. So, frequency control is one of the major concerns of the power grids operators. Many papers studied the frequency control requirements and optimization techniques. In this study, we apply Kharitonov's theorem to tune the PI controller parameters of a two-area power system in the presence of EV fleets. Each area consists of EV fleets, thermal, gas, and hydro units. We conduct the primary stability of the system by the zero-inclusion principle and examination of the Routh-Hurwitz stability criterion. After tuning the gains of the PI controller, we analyze the performance of the proposed method based on an attack on the communication of EV fleets, variation in system parameters, and load variation.

2 - Learning-based Predictive Control via Real-time Aggregate Flexibility

Tongxin Li, California Institute of Technology, Pasadena, CA, 91125, United States, Yue Chen, Bo Sun, Adam Wierman, Steven Low

Aggregators have emerged as crucial tools for the coordination of distributed, controllable loads with a system operator via aggregate flexibility. However, most of existing aggregate flexibility measures often are slow-timescale and much less attention has been paid to real-time coordination. In this presentation, we consider solving an online optimization in a closed-loop system and present a design of real-time aggregate flexibility. Combining learning and control, we show that the feedback can be approximated using reinforcement learning and used as a penalty term in a novel control algorithm the penalized predictive control (PPC). We show that under certain regularity assumptions, the PPC is optimal. We illustrate its efficacy for electric vehicle charging networks and show that PPC outperforms the classical MPC.

3 - An Iterative Approach to Finding Global Solutions of AC Optimal Power Flow Problems

Ling Zhang, University of Washington, Seattle, WA, 98119, United States, Baosen Zhang

The existence of multiple solutions to AC optimal power flow (ACOPF) problems has been noted for decades. Existing solvers are generally successful in finding local solutions, which are stationary points but may not be globally optimal. In this paper, we propose a simple iterative approach to find globally optimal solutions to ACOPF problems. First, we call an existing solver for the ACOPF problem. From the solution and the associated dual variables, we form a partial Lagrangian. Then we optimize this partial Lagrangian and use its solution as a warm start to call the solver again for the ACOPF problem. By repeating this process, we can iteratively improve the solution quality, moving from local solutions to global ones. The simulation results show that our algorithm can escape from local solutions to achieve global optimums within a few iterations.

■ TB43

CC Room 213A

In Person: Education

Contributed Session

Chair: Cody Baldwin, Brigham Young University-Hawaii, Hauula, HI, 96717, United States

1 - Key Performance Indicators in Virtual Education Systems for Adolescent Students with Attention-deficit/hyperactivity Disorder During the Covid-19 Era

Janet Choi, University of Southern California, Los Angeles, CA, United States

"Kx" Due to the COVID-19 pandemic, public health guidelines displaced students from in-person learning conditions to online and socially distant platforms. The study explores this newly adapted format, namely virtual education, and its role on individuals vulnerable to these transitions, specifically students diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). The goal is to identify the academic performance indicators from virtual education that challenge adolescent students with ADHD and evaluate the symptom amplification. The study inquired more indicators with inattentive type ADHD over hyperactive type ADHD, implying that virtual systems likely incite inattentiveness.

"2 - Training Analytics Students to Work in Cloud Computing Environments

Cody Baldwin, Director (M S. of Business Analytics), University of Wisconsin-Madison, Madison, WI, United States

Many employers are now demanding that recent graduates in business analytics be comfortable working in cloud computing environments. (As an example, students should be able to load, transform, and connect to data in a cloud data warehouse.) University programs that neglect this fact will leave their students at a disadvantage going into the job market. This paper outlines work at the University of Wisconsin-Madison to address this need within their Master of Business Analytics program and includes proposed learning objectives and lessons.

■ TB44

CC Room 213B

In Person Committee's Choice

Committee Choice: Committee's Choice

Committee Choice Session

Chair: David Morton, Northwestern University, Evanston, IL, 60208-0834, United States

Co-Chair: Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY, 10598, United States

1 - Can't Wait: Reducing Treatment Delay for Psychiatric Patients

Nathan Adeyemi, Northeastern University, Boston, MA, United States, Nasibeh Zanjirani Farahani, Amanda Graham, Kalyan Pasupathy, Kayse Lee Maass

Hospital emergency departments (ED) are often heavily backlogged by patients in need of care but awaiting placement in an inpatient bed (IP) either at their current hospital or transfer to another facility. This is known as ED boarding and disproportionately affects patients requiring psychiatric care and to a greater extent, its subpopulation of pediatric patients. Our goal is to find novel modifications for the current system that are effective in reducing ED boarding due to lack of available IP beds, distance-related transfer restrictions, and patient-characteristic related inclusion and exclusion criteria that minimize disparities by age and geographic region.

2 - Design of Staged Alert Systems for COVID-19

David Morton, Northwestern University, Evanston, IL, 60208-0834, United States, Nazlican Arslan, Daniel Duque, Bismark Singh, Ozge Surer, Haoxiang Yang, Lauren Meyers

Judicious implementation and relaxation of pandemic restrictions amplify their public health benefits while reducing costs. We derive optimal strategies for toggling between mitigation stages using daily COVID-19 hospital admissions. We describe the optimization and maintenance of the staged alert system that has guided COVID-19 policy in Austin, Texas through the COVID-19 pandemic, acknowledging inequities, and accounting for an exit strategy under effective vaccines.

3 - Simpler (classical) and Faster (quantum) Algorithms for Gibbs Partition Functions

Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY, 10598, United States, Srinivasan Arunachalam, Vojtech Havlicek, Kristan Temme, Pawel Wocjan

We consider the problem of approximating the partition function of a classical Hamiltonian using simulated annealing. This requires the computation of a cooling schedule, and the ability to estimate the mean of the Gibbs distributions at the corresponding inverse temperatures. We propose classical and quantum algorithms for these two tasks, achieving two goals: (i) we simplify the seminal work of Štefankovi , Vempala and Vigoda (J. ACM, 56(3), 2009), improving their running time and almost matching that of the current classical state of the art; (ii) we quantize our new simple algorithm, improving upon the best known algorithm for computing partition functions of many problems, due to Harrow and Wei (SODA 2020). A key ingredient of our method is the paired-product estimator of Huber (Ann. Appl. Probab., 25(2),2015).

■ TB45

CC Room 213C

In Person: Using Drones in Smart Cities

General Session

Chair: Nima Molavi, Elizabeth City State University, Toledo, OH, 43623, United States

1 - An Exact Algorithm for Drone-truck Cooperative Routing Problem with Deadlines under Travel Time Uncertainty
Jaegwan Joo, Hankuk University of Foreign Studies, Yongin-si, Korea, Republic of, Hyunwoo Park, Chungmok Lee

We consider a drone-truck cooperative delivery problem with deadlines. The truck carries multiple drones which are deployed to serve customers. Because multiple drones can be used simultaneously, the truck waits until all drones finish the delivery at the spot. Due to the deadlines, we also should determine the visiting sequence of drones for the customers. The travel times of truck is assumed uncertain, for which we employ the robust optimization to protect the solution from late deliveries. An exact branch-and-price approach is developed to tackle the problem. The computational efficiency of the proposed algorithm is compared to the state-of-the-art MIP solvers.

2 - Sustainable Location and Routing Problem of Commercial Hybrid Drones with Stochastic Customer Locations
Nima Molavi, Assistant Professor, Elizabeth City State University, Elizabeth City, NC, United States, Yue Zhang, Marcelo J. Alvarado Vargas

Commercial drones' operation often includes uncertainty in customer locations. This research aims to design a sustainable hybrid commercial drone system with stochastic customer locations by minimizing economic, environmental, and social costs. A two-stage approach is used to assist decision-making at strategic, tactical, and operational levels. First, a scenario-based mathematical model is developed to find the optimal station locations, and then a simulation-optimization approach is used to optimize the total number of drones and the routing to each customer.

Tuesday, 9:45AM-10:45AM

■ Tuesday Plenary 01

CC Ballroom E /Virtual Theater 1

Plenary: Role of Optimization in Managing Amazon's Supply Chain

Plenary Session

1 - Plenary: Role of Optimization in Managing Amazon's Supply Chain
Huseyin Topaloglu, Cornell Tech, New York, NY, 10044-1501, United States

Amazon runs a complex supply chain to manage the journey of each unit of inventory from the warehouses of the vendors to the hands of the customers, as the inventory passes through cross-docks, fulfillment centers, and delivery stations. At each step of this journey, optimization models play a critical role. In this talk, I will give an overview of these optimization models in a way that is biased towards my personal experience. The models operate on different scales in terms of granularity of time, geography, and product groups, which make them particularly difficult to coordinate. Thus, coordination will be a prevalent theme throughout the talk. I will conclude with a more technical discussion based on models that have been abstracted from my work at Amazon.

Tuesday, 11:00AM-12:30PM

■ TC01

CC Ballroom A / Virtual Theater 1

Hybrid Dynamic Data Driven Application Systems

Sponsored: Simulation Society

Sponsored Session

Chair: Jie Xu, George Mason University, Fairfax, VA, 22030, United States

1 - Dynamic Data Driven Application Systems
Jie Xu, George Mason University, Fairfax, VA, 22030, United States

The Dynamic Data Driven Applications Systems (DDDAS) presents a paradigm whereby instrumentation data are dynamically integrated into an executing application simulation and in reverse, the executing model controls the instrumentation. DDDAS plays a key role in advancing capabilities in many application areas ranging from aerospace, materials sciences, biosciences, geosciences and space sciences, resilient security, and cyber systems for critical infrastructures. In addition, DDDAS is also driving advances in foundational methods, through system-level (as well as subsystems-level) representations, that include comprehensive principle- and physics-based-models and instrumentation, uncertainty quantification, estimation, observation, sampling, planning and control. This panel brings together a diverse group of leading DDDAS researchers to discuss significance advances that have been made and highlight crosscutting research opportunities.

2 - Panelist
Nurcin Celik, University of Miami, Coral Gables, FL, 33146-2509, United States

3 - Panelist
Salim Hariri, AZ, United States

4 - Panelist
Kevin Jin, University of Arkansas, Fayetteville, AR, 72701, United States

5 - Panelist
Chun-Hung Chen, George Mason University, Fairfax, VA, 22030-4422, United States

■ TC02

CC Ballroom B / Virtual Theater 2

Hybrid Location and logistics

Sponsored: Location Analysis

Sponsored Session

Chair: Sibel Alumur Alev, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

1 - Server Positioning and Response Strategies for Spatially Arriving Jobs with Degradation: Light and Medium Traffic Cases
Rajan Batta, University at Buffalo (SUNY), NY, 14214-3001, United States, Fatemeh Aarabi

This talk studies server positioning and response strategies for spatially arriving jobs with degradation, for situations of light and medium traffic. For the light traffic case it is shown that the p-median solution provides the optimum server positioning, and the optimum response strategy involves no server cooperation. To analyze the medium traffic case, an extended Hypercube queuing model tailored to handle spatially distributed jobs with degradation rate is formulated. The main findings for the medium traffic case are that the degree of server cooperation is strongly related to the rate of job degradation and to the cost of assigning jobs that find all servers busy to a backup server.

2 - Nested-Solution Facility Location Models
Ronald McGarvey, University of Missouri, IMSE and TSPA, Columbia, MO, 65211, United States, Andreas Holger Thorsen

Classical facility location models can generate solutions that do not maintain consistency in the set of utilized facilities as the number of utilized facilities is varied. We introduce the concept of nested facility locations, in which the solution utilizing p facilities is a subset of the solution utilizing q facilities, for all $i \leq p < q \leq j$, given some lower limit i and upper limit j on r, the number of facilities that will be utilized in the future. This approach is demonstrated with application to the p-median model, with computational testing showing these new models achieve reductions in both average regret and worst-case regret when r <> p facilities are actually utilized.

3 - Profit Maximizing Hub Network Design with Flow Threshold And Time-Sensitive Demand
Sibel Alumur Alev, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, Gita Taherkhani

We model a profit maximizing hub network design problem in which the demand of some origin-destination pairs can remain unserved. We adopt a flow threshold for incorporating economies of scale so that if the flow routed on a link exceeds the given threshold, no matter if it is an inter-hub link or an allocation link, the transportation cost on this link is to be discounted. In this setting, we do not explicitly decide on the locations of hubs, but rather decide on the connections with the discounted flow. The aim is to build a network to consolidate flows and reduce the transportation as well as the cost of building this network. Moreover, we model time-sensitive demand and incorporate time limits for delivering demand at its destination as commonly faced in the design of less-than-truckload or truckload transportation networks.

■ TC03

CC Ballroom C / Virtual Theater 3

Hybrid Platform Design for Social Good

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Vahideh Manshadi, Yale University, CT, United States

Co-Chair: Scott Rodilitz, Yale, New Haven, CT, 06511-2572, United States

1 - Improving Kidney Exchange via Pre-screening
Duncan McElfresh, University of Maryland, College Park, Palo Alto, CA, 94306, United States

Planned transplants in kidney exchanges fail for a variety of reasons—if the donor organ is rejected by the recipient's medical team, or if the donor and recipient are found to be medically incompatible. Failed transplants can "cascade" through an exchange, causing substantial delays for transplant recipients. Many optimization-based approaches have been designed to avoid these failures; however most exchanges cannot implement these methods, due to legal and policy constraints. Instead, we consider a setting where exchanges can query recipient preferences—asking whether they would accept a particular transplant. We characterize this as an optimization problem, in which the exchange program (a) queries a transplants before committing to a matching, and (b) constructs a matching according to fixed policy.

2 - Fair Algorithms for Selecting Citizens' Assemblies
Paul Gölz, Carnegie Mellon University, Pittsburgh, PA, United States, Bailey Flanagan, Anupam Gupta, Brett Henning, Ariel Procaccia

Recently, there has been a global surge in citizens' assemblies: panels of randomly-selected citizens weighing in on a policy question. Since these panels must proportionally represent many demographic groups, the selection algorithms currently used for choosing panels select different individuals with highly unequal probabilities. We develop selection algorithms that satisfy the given quotas while choosing pool members with probabilities as close to equal as possible. We have implemented one such algorithm, which has been adopted by a number of organizations around the world and has been used to select dozens of citizens' assemblies.

3 - Simple and Optimal Contract Design for Payment for Ecosystem Services
Wanyi Li, Stanford University, Stanford, CA, United States, Itai Ashlagi, Irene Yuan Lo

Many countries have adopted Payment for Ecosystem Services (PES) programs to reduce deforestation. Empirical evaluations find such programs, which pay forest owners to conserve forest, can lead to anywhere from no impact to a 50% reduction in deforestation level. To better understand PES contracts, we use a principal-agent model, in which the agent with some amount of initial forest land has a privately-known baseline conservation level. Commonly-used conditional contracts perform well when the environmental value of forest is sufficiently high or sufficiently low, but can do arbitrarily poorly compared with the optimal contract for intermediate values. We identify a linear contract with a distribution-free per-unit price that guarantees at least half of the optimal contract payoff. A numerical study using United States land use data supports our findings.

4 - Optimization Enables Transparent and Inclusive Policies: Improving School Schedules in San Francisco
Arthur J. Delarue, MIT, Cambridge, MA, 02139-4310, United States, Zhen Lian, Sebastien Martin

We developed a multiobjective optimization framework to evaluate the policy tradeoffs of changing start times at San Francisco Unified School District (SFUSD). We used our methodology to optimize start times for SFUSD's post-COVID reopening in the spring of 2021. In addition, we developed participative tools that SFUSD used to select new start times for the Fall of 2021, satisfying a number of community priorities, and leading to projected transportation savings of up to $3 million per year.

■ TC04

CC Ballroom D / Virtual Theater 4

Hybrid Publications and Review Process

Informs Special Session: Junior Faculty Interest Group

Informs Special Session Session

Chair: Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States

1 - Moderator
Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States

2 - Panelist
Cole Smith, Syracuse University, Syracuse, NY, 13244-1240, United States

3 - Panelist
John R. Birge, University of Chicago, Chicago, IL, 60637-1656, United States

4 - Panelist
Douglas R. Shier, Clemson University, Pittsboro, NC, 27312-8612, United States

5 - Panelist
David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

6 - Panelist
Ozlem Ergun, Northeastern University, Boston, MA, 2115, United States

■ TC05

CC Ballroom E / Virtual Theater 5

Hybrid Getting Started in Public Sector Operations Research II

Sponsored: Public Sector OR

Sponsored Session

Chair: Andrew C. Trapp, Worcester Polytechnic Institute, Worcester, MA, 01609-2247, United States

1 - Getting Started in Public Sector Operations Research II
Andrew C. Trapp, Worcester Polytechnic Institute, Worcester, MA, 01609-2247, United States

Public sector operations research is dedicated to decision problems with outcomes that can impact the public / society at large. Such problems often involve complex situations, uncertainty, and multiple stakeholders with differing and potentially conflicting objectives. This panel features speakers with complementary expertise in public sector operations research, who will discuss how to get started in this broad and impactful domain. Panelists will briefly describe their own research, and discussion will proceed to a moderated question and answer session. Questions from the audience are welcomed.

2 - Panelist
Feyza G. Sahinyazan, Simon Fraser University, Burnaby, BC, V5A 1S6, Canada

3 - Panelist
Karen Smilowitz, Northwestern University, Evanston, IL, 60208-0834, United States

■ TC06

CC Room 303A

In Person: Analytics for Policing and Urban Public Service Operations

General Session

Chair: He Wang, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

1 - Data-driven Optimization for Atlanta Police Zone Design

Shixiang Zhu, Georgia Institute of Technology, Atlanta, GA, 30318-2990, United States

We present a data-driven optimization framework for redesigning police patrol zones in an urban environment. The objectives are to rebalance police workload among geographical areas and to reduce response time to emergency calls. We develop a stochastic model for police emergency response by integrating multiple data sources, including police incidents reports, demographic surveys, and traffic data. Using this stochastic model, we optimize zone redesign plans using mixed-integer linear programming. Our proposed design was implemented by the Atlanta Police Department in March 2019. By analyzing data before and after the zone redesign, we show that the new design has reduced the response time to high priority 911 calls by 5.8\% and the imbalance of police workload among different zones by 43\%.

2 - Optimizing Shift Schedules and Dispatch of Safety Patrol Officers for Denver Public Schools

Amanda Chu, ISyE Georgia Institute of Technology, Atlanta, GA, United States, Pinar Keskinocak, Onkar Kulkarni, Ritesh Ojha

Each year, the Safety Department at Denver Public Schools (DPS) manually creates patrol officer schedules to respond to calls for over 200 schools to ensure the safety of all students and staff. The Safety Department struggles to adjust schedules in response to changes such as available officers due to the manual process. To address these drawbacks, we developed optimization and simulation models to create officer shift schedules based on call demand, factor in call demand uncertainty, and estimate the performance of the generated schedules. The DPS Safety Department used one of multiple generated schedules for the 2019-2020 academic year and we able to meet their target call response times.

■ TC07

CC Room 303B

In Person: Crowdfunding and Platform Economics in Social Media

General Session

Chair: Zhen Fang, University of Washington, Seattle, WA, 98105, United States

1 - Opinion Leader Identification Associated With Covid-19 in Online Social Networks

Behnam Malmir, Virginia Tech, VA, United States

Safety culture is a collection of beliefs, attitudes, and practices that is focused on improving individual and organizational health and safety. Providing interactions between citizens and governments could elevate this improvement. Social media has been known as one of the most valuable tools to this aim and government agencies eagerly have applied social media applications to enhance citizen engagement in managing crises. However, employing opinion leaders (OLs) to improve the effects of social media on people's safety culture has been neglected in the literature. This paper provides a framework for OLs identification in the era of pandemic situations called 'Pandemic OL Finder'. The proposed framework comprises three steps of finding potential OLs on the Twitter platform, determining the characteristics of those OLs, and discovering real OLs.

2 - More Than Double Your Impact: An Empirical Study of Match Offers on Charitable Crowdfunding Platforms

Zhen Fang, University of Washington, Seattle, WA, 98105, United States, Xue Tan, Shengsheng Xiao, Yong Tan

To promote charitable giving, charitable crowdfunding platforms adopted match offers, whereby leadership donors match the others' donations at a given rate. Our study seeks to understand how the suppliers (donors) evaluate projects with and without match offers differently, especially varying with their donation experience, and how the demanders (fundraisers) react to match offers. At an individual level, we find that, on average, donors derive a higher utility toward matched projects. Warm-list donors are three times more likely to contribute to matched projects, while cold-list donors are twice more likely to do so. New donors prefer unmatched projects. The market-level analysis shows that increasing the matched project ratio benefits both sides of the market. Our work connects micro-level and macro-level to disentangle the impact of match offers systematically.

■ TC09

CC Room 303D

In Person: Trending Topics in Applied Probability

General Session

Chair: Anton Braverman, Northwestern University, Evanston, IL, 60208, United States

1 - Stability, Memory, and Messaging Tradeoffs in Heterogeneous Service Systems

Martin Zubeldia, Georgia Institute of Technology, Atlanta, GA, United States, David Gamarnik, John N. Tsitsiklis

We consider a heterogeneous distributed service system, consisting of N servers with unknown and possibly different processing rates. Jobs with unit mean arrive as a renewal process of rate proportional to N, and are immediately dispatched to one of several queues associated with the servers. We assume that the dispatching decisions are made by a central dispatcher with the ability to exchange messages with the servers, and endowed with a finite memory used to store information from one decision epoch to the next, about the current state of the queues and about the service rates of the servers. In this setting, we study the fundamental resource requirements (memory bits and message exchange rate) in order for a dispatching policy to be always stable.

2 - Dynamic Pricing and Assortment under an Unknown MNL Demand

Noemie Perivier, Columbia University, New York, NY, United States, Vineet Goyal

We consider dynamic multi-product pricing and assortment problems under an unknown demand over T periods, where in each period, the seller decides on the price for each product or the assortment of products to offer to a customer who chooses according to an unknown Multinomial Logit Model (MNL). We propose a randomized dynamic pricing policy based on a variant of the Online Newton Step algorithm that achieves a near-optimal regret guarantee under an adversarial arrival model. We also present a new optimistic algorithm for the adversarial MNL contextual bandits problem, which achieves a better dependency than the state-of-the-art algorithms in a problem-dependent constant.

3 - Distributionally Robust Batch Contextual Bandits

Nian Si, Stanford University, Stanford, CA, 94305, United States, Fan Zhang, Zhengyuan Zhou, Jose Blanchet

Policy learning using historical observational data is an important problem that has found widespread applications. However, existing literature rests on the crucial assumption that the future environment where the learned policy will be deployed is the same as the past environment that has generated the data—an assumption that is often false or too coarse an approximation.In this paper, we lift this assumption and aim to learn a distributionally robust policy with incomplete (bandit) observational data. We propose a novel learning algorithm that is able to learn a robust policy to adversarial perturbations and unknown covariate shifts. We first present a policy evaluation procedure in the ambiguous environment and then give a performance guarantee based on the theory of uniform convergence.

■ TC10

CC Room 304B

In Person: Data Driven Decision Making for Agriculture

General Session

Chair: Saeed Khaki, Iowa State University, Ames, IA, 50010, United States

1 - A Multi-objective, Soft Constraint Solution To A Capacity-constrained Corn Planting Schedule Problem

Mingshi Cui, Miami University, Oxford, OH, 45056, United States Mingshi Cui, Rutgers University, New Brunswick, NJ, United States, Kunting Qi

Our research describes a general solution to optimize the planting schedule for corn population seeds that attempts to minimize the median and maximum absolute deviation from location storage capacity, as well as minimizing the number of nonzero harvest weeks while respecting planting windows and weekly harvest capacities. We used a Long Short-Term Memory model to predict daily GDUs, based on historical daily GDUs data. The Genetic Algorithm with multi-objective function and soft constraint models has been implemented based on the predicted values. All of the models' parameters have been tuned to get the optimized corn planting schedule through an innovative tree-based algorithm.

2 - A Transformer-based Approach for Soybean Yield Prediction Using Time-series Images

Luning Bi, Iowa State University, Ames, IA, United States, Guiping Hu

Accurate yield estimation techniques which can provide information for management decision-making is of critical importance in precision agriculture. However, traditional manual inspection and calculation is often laborious and time-consuming. To overcome the shortcomings, this paper proposes a transformer-based approach for yield prediction using early-stage images. First, a vision transformer (ViT) base model is designed to extract features from the images. Then another transformer-based model is established to predict the yield using the time-series features. A case study has been conducted using a dataset that was collected during 2020 soybean-growing seasons in Canada. The experiment results show that compared to non-time series prediction and other baseline models, the proposed approach can reduce the mean squared error by 25%-40%.

3 - Image-based Plant Phenotyping Using Deep Learning Methods

Saeed Khaki, Iowa State University, Ames, IA, 50010, United States

According to the United Nations, by 2050 we will need to produce 60% more food to feed the world due to global population growth. As such, agriculture which is at the heart of the food systems requires more data-driven approaches to further increase productivity, optimize management of resources, improve crop quality and quantity in a changing climate. However, the success of data-driven approaches relies on accurate and efficient collection of data. For a commercial organization that manages large amounts of crops, collecting accurate and consistent phenotypic data is a bottleneck. In this presentation, we present a state-of-the-art deep learning based method for image-based plant phenotyping which shows promise in mitigating this data collection bottleneck and fast decision-making in agriculture.

■ TC11

CC Room 304C

In Person: Analytics to Address Opioid Use Disorder

General Session

Chair: Md Saiful Islam, Northeastern University, Quincy, MA, 02170, United States

1 - Analyzing Long-term Health Outcomes of Patients Following the Treatment for Opioid Use Disorder: A Study of Massachusetts Commercially Insured Population

Md Mahmudul Hasan, Northeastern University, Boston, MA, United States, Jiesheng Shi, Noor E. Alam, Gary J. Young

We will present the findings from our investigation on patients' long-term outcomes from buprenorphine/naloxone treatment for opioid use disorder (OUD) for a commercially insured population during a follow-up period of up to three years. The outcome of this research will potentially inform efforts that should be undertaken to increase awareness among prescribers and patients of the potential clinical value of longer treatment periods for buprenorphine/naloxone.

2 - Evaluating Policy with Matching Method From High-dimensional Data to Address Opioid Epidemic

Md Saiful Islam, Northeastern University, Boston, MA, United States, Noor E. Alam

Existing causal inference methods include all the observed variables just to ensure there is no confounding. Recent research shows that this approach increases the variance of the causal effect estimates without reducing the bias. In this research, we develop a novel variable selection technique to make causal inference from high-dimensional observational data. We will use all pair claim data to evaluate important policy related to Opioid Epidemic.

■ TC12

CC Room 304D

In Person: Human-Algorithm Interactions in Operations

General Session

Chair: Clare Snyder, Ann Arbor, MI, 48105, United States

1 - Learning Best Practices: Can Machine Learning Improve Human Decision-Making?

Park Sinchaisri, Assistant Professor, Haas School of Business, UC Berkeley, Jon M. Huntsman Hall, Berkeley, CA, 19104, United States, Hamsa Sridhar Bastani, Osbert Bastani

Workers spend a significant amount of time learning how to make good decisions. Evaluating the efficacy of a given decision, however, is quite complicated as decision outcomes are often long-term and relate to the original decision in complex ways. We propose a novel machine-learning algorithm for extracting "best practices" from trace data and inferring interpretable tips that can help workers improve their performance in sequential decision-making tasks. To validate our approach, we design a virtual kitchen-management game in which participants learn to minimize service time. Our experiments show that the tips generated by our algorithm are effective at improving performance, significantly outperform tips generated by human experts and a baseline algorithm, and successfully help participants build on their own experience to discover additional strategies.

2 - Does Algorithm Aversion Exist in the Field? An Empirical Analysis of Algorithm Use Determinants in Diabetes Self-management

Wilson Lin, University of Southern California, Arcadia, CA, United States, Jordan D. Tong, Song-Hee Kim

Advancements in algorithms hold promise to better operations by improving users' decision-making. However, humans may exhibit so-called "algorithm aversion," which would be a barrier to achieving such improvements — though these claims are based primarily on laboratory experiments. Using the decision-support algorithm behavior in over 230,000 bolus insulin dosing decisions from diabetes self-management, we contribute field analysis to identify drivers of algorithm use. We precisely define dynamic algorithm aversion — an asymmetric usage response to performance feedback that favors humans over algorithms — as one key hypothesis from the experimental literature. We then reject this hypothesis, instead finding that patients respond to performance feedback asymmetrically, but in favor of the algorithm.

3 - Algorithm Use in the Service Setting

Clare Snyder, University of Michigan, Ann Arbor, MI, United States, Samantha Keppler, Stephen Leider

Computer algorithms can improve human recommendations by providing accurate advice quickly. Prior research shows however that they often do not, because people are reluctant to accept algorithms' suggestions when recommendation quality alone is incentivized. We experimentally study the use of algorithms in a service context where servers have incentives for both recommendation quality and service time. We hypothesize that high time pressure (represented by higher customer arrival rates) will induce subjects to follow the algorithm's recommendation. We find that under higher arrival rates, people are indeed more likely to follow the algorithm's recommendation, especially with experience.

■ TC13

CC Room 201A

In Person: Data Analytics and Optimization

General Session

Chair: Ozge Surer, Northwestern University, Evanston, IL, 60201, United States

Co-Chair: Tulay Flamand, Colorado School of Mines, Golden, CO, 80401-1878, United States

1 - Uncertainty Quantified Functional Curve Comparisons and its Application in Wind Energy

Yu Ding, Texas A&M University, Dept Industrial & Systems Engineering, College Station, TX, 77843-3131, United States, Abhinav Prakash, Rui Tuo

Wind turbine performance comparison can be framed as a data science problem, which is to compare nonparametric functional curves. This talk discusses how to quantify uncertainty for such nonparametric functional curve comparison and how to use the resulting method to track and compare performance changes of the same turbine over different periods or different wind turbines over the same period.

2 - Calibration Using Emulation of Filtered Simulation Results

Ozge Surer, Northwestern University, Evanston, IL, 60201, United States, Matthew Plumlee

A scalable method for calibration involves building an emulator after conducting an experiment on the simulation model. However, when the parameter space is large, the resulting simulator responses drastically differ from the observed data. One solution to this problem is to simply discard, or filter out, the parameters that gave unreasonable responses and then build an emulator only on the remaining simulator responses. In this article, we demonstrate the key mechanics for an approach that emulates filtered responses but also avoids unstable and incorrect inference.

3 - An Optimization Framework for the Optimal Investment Technology to Support the Grid Hosting Electric Vehicles' Fast-charging Demand

Harprinderjot Singh, PhD Student, Michigan State University, East Lansing, MI, United States, Farish Jazlan, Mohammadreza Kavianipour, Mehrnaz Ghamami, Ali Zockaie

The rapid market growth of electric vehicles (EV) and the energy demand will affect grid stability and supply-demand balance in the electricity distribution system. Distributed energy resources (DER) (i.e., solar, battery, flywheel) can mitigate these impacts. This study proposes an optimization framework capturing EVs travel and grid requirements to support the EV demand at fast-charging stations while minimizing the total system cost, including potential grid upgrades, electricity cost, and solar and/or energy storage installation. The case study (Michigan) shows that the results are sensitive to the unit cost of DER, weather conditions, seasonal variation in solar and grid conditions.

4 - Retail Analytics for Store-Wide Shelf Space Allocation

Tulay Flamand, Colorado School of Mines, Division of Economics And Bus. Engineering Hall, Golden, CO, 80401-1878, United States, Ahmed Ghoniem, Bacel Maddah

We address a store-wide shelf-space allocation problem that seeks to maximize the profit from shoppers' impulse buying. By analyzing thousands of customer baskets, we build a predictive model for in-store traffic, as a function of the space allocation and the store layout and then embed it in a non-linear mixed-integer programming model. The latter is linearized by using linear equivalent constraints and piecewise linear approximations. This helps prescribe improved store configurations and yields managerial insights for retailers.

5 - Sports Analytics for an NBA Team to Optimize Team-Building Decisions

Megan Muniz, Colorado School of Mines, Golden, CO, United States, Tulay Flamand

We address a team-building problem for a basketball team, where the team decides on players to draft, current players to trade and free agents to acquire. We develop a predictive model to predict the value of new players who can be drafted, and a methodology to create a new metric that encompasses the synergy potential for each player. A predictive method is also developed to predict the synergy potential between players who have not yet played together. These inform a 0-1 integer programming model for the team-building decisions that maximizes the total team value. A case study is conducted using 2018-2019 NBA data. Results show that prescribed decisions are comparable with actual decisions, and we provide insights to the General Managers based on these decisions.

■ TC14

CC Room 201B

In Person: Optimization and Machine Learning

General Session

Chair: Arthur J. Delarue, MIT, Cambridge, MA, 02139-4310, United States

Chair: Vassilis Digalakis, Massachusetts Institute of Technology, United States

1 - Slowly Varying Regression under Sparsity

Vassilis Digalakis, Massachusetts Institute of Technology, Cambridge, MA, United States, Dimitris Bertsimas, Michael Lingzhi Li, Omar Skali Lami

We consider the problem of parameter estimation in slowly varying regression models with sparsity constraints. We formulate the problem as a mixed integer program and reformulate it exactly as a binary convex program, through a novel exact relaxation that utilizes a new equality on Moore Penrose inverses. This allows us to solve it to optimality using a cutting plane type algorithm; we develop an optimized implementation of such algorithm and a heuristic method that generates warm start solutions. We show on both synthetic and real world datasets that the algorithm outperforms competing formulations in comparable times across a variety of metrics and scales to problems with 10000s of parameters.

2 - Screening Rules for Sparse Regression

Andres Gomez, University of Southern California, Los Angeles, CA, 90014-3287, United States, Alper Atamturk

We propose techniques to quickly reduce the number of variables in large-scale sparse regression without affecting the quality of the resulting solution. The propose methods are based on using tight convexifications of sparse regression problems to determine variables which are necessarily fixed to zero or one, and adapt formulations to find the maximum number of such variables. We illustrate with computational experiments that the resulting formulations can lead to significant speedups over alternatives that do not use screening.

3 - Convexifications for Mixed Integer Quadratic Programs

Linchuan Wei, Northwestern University, Evanston, IL, 60201-4589, United States, Simge Kucukyavuz, Andres Gomez

We study the convexification of mixed-integer convex quadratic problems by decomposing the Hessian matrix Q into a sum of two-by-two positive semidefinite matrices. We give a convex hull description for the corresponding two-dimensional mixed-integer quadratic problem using the disjunctive programming approach. When a proper two-by-two decomposition is not straightforward, we formulate the problem of finding the tightest relaxation via two-by-two decomposition as a semidefinite programming problem (SDP).

■ TC15

CC Room 201C

In Person: Data Analytics in Service Operations

General Session

Chair: Shuai Hao, University of Illinois at Urbana-Champaign, IL, United States

1 - Lower-Tier Products: Friends or Foes? The Impact of Carpool on Ride-hailing Platforms

Tingting Nian, University of California, Stern School of Business, New York, NY, 10012, United States, Vidyanand Choudhary, Jinan Lin, Rambo Tan, Cheng Gong

The introduction of a new product to existing product lines typically gives rise to two opposing effects to the firm market expansion and cannibalization. In this study, we seek to understand and evaluate the causal impacts of introducing carpool rides on both riders' and drivers' welfare. In doing so, we use a unique dataset with fine-grained trip-level information provided by a leading ride-hailing platform, and exploit a natural experiment of the introduction of carpool rides. We are among the first studies investigating how new product introduction affects their ecosystems and revenues.

2 - Establishing the Link Between Overtreatment and Bad Debt in the Healthcare System

Shi Qiu, University of Illinois Urbana-Champaign, Urbana, IL, 61801-1024, United States, Yuqian Xu, Michael Freeman

Unnecessary health care, also known as overuse or overtreatment, is increasingly being recognized as a cause of patient harm and excess costs. However, it has not been studied whether overtreatment effect could contribute to patients' increasing bad debt. This paper aims to examine the relationship between overtreatment and bad debt, and the underlying moderators.

3 - The Invisible Risk: The Data-sharing Activities of Data Brokers and Information Leakage

Arion Cheong, Assistant Professor, California State University at Fullerton, Fullerton, CA, 07302, United States

Data brokers are the major players in the market of collecting, selling, and sharing online user information. This paper analyzes the leaked information on the dark web to examine the personal information leakage caused by data-sharing activities of data brokers. We consider the data-sharing activities of data brokers as a co-opetition between the data brokers and study how it relates to information leakage. We further examine empirical evidence of discretionary disclosure in the recent data broker registration and information disclosure act in Vermont and California. In specific, we evaluate whether registered data brokers have lower information leakage due to data-sharing activities than the unregistered coopetitors. Our study contributes to privacy and cybersecurity risk assessment literature by unveiling the shadowy data-collecting and data-sharing market.

4 - Impact of Showrooming in the Presence of Supplier Encroachment

Samayita Guha, Temple University, Philadelphia, PA, 19121-3444, United States, Abhishek Roy

The popularity of retail e-commerce has enabled many suppliers to reach diverse customer segments through direct channels. This practice is called supplier encroachment. Often, the supplier chooses to open a direct channel online to compete with an omnichannel retailer who carries the same product. However, consumers are unable to experience the tangible properties of the products using the online channel, and may use the retailer's physical store to determine product fit. This often results in a practice called showrooming, where some consumers visit physical retail store to evaluate a product, but ultimately buy it from another online retail store. In this paper, we study how these two practices, if occurring simultaneously, will impact both the omnichannel retailer and the online supplier.

5 - The Invisible Risk: The Data-sharing Activities of Data Brokers and Information Leakage

Tawei Wang, Won No

Data brokers are the major players in the market of collecting, selling, and sharing online user information. This paper analyzes the leaked information on the dark web to examine the personal information leakage caused by data-sharing activities of data brokers. We consider the data-sharing activities of data brokers as a co-opetition between the data brokers and study how it relates to information leakage. We further examine empirical evidence of discretionary disclosure in the recent data broker registration and information disclosure act in Vermont and California. In specific, we evaluate whether registered data brokers have lower information leakage due to data-sharing activities than the unregistered coopetitors. Our study contributes to privacy and cybersecurity risk assessment literature by unveiling the shadowy data-collecting and data-sharing market.

6 - Impact of Showrooming in the Presence of Supplier Encroachment

Subodha Kumar

The popularity of retail e-commerce has enabled many suppliers to reach diverse customer segments through direct channels. This practice is called supplier encroachment. Often, the supplier chooses to open a direct channel online to compete with an omnichannel retailer who carries the same product. However, consumers are unable to experience the tangible properties of the products using the online channel, and may use the retailer's physical store to determine product fit. This often results in a practice called showrooming, where some consumers visit physical retail store to evaluate a product, but ultimately buy it from another online retail store. In this paper, we study how these two practices, if occurring simultaneously, will impact both the omnichannel retailer and the online supplier.

■ TC17

CC Room 202A

In Person: Multi-objective Optimization/COVID-19 Applications

General Session

Chair: Tim Marler, PhD, RAND Corporation, Santa Monica, CA, United States

1 - The Role of Overconfidence on Personal Attitude Toward Covid-19 and Risk Mitigating Factors

Dominik Piehlmaier, Assistant Professor, University of Sussex, Brighton, United Kingdom

The experimental study sheds light on the impact of overconfidence on a person's attitude toward COVID-19 as well as the likelihood of wearing face masks, getting vaccinated, utilizing contact tracing apps, and following mandatory quarantine rules by conducting a randomised controlled trial data from 600 UK panellists. Building on the theory of correlation neglect, we show that respondents who are overconfident in their knowledge about infectious diseases illustrate a laxer attitude toward the current outbreak. The study provides evidence to help inform public health officials to focus on a subpopulation who would benefit from a nudge to follow official COVID-19 guidance and regulations.

2 - A Game Theory Approach for Engineering Optimization and Decision-making

Tim Marler, RAND Corporation

Groups of decision-makers, interacting in a design process, can be modeled using game theory, which in turn can be solved as a multi-objective optimization problem. From this perspective, decision-makers rarely cooperate completely in a theoretical sense; rather, the exchange of information is iterative. Ultimately, this can result in a non-optimal solution or design. Given multiple decision-makers, each managing a separate objective function and controlling unique variables, this paper presents a new algorithm for modeling design process as a non-cooperative game theoretic scenario. This algorithm is then used in the context of a broader novel multi-objective optimization approach for resolving such non-cooperative situations, thus yielding a Pareto optimal solution. This approach provides not only a mathematical method for extending a Nash equilibrium point (non-cooperative solution) towards the Pareto optimal set, but also a means for modeling how decision-makers actually interact. This, in turn provides significant insight into engineering project management and decision-making. The proposed approach is demonstrated with two illustrative design problems.

■ TC18

CC Room 202B

In Person: Topics in Sustainability

General Session

Chair: Manali Sunil Zantye

Co-Chair: Kristen Schell, Carleton University, Ottawa, ON, K1S 5B6, Canada

1 - Distribution Model of Subsidy and Tax in Sustainable Energy Value-chain

Mohammad Amini, U T. Austin, Austin, TX, United States, Shadi Goodarzi

The growing need of society for energy on the one hand and the increasing environmental problems, on the other hand, led policymakers designe different policies to limit the usage of fossil fuels and promote renewable energies(taxes and subsidies). However, designing an optimal policy that increases social welfare, promotes using renewable energy consumption, and reduces environmental pollution still remains a great challenge. This study aims to provide an appropriate tax/subsidy distribution model to promote renewable energy usage where the amount of tax collection and the payment subsidy have been determined using game theory. The components of the game have been determined based on conducted studies and the experiences of different countries.

2 - Consumer Behavior Towards Different Carbon Footprint Reductions

Nils Roemer, Universität Hamburg, Hamburg, Germany, Guido Voigt, Gilvan Souza, Christian Tröster

Responding to demands for sustainable products and services, many firms have the goal to become "net zero" carbon emissions. With different options to achieve this goal, such as buying offsets or switching to renewables, it is unclear how consumers perceive them. We empirically investigate this through surveys and incentivized experiments.

3 - A Dynamic Optimization Framework for Integrated Fossil Energy, Renewables and Flexible Carbon Capture for Transitioning Towards Clean Energy

Manali S. Zantye, Texas A&M University, College Station, TX, United States, Akhil Arora, M.M. Faruque Hasan

We address the intermittency of renewables and the high cost of CO2 capture through integration with existing fossil power plants and exploration of operational synergies for grid decarbonization. A mathematical optimization-based framework and a two-stage solution strategy is developed to evaluate if the benefits obtained from integration outweigh the investment cost under spatiotemporal variability of electricity markets and renewables. The results show that it is economically beneficial to integrate solar-assisted CO2 capture with one-third of the coal plants in the US to reduce emissions.

■ TC19

CC Room 203A

In Person: Data-Driven Decision-Making in Healthcare Applications

General Session

Chair: Maryam Alimohammadi, University of Arkansas, Fayetteville, AR, 72701, United States

1 - WiFi Network Logs Enable Data-driven Closure Policies for COVID-19 on University Campuses

Lauren N. Steimle, Georgia Institute of Technology, Atlanta, GA, 30308, United States, Jingyu Li, Meghan Meredith, Dima Nazzal

Universities commonly control infectious diseases like COVID-19 by employing broad closures, which come at the cost of learning outcomes and mental wellbeing concerns. To meet infection reduction goals while minimizing burdens, universities need a flexible approach to design and assess closure policies. We demonstrate that universities can conceive such localized closure by modeling campus mobility with anonymized WiFi logs already collected in their infrastructure. Using an agent-based model, we show that policies designed using these data can outperform simple remote instruction policies in terms of mobility reduction and disease outcomes.

2 - Prediction of Mechanical Ventilation Outcome in Intensive Care Units Using Modified Recurrent Neural Network

Maryam Alimohammadi, University of Arkansas, Fayetteville, AR, 72701, United States, Shengfan Zhang

Mechanical ventilation is one of the most widely used interventions in ICU. Because of the high usage and limited sources, the management of mechanical ventilation is significant. Predicting the ventilation outcome before the start of ventilation or at the beginning of the ventilation can improve decision-making in mechanical ventilation interventions in the ICU. However, dealing with the electronic health record data of patients admitted to ICU is complicated due to its complex temporal nature, noisiness, and irregularity. We proposed a modified recurrent neural network to predict the mechanical ventilation outcome using optimized decision-making time windows. This method helps reduce the missingness and noisiness of data and predicts the outcome with higher accuracy in comparison to the traditional classification methods.

3 - Evidence of Worse Outcomes Related to Out-of-Hospital Cardiac Arrest During the COVID-19 Pandemic Due to Patient Reluctance to Seek Care

Christopher Sun, Massachusetts Institute of Technology, Boston, MA, 02114-3756, United States, Sophia Dyer, James Salvia, Laura Segal, Retsef Levi

Delays in seeking emergency care stemming from patient reluctance may explain the rise in cases of out-of-hospital cardiac arrest (OHCA) and associated poor health outcomes during the coronavirus disease 2019 (COVID-19) pandemic. In this talk, we will discuss how we used emergency medical services (EMS) call data from the Boston area to describe the association between patient reluctance to call EMS for cardiac-related care and both excess OHCA incidence and OHCA-related outcomes during the COVID-19 pandemic.

■ TC20

CC Room 203B

In Person: OR Applications for Medical Decision-making

General Session

Chair: Daniel Felipe Otero-Leon, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Optimizing Repeated Decisions in Infectious Disease Control

Suyanpeng Zhang, University of Southern California, Los Angeles, CA, United States, Sze-chuan Suen

The Covid-19 outbreak emphasizes the necessity of studying policies to prevent or control the transmission of infectious diseases. However, evaluating dynamic policies for disease modeling can be challenging due to the complexity of the state space and transitions associated with realistic models of transmissible disease. We develop a Markov decision process framework for optimizing repeated decisions for infectious disease control over a population over time while considering uncertainty in parameters.

2 - Delivering Preventive Dental Care in Florida Schools: understanding System Limits

Amin Dehghanian, Georgia Institute of Technology, Atlanta, GA, 30329, United States, Simin Ma, Yasin Cagatay Gultekin, Nicoleta Serban, Scott Tomar

We evaluate the dental care availability to deliver preventive care for children in Florida elementary schools, with inferences on the availability limits to meet demand across all school. For this purpose, we use a bi-level optimization model to reallocate dentists' caseload to school-based programs to meet the need for preventive dental care under a series of access and supply constraints.

3 - Patient Prioritization Model with Limited Resources and Stochastic Compliance

Daniel Felipe Otero-Leon, PhD Student, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States, Mariel Sofia Lavieri, Brian T. Denton, Jeremy Sussman, Rodney Hayward

Physicians seek to prevent chronic diseases by tracking the patients' healthcare behavior. They handle a large heterogeneous panel of patients, which is costly or demands multiple resources. Unfortunately, physicians do not count on infinite resources, for which they need to prioritize the panel. Not prioritize patients may forgo needed treatment and suffer adverse events related to the disease. Additionally, despite the physician's efforts, prioritize patients may not adhere to medication and follow-up recommendations. We present a Multi-armed bandit model to maximize the panel's total life years gain. Further, we tested the model using longitudinal data for cardiovascular diseases in a large cohort of patients seen in the national Veterans Affairs health system. Finally, we study the resulting prioritization policies and their structure.

■ TC21

CC Room 204A

In Person: Nonlinear Optimization Techniques in Stochastic Optimization

General Session

Chair: Ashish Chandra, Krannert School of Management, Purdue University

1 - Robust Optimization Approaches to Incentivize Carbon Footprint Reduction

Aurelie Thiele, Southern Methodist University, Dallas, TX, 75275-0123, United States

It has become very important for many sustainability-conscious individuals and companies alike to reduce their carbon footprint (CO2 emissions), from operations to shipping to travel. We investigate tractable choice models with uncertain coefficients for incentivizing operational modalities for a heterogeneous population, provide theoretical insights into the tradeoffs between modalities and apply our approach to a real data set.

2 - Optimization for Probability Estimation and Application to Network Reliability

Ashish Chandra, Purdue University, West Lafayette, IN, United States, Mohit Tawarmalani

We develop optimization techniques to estimate the probability of an event (E) where the optimal value of a convex program exceeds a given threshold. A particular example we consider is the network reliability problem where we determine the probability of failures which result in network utilization exceeding one. The uncertain parameters in the problem are assumed to be drawn from the vertices of a 0/1 polytope and, for the network reliability problem, model the links that fail. Our techniques rely on a new fully polynomial approximate counting and sampling algorithms to compute the probability of an event described as a union of 0/1 knapsack polytopes.

■ TC22

CC Room 204B

In Person: Learning Algorithms in Resource Allocation and Healthcare Applications

General Session

Chair: Pengyi Shi, Purdue University, West Lafayette, 47907, United States

1 - Near-optimal Bayesian Online Assortment of Reusable Resources

Yiding Feng, Northwestern University Electrical Engineering and Computer Science, Evanston, IL, United States, Rad Niazadeh, Amin Saberi

Motivated by the applications of rental services in e-commerce, we consider revenue maximization in online assortment of reusable resources for a stream of arriving consumers with different types. We design competitive online algorithms with respect to the optimum online policy in the Bayesian setting, in which types are drawn independently from known heterogeneous distributions over time. In the regime where the minimum of initial inventories c_min is large, our main result is a near-optimal 1-min(1/2,\sqrt{log(c_min)/c_min}) competitive algorithm for the general case of reusable resources. For the special case of non-reusable resources, we further show an improved near-optimal 1-1/\sqrt{c_min+3} competitive algorithm.

2 - The Role of Horizontal Physician Integration in Alternative Payment Models

Christopher Chen, Indiana University Kelley School of Business, Bloomington, IN, United States, Kraig Delana

We analyze the role of consolidation of physicians within physician groups on the effectiveness of Alternative Payment Models. In the context of the Comprehensive Joint Replacement (CJR) program, we examine the extent to which this consolidation, both horizontal and vertical, increases or decreases costs and performance.

3 - The Impact of Vertical Integration on Physician Behavior And Healthcare Delivery: Evidence From Gastroenterology Practices

Lina Song, University College London School of Management, London, United Kingdom, Soroush Saghafian, Joseph Newhouse, Mary Beth Landrum, John Hsu

The U.S. healthcare system is undergoing a substantial change, with hospitals purchasing many physician practices ("vertical integration"). Integration could improve quality by promoting care coordination, but could also worsen it by impacting the care delivery patterns. We study the impact of vertical integration on quality and spending by examining 2.6 million Medicare patient visits across 5,488 gastroenterologists. We find that integration results in increased spending and worse quality of care. In particular, physicians reduce recommended care processes (e.g., anesthesia with deep sedation) after they integrate, which results in an increase in patients' post-procedure complications. Policymakers should carefully design the financial incentives of the integrated providers to prevent the unintended consequences of the current integration trends.

■ TC23

CC Room 204C

In Person: Towards the Future of Air Traffic Flow Management

General Session

Chair: Lu Dai, University of California, Berkeley

1 - Evaluation of Wind and Convective Weather Impacts on Trajectory-based Operations (TBO)

Gabriele Enea, Technical Staff, MI T. Lincoln Laboratory, Lexington, MA, 02421, United States, Michael McPartland

The FAA is evolving the air traffic control system from a tactical, position-based approach, to a more strategic, trajectory-based operations (TBO) approach. Currently, TBO systems do not have appropriate information about convective weather and extreme wind conditions to continue to operate effectively under these demanding conditions. This presentation will discuss MIT Lincoln Laboratory work in building the TBO Weather Testbed to develop a roadmap of studies and enhancements necessary to support TBO under all wind and weather conditions and the vision to create weather-aware TBO automation.

2 - Requirements Consideration for Commercial Aircraft Formation Flight

Safa Saber, King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia, Eric Feron

Aircraft have been flying in formation for mutual benefit for about a century. The possibility of commercial aircraft formations are only now becoming a viable option due to modern flight control systems and more capable computation. At the same time, commercial aircraft formations are also becoming a valuable construct due to congested airspace and the desire for greater fuel efficiency. The realization of commercial formations requires serious consideration of aircraft deconfliction and safety during closer-in maneuvering of large aircraft. This paper introduces formation deconfliction of transport category aircraft and presents possible solutions and questions for further research.

3 - Air Travel and COVID-19 Pandemic Spread: A US Case Study

Lu Dai, University of California, Berkeley, Berkeley, CA, United States
Lu Dai, National Center of Excellence for Aviation Operations Research, Berkeley, CA, United States

The COVID-19 pandemic has immensely caused air transportation network disruptions. In this talk, we demonstrate models to quantify the dynamics of the impact of air travel on the spread of the COVID-19 pandemic, using a wide range of datasets covering the period from March to December 2020. Our analysis is built upon the dynamic air transportation network, where the nodes are the operating airports and the links between them inferred from realized daily flight activity. We developed a novel approach to estimate the county-level daily air passenger traffic during the pandemic, and employed cross-sectional models to estimate the impacts over different periods.

■ TC24

CC Room 205A

In Person: Innovative Business Models in Supply Chain Management

General Session

Chair: Xiaoyang Long, University of Wisconsin-Madison, Madison, WI, 53706-1324, United States

1 - Retail Power: A Double Edged Sword for Suppliers

Shuya Yin, University of California-Irvine, Paul Merage School of Business, Irvine, CA, 92697-3125, United States, Yuhong He, Saibal Ray

In distribution channels, growing power of downstream firms (retailers) is a cause of both pleasure and pain for their upstream partners (suppliers). On one hand, suppliers rely on these key retailers to generate sales. On the other hand, these retailers may have the standing to negotiate vigorously on issues like sharing of channel revenues. We use an analytical model to explore how the level of product competition (whether they are differentiated or similar), the correlation between popularity of the retailers and their bargaining powers and intensity of competition from other channels shape a supplier's perspective about retail power: specifically, her preference about the structure of downstream retail distribution channel for her own product variants.

2 - Friend or Foe: Search Engine Advertising Strategies when Contracting with an Online Search Infomediary

Abhishek Roy, Temple University, Philadelphia, PA, United States, Siddharth Bhattacharya

The widespread growth of e-commerce has resulted in proliferation of online search infomediaries (OSIs), who provide consumers with information about products and services sold by different firms (Parents), while also referring interested consumers to the Parents' website. Very often, both Parent and OSI advertise and compete for a spot on sponsored search page on Parent's keyword. This leads to an interesting conundrum where Parent and OSI both compete and cooperate at same time. In this unique context, how equilibrium payment and advertising strategies affect factors such as traffic quality, advertising effectiveness, leakage, and nature of contract between two firms, is this study's focus.

3 - Online Task Assignment with Multi-capacity Constraints
Liron Yedidsion, Amazon, Seattle, WA, 3491319, United States

Striving to satisfy customers' demands within one day for an increasing variety of products, companies are required to assign operations to resources on any level in the supply chain within minutes of any incoming customer order. These include fulfillment centers, sort centers, delivery stations, carriers, subcontractors, and down to the level of a single route. Each resource has its own capacities of processing time and space. Amazon is required to make decisions in an online and dynamic manner. We present a multidimensional stochastic dynamic program designed for that purpose.

■ TC25

CC Room 205B

In Person: Advances in Discrete Optimization

General Session

Chair: Jongeun Kim, University of Minnesota, Minneapolis, MN, 55414, United States

1 - Heterogeneous Multi-Resource Allocation Problem
Arden Baxter, Georgia Institute of Technology, Atlanta, GA, 30309, United States, Pinar Keskinocak, Mohit Singh

Motivated by resource allocation settings that may require coordination, we consider the problem of allocating multiple heterogeneous resources geographically and over time to meet demands that require some subset of the available resource types simultaneously at a specified time, location, and duration. The objective is to maximize total reward accrued from meeting (a subset of) demands. We model this problem as an integer program, show it is NP-hard, analyze the complexity of special cases, and introduce approximation algorithms. We further study uncertainty in demand through the stochastic version of the problem using a two-stage stochastic integer program where the first-stage decision determines the number of resources of each type and the second-stage decision initializes resources at starting locations and assigns them to demands.

2 - A Reciprocity Between Tree Ensemble Optimization and Multilinear Optimization Over the Cartesian Product of Simplices
Jongeun Kim, University of Minnesota, Minneapolis, MN, 55414, United States, Jean-Philippe P. Richard, Mohit Tawarmalani

We study the connection between tree ensemble optimization problem and multilinear optimization over the cartesian product of simplices. We show that two problems are equivalent. We also provide some polyhedral results on a multilinear set that can be used to derive an improved formulation in tree ensemble optimization.

■ TC26

CC Room 206A

In Person: Optimization Over Sparse and Low-rank Structures

General Session

Chair: Ryan Cory-Wright, MIT, Cambridge, MA, 02141-1534, United States

1 - Sparse and Low Rank Matrix Decomposition: A Discrete Optimization Approach
Nicholas Andre G. Johnson, United States

The Sparse Plus Low-Rank decomposition problem (SLR), or the problem of approximately decomposing a data matrix into a sparse matrix plus a low-rank matrix, arises throughout many fundamental applications in Operations Research, Machine Learning and Statistics. The difficulty of this problem stems from the natural rank and sparsity constraints which are non convex and non smooth. Existing approaches are heuristic in nature, many relying on nuclear norm and L1 norm based convex relaxations, and do not possess optimality guarantees. We introduce a novel formulation for SLR that directly models the underlying discreteness of the problem. For this formulation, we develop an algorithmic approach to solving SLR to certifiable optimality by deriving a strong heuristic, a strong convex relaxation and embedding these within a custom branch and bound routine.

2 - Sparse Quadratic Optimization with Sparse Matrices
Peijing Liu, University of Southern California, Los Angeles, CA, United States, Andres Gomez, Simge Kucukyavuz

We study problems arising in sparse regression, where additionally the model matrix is sparse. We first show that a class of problems with tridiagonal matrices can be solved efficiently in polynomial time. For problems involving sparse but not tridiagonal matrices, we discuss decomposition approaches using Fenchel duality that leverage sparsity and produce high quality solutions in a fraction of the time required to solve the problems using standard techniques.

3 - KFW: A Frank-wolfe Style Algorithm with Stronger Subproblem Oracles
Lijun Ding, Cornell University, Ithaca, NY, 14850-2842, United States

This talk proposes a new variant of Frank-Wolfe (FW),called kFW. Standard FW suffers from slow convergence:iterates often zig-zag as update directions oscillate around extreme points of the constraint set. The new variant, kFW, overcomes this problem by using two stronger subproblem oracles. The first is a k linear optimization oracle (kLOO) that computes the k best update directions. The second is a k direction search (kDS) that minimizes the objective over a constraint set represented by the k best update directions and the previous iterate. When the problem solution admits a sparse representation, both oracles are easy to compute, and kFW converges quickly for smooth convex objectives and several interesting constraint sets: kFW achieves finite convergence on polytopes and group norm balls, and linear convergence on spectrahedra and nuclear norm balls.

4 - A New Perspective on Low Rank Optimization
Ryan Cory-Wright, MIT, Cambridge, MA, 02141-1534, United States, Dimitris Bertsimas, Jean Pauphilet

A key question in many low-rank problems is to characterize the convex hulls of simple low-rank sets and judiciously apply these convex hulls to obtain strong yet affordable convex relaxations. We apply the matrix perspective function —the matrix analog of the perspective function — to characterize explicitly the convex hull of epigraphs of convex quadratic, matrix exponential, and matrix power functions under rank constraints. Further, we exploit these characterizations to develop strong relaxations for a variety of low-rank problems including reduced rank regression and factor analysis. We establish that these relaxations can be modeled via semidefinite, relative entropy, and matrix power cone constraints and thus optimized over tractably. The proposed approach parallels and generalizes the perspective reformulation technique in mixed-integer optimization.

■ TC28

CC Room 207B

In Person Technology Tutorial: This IS IT! Interactive Smart Textbooks for the Modern Program!

Technology Tutorial

1 - This IS IT! Interactive Smart Textbooks for the Modern Program!
Jaret Wilson, MyEducator, Orem, UT, United States, Scotty Pectol

This is modern higher education! An affordable alternative to OER with up-to-date content from world-class author teams. Created by professors for professors, MyEducator smart interactive textbooks and learning resources are ideal for any classroom setting and work within live technology environments so your students don't just learn, they do! Our approach enhances student engagement, improves learning outcomes, instructors receive better teaching evaluations, and students have more fun in the classroom.Each smart learning resource is hosted on our intuitive platform with auto-graded assessments, ample instructor material, robust analytics, all with seamless single sign-on LMS integration, low student cost, lifetime access, and best-in-class service. Full access will be given to any book on our platform to attendees.

■ TC28

CC Room 207B

In Person Technology Tutorial: Turning Models Into Applications– GAMS Engine and GAMS Transfer

Technology Tutorial

1 - Turning Models Into Applications- GAMS Engine and GAMS Transfer
Steven Dirkse, GAMS. Development Corporation, Fairfax, VA, United States, Adam Christensen

The right tools help you deploy your GAMS model and maximize the impact of your decision support application. GAMS Engine is a powerful tool for solving GAMS models, either on-prem or in the cloud. Engine acts as a broker between applications or users with GAMS models to solve and the computational resources used for this task. Central to Engine is a modern REST API that provides an interface to a scalable Kubernetes-based system of services, providing API, database, queue, and a configurable number of GAMS workers. GAMS Transfer is an API (available in Python, Matlab, and soon R) that makes moving data between GAMS and your computational environment fast and easy. By leveraging open source data science tools such as Pandas/Numpy, GAMS Transfer is able to take advantage of a suite of useful (and platform independent) I/O tools to deposit data into GDX or withdraw GDX results to a number of data endpoints (i.e., visualizations, databases, etc.).

■ TC29

CC Room 207C

In Person: Practice Curated: Analytics Enabling Healthcare Access through Telehealth/Enterprise Revenue Management at 84.51

General Session

Chair: Yifan Liu, 84.51°, Cincinnati, OH

1 - Service System Design of Video Conferencing Visits with Nurse Assistance

Xiang Zhong, University of Florida, Gainesville, FL, 32612-1701, United States, Xiaojie Wang, Yongpei Guan

Video-conferencing (VC) clinical visits (aka telehealth service) are gaining popularity over the past decades. We explore the implementability of VC visits with nursing services using a game-theoretic model, and investigate the impact of different pricing schemes (discriminative pricing based on patient characteristics vs. non-discriminative) on patients' care choices between VC visits and in-person visits. Our results identify the conditions where the interest of the social planner and the medical institution could be aligned, and highlight that, compared to a uniform price of VC visits which seems fair, a discriminative pricing strategy can be more beneficial for patients and the medical institution alike. The insurance coverage of telehealth-related services is important to promote the adoption of telehealth by patients and care providers.

2 - Regular Price Decision Making under Uncertainties

Yifan Liu, 84.51°, Cincinnati, OH, United States

In retail businesses, a decision maker often needs to make long-term strategic pricing decisions (regular price) without finalizing a complete set of short-term tactical decisions such as promotional price, ads plan and display plan. We present a framework using a stochastic programming model to help Kroger make this type of regular price decision that hedges against future uncertainties while maintaining logic on shelf and improving financial metrics.

■ TC30

CC Room 207D

In Person: Modeling and Analytics for Heterogeneity in System Informatics

Joint Session

Chair: Minhee Kim, University of Wisconsin-Madison, Madison, WI, 53706-1539, United States

1 - Multi-modal Predictive Model for Persistent Post-traumatic Headache

Nathan B. Gaw, Georgia Institute of Technology, Atlanta, GA, 85258-2222, United States, Catherine Chong, Todd Schwedt, Visar Berisha, Teresa Wu, Katherine Ross, Gina Dumkrieger, Jianwei Zhang, Simona Nikolova, Jing Li

Each year, there are approximately 2 million individuals diagnosed with mild traumatic brain injury (mTBI). Post traumatic headache (PTH) is the most common symptom following mTBI, which can either resolve or continue into persistent PTH (PPTH). There is a need to determine biomarkers that can be used to predict resolution or persistence of PTH in order to allow for timely treatment of the condition. The current study builds a multi-modality predictive model that combines clinical measures, medical images, and longitudinal speech data to predict at-risk patients and identify highly relevant biomarkers.

2 - Covariate Dependent Sparse Functional Data Analysis

Minhee Kim, University of Wisconsin–Madison, Madison, WI, 53705, United States, Kaibo Liu

We propose a method to incorporate intrinsic covariate information into sparse functional data analysis. The method aims at cases where each unit has a small number of longitudinal measurements and records intrinsic covariates. Unlike external covariates which may change over time, intrinsic covariates represent the basic nature of a unit and static. Existing methods often do not use covariate information or only model the additive effects of dynamic external covariates. Yet, the incorporation of intrinsic covariate information into functional data analysis can significantly improve modeling and prediction performance. The proposed method decomposes the variation of measurements into the variation coming from intrinsic covariates and the variation left conditioned on intrinsic covariates. We also develop a bootstrapping covariate selection algorithm.

■ TC31

CC Room 208A

In Person: Mechanism Design, Networks, and New Markets

General Session

Chair: Francisco Castro, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

1 - Dynamic Moral Hazard with Adverse Selection: A Pontryagin Approach

Feifan Zhang

We study the optimal incentive scheme for a long-term project with both moral hazard and adverse selection. The moral hazard issue is due to the fact that the agent's effort, which increases the arrival rate of a Poisson process, is not observable by the principal. In addition, the agent's effort cost, which needs to be reimbursed by the principal, is also the agent's private information. This gives rise to the adverse selection problem. The principal needs to design the optimal menu of contracts, each of which is chosen by the agent with a specific effort cost. We fully characterize the optimal menu in the case of two types of agents. Specifically, the agent with a lower cost is offered a probation contract, which confirms the agent's type if there is an arrival during a probation period; the agent with the higher cost is offered a sign-on-bonus contract with an immediate direct initial payment. We then explore the more general case with continuous types of agents. In particular, we provide an easy-to-compute upper bound on the principal's utility. The upper bound computation also yields a feasible menu of probation and sign-on-bonus contracts, and the corresponding lower bound it generates. We further provide a condition which can be used to verify whether the upper and lower bounds coincide, implying the optimality of our feasible menu of contracts. Numerical studies confirm that the verficiation condition almost always holds for commonly used probability distributions of the effort cost.

2 - Mechanism Design under Approximate Incentive Compatibility

Francisco Castro, UCLA Anderson School of Management, 1315 Devon Avenue, Los Angeles, CA, 90024, United States

We extend the classical Myerson setting to the case where the buyer is not a perfect optimizer and only -incentive compatibility is required. Our paper is the first to study the design of optimal mechanisms in the space of approximate IC mechanisms and to explore how much revenue can be garnered by moving from exact to approximate incentive constraints. We show that deterministic mechanisms are not optimal and that randomization is needed. We then establish that no mechanism can garner gains higher than order 2/3. This improves upon known results that imply maximum gains of 1/2. Furthermore, we construct a mechanism that is guaranteed to achieve order 2/3 additional revenues, leading to a tight characterization of the revenue implications of approximate IC constraints. Importantly, to find the optimal mechanism it is necessary to optimize over best reporting functions.

3 - Providing Data Samples for Free

Kimon Drakopoulos, University of Southern California, Los Angeles, CA, 90305-1028, United States

We consider the problem of a data provider (Seller of information) who sells information to a firm (Buyer of information) regarding an unknown (to both parties) state of the world. Traditionally, the literature explores one-round strategies for selling information due to the Seller's hold-up problem: once a portion of the dataset is released, the Buyer's estimate improves and as a result the value of the remaining dataset drops. In this paper we show that this intuition is true when the Buyer's objective is to improve the precision of her estimate. On the other hand, we establish that when the Buyer's objective is to improve operational decisions (e.g. better pricing decisions on a market with unknown elasticity) and when the Buyer's initial estimate is misspecified, one-round strategies are outperformed by free-sample selling strategies and dynamic pricing.

■ TC32

CC Room 208B

In Person: Algorithmic Competition and Collusion in Revenue Management

General Session

Chair: Chamsi Hssaine, Cornell University, Ithaca, NY, 14850, United States

1 - Pseudo-Competitive Games

Chamsi Hssaine, Cornell University, Los Angeles, CA, 90025-5692, United States, Vijay Kamble, Siddhartha Banerjee

We study algorithmic price competition in a duopoly under a model of satisficing customer behavior. In this model, customers consider firms in some exogenously determined order of preference until they find a price that satisfies an ideal surplus target, choosing the lowest price they can afford if every firm fails to satisfice. We exhaustively characterize the equilibrium landscape of the game, and show that it is frequently plagued by strictly-local Nash equilibria, an outcome

with potentially unbounded loss for one of the firms. We numerically find that price dynamics resulting from gradient-based algorithms often converge to this undesirable outcome. We finally discuss extensions of our insights to a general model of "pseudo-competitive" pricing games with multiple firms, allowing for a mixture of loyal, satisficing, and opportunistic customers.

2 - How Does Competition Affect Exploration vs. Exploitation? A Tale of Two Recommendation Algorithms

Z. Eddie Ning, CKGSB, Beijing, China

In this paper, we use a continuous-time multi-agent bandit model to analyze firms that supply content to consumers. We compare a forward-looking recommendation algorithm that balances exploration and exploitation to a myopic algorithm that only maximizes the current quality of the recommendation in both monopoly and duopoly settings. Our analysis shows that competition can discourage learning. In duopoly, firms focus more on exploitation than exploration in their recommendations than a monopoly would. Competition decreases firms' incentives to develop forward-looking algorithms when users are impatient. Development of the optimal forward-looking algorithm may hurt users under monopoly but benefits users under competition.

■ TC33

CC Room 209A

In Person: Operations Research at Facebook/Ride Sharing Operations

General Session

Chair: Amine Allouah, Columbia University, New York, NY, 10027, United States

1 - The Parity Ray Regularizer for Pacing in Auction Markets

Andrea Celli, Bocconi University, Milano, Italy

Internet advertising platforms typically offer advertisers the possibility to pace the rate at which their budget is depleted, through budget-pacing mechanisms. We focus on multiplicative pacing mechanisms in an online setting in which a bidder is repeatedly confronted with a series of advertising opportunities. Building on recent work, we study the frequent case in which advertisers seek to reach a certain distribution of impressions over a target population of users. We introduce a novel regularizer to achieve this desideratum, and show how to integrate it into an online mirror descent scheme with optimal order of sub-linear regret when inputs are drawn independently, from an unknown distribution. We demonstrate its effectiveness through numerical experiments on real-world data.

2 - Labor Cost Free-Riding in the Gig Economy

Zhen Lian, Cornell University, Cornell Tech, New York, NY, 10044, United States, Sebastien Martin, Garrett J. van Ryzin

We propose a theory of gig economies in which workers participate in a shared labor pool utilized by multiple firms. Since firms share the same pool of workers, they face a trade-off in setting pay rates; high pay rates are necessary to maintain a large worker pool and thus reduce the likelihood of lost demand, but they also lower a firm's profit margin. We prove that larger firms pay more than smaller firms in the resulting pay equilibrium. These diseconomies of scale are strong too; firms smaller than a critical size pay the minimal rate possible (the workers' reservation wage), while all firms larger than the critical size earn the same total profit regardless of size. This scale disadvantage in labor costs contradicts the conventional wisdom that gig companies enjoy strong network effects and suggests that small firms have significant incentives to join an existing gig economy, implying gig markets are highly contestable. Yet we also show that the formation of a gig economy requires the existence of a large firm, in the sense that an equilibrium without any firms participating only exists when no single firm has enough demand to form a gig economy on its own. The findings are consistent with stylized facts about the evolution of gig markets such as ridesharing.

3 - Matching Drivers to Riders: A Two-stage Robust Approach

Oussama Hanguir, Columbia University, New York, NY, 10025, United States, Omar El Housni, Vineet Goyal, Clifford Stein

Matching riders to drivers efficiently is a fundamental problem for ridesharing platforms who need to match the riders as soon as the request arrives with partial knowledge about future requests. A myopic approach that computes an optimal matching for current requests ignoring future uncertainty can be highly sub-optimal. In this paper, we consider a two-stage robust optimization framework for this matching problem where future demand uncertainty is modeled using a set of demand scenarios (specified explicitly or implicitly). The goal is to match the current request to drivers (in the first stage) so that the cost of first stage matching and the worst case cost over all scenarios for the second stage matching is minimized. We show that the two-stage robust matching is NP-hard under various cost functions and present constant approximation algorithms for different settings.

4 - Information Design for Congested Social Services: Optimal Need-based Persuasion

Jerry Anunrojwong, Columbia Business School, New York, NY, United States, Krishnamurthy Iyer, Vahideh Manshadi

We study the effectiveness of information design in reducing congestion in social services catering to users with varied levels of need. We consider a model where an arriving user decides either to wait for the service by joining an unobservable FCFS queue, or to seek her outside option. To reduce congestion, the service provider seeks to persuade more low-need users to avail their outside option, thereby better serving high-need users. We show that with enough heterogeneity in need, information design not only Pareto dominates full-information and no-information mechanisms, in some regimes it also achieves the same welfare outcomes as the "first-best", i.e., the optimal admission policy.

■ TC34

CC Room 209B

In Person: Economics of Retail Distribution Services/Healthcare and Service Operations Management

General Session

Chair: Soraya Fatehi, University of Texas at Dallas, Richardson, TX, 75080, United States

1 - Analysis on Costs and Benefits of Machine Learning-based Early Hospitalization Prediction

Eunbi Kim, Korea University, Seoul, Korea, Republic of, Kap-su Han, Taesu Cheong, Sung-Woo Lee, Sujin Kim, Joonyup Eun

Overcrowding is often derived from boarding time delays of ED patients to wards. If we predict a patient's hospitalization early enough and accurately in the ED, an inpatient bed for the patient can be prepared in advance. We predict an ED patient's hospitalization and compare the performances between models. Based on the prediction results, we estimate how much time is saved in an ED. We also estimate time costs of beds to be kept as being empty for patients to be hospitalized in wards. According to the analysis, we provide the linkage between prediction performances, costs, and benefits.

2 - Contingent Free Shipping: Drivers of Bubble Purchases

Sahar Hemmati, University of Maryland, College Park, MD, United States, Wedad Elmaghraby, Ashish Kabra, Nitish Jain

Retailers often offer free shipping on orders above a pre-specified threshold (Contingent Free Shipping, CFS). In response, customers may pad below-threshold orders to avoid shipping fees. This behavior can economize logistics costs if customers do not engage in bubble purchases, padded orders with above-par return propensity. In this study, we empirically examine how the customers' engagement in bubble purchases relates to: 1. CFS policy's threshold and shipping fee and 2. ease of product return. We find that, in response to CFS policies, customers pad 12.4% to 28.4% of below-threshold orders. Both policy levers considerably affect their order padding and bubble purchase propensity. In markets with a customer-friendly return process, share of bubble purchases varies from 8.4% to 14.7% and is altogether eliminated in markets with inconveniences in the return process.

3 - Capacity Flexibility via On-demand Warehousing

Soraya Fatehi, University of Texas at Dallas, Richardson, TX, United States, Leela Aarthy Nageswaran, Michael R. Wagner

We study the on-demand warehousing business practice where firms who seek capacity for short term needs match with third-party warehouse providers who have excess capacity. We derive a firm's optimal capacity investment decision in the presence of the on-demand warehousing option. Motivated by the practice of on-demand warehousing players and prior work on sharing platforms, we also investigate the implications of two pricing strategies, surge pricing and bid pricing. Our results indicate that on-demand warehousing allows firms to absorb their demand fluctuations and increase their profit. Our findings provide valuable insight into when the different pricing strategies may be used by an on-demand warehousing platform. We also study whether platforms should share information regarding available capacity of providers and how it impacts the system performance.

■ TC35

CC Room 210A

In Person: Last-Mile Logistics for E-Commerce

General Session

Chair: Dipayan Banerjee, Georgia Institute of Technology, Atlanta, GA, 30318-5644, United States

1 - Marketplace Design for Crowdsourced Delivery

Adam Behrendt, Georgia Tech, Atlanta, GA, United States, Martin W P Savelsbergh, He Wang

Crowdsourced delivery platforms face the unique challenge of meeting dynamic customer demand using couriers not employed by the platform. As a result, the delivery capacity of the platform is uncertain. To reduce the uncertainty, the platform can offer a reward to couriers that agree to make deliveries for a specified period of time. We consider a crowdsourced courier scheduling problem in which a mix of scheduled and ad-hoc couriers is available to serve dynamically arriving orders. The platform's objective is to determine shifts for scheduled couriers so as to minimize total courier payments and penalty costs for expired orders. We present a prescriptive machine learning method that combines simulation optimization for offline training and a neural network for online solution prescription. We validate this method using data from a crowdsourced delivery platform.

2 - Does Parking Matter in Routing Last-Mile Deliveries?

Sara Reed, University of Kansas, University Of Iowa, Lawrence, KS, 52242, United States, Ann Melissa Campbell, Barrett Thomas

Parking the delivery vehicle is a necessary component of traditional last-mile delivery practices but finding parking is often difficult. The Capacitated Delivery Problem with Parking (CDPP) is the problem of a delivery person needing to park the vehicle in order to service customers on foot. Unlike other models in the literature, the CDPP considers the search time for parking in the completion time of the delivery tour. We present valid inequalities and a variable reduction technique to solve this problem on realistically-sized instances. We compare the CDPP to industry practices as well as other models in the literature to understand how including the search time for parking impacts the completion time of the delivery tour.

3 - Who Has Access to E-Commerce and When? Time-Varying Service Regions in Same-Day Delivery

Dipayan Banerjee, Georgia Institute of Technology, Atlanta, GA, 30318-5644, United States, Alexander Stroh, Alan Erera, Alejandro Toriello

We study the tactical optimization of same-day delivery (SDD) systems under the assumption that service regions are allowed to vary over the course of each day. In most existing studies of last-mile logistics problems, service regions are assumed to be static. We use a continuous approximation approach and derive optimal dynamic service region areas and tactical vehicle dispatching policies that maximize the expected number of SDD orders served per day. We use these results to quantify the improvement in expected order fill rate when SDD service regions are allowed to vary. We discuss efficient solution algorithms, theoretical results, and issues related to equity and access within SDD systems. We illustrate and validate our models through computational studies set in the Phoenix, Arizona metropolitan area.

■ TC36

CC Room 210B

In Person: Multi-modal Transit Network Design

Award Session

Chair: Samitha Samaranayake, Cornell University, Ithaca, NY, 14853, United States

1 - On the Value of Demand-Responsiveness in Transit Systems

Carlos Martinez Mori, Cornell University, Ithaca, NY, 14853, United States

Transit systems traditionally operate fixed lines under fixed schedules. However, there is growing interest in demand-responsive transit systems, whereby operators complement their fixed services with dynamic services (e.g., microtransit) in real-time. In this work, we study fundamental benefits and limitations of demand-responsiveness on the overall performance of transit systems.

2 - Algorithmic Foundations for Multi-modal Transit Systems (Helping Better Buses Make Better Cities)

Samitha Samaranayake, Cornell University, School of Civil & Environmental Engineering, Ithaca, NY, 14853, United States, Siddhartha Banerjee, Chamsi Hssaine, Noemie Perivier

Emerging mobility services have disrupted the urban transportation ecosystem and instilled hope that new data-driven mobility solutions can improve personal mobility for all. While these apps provide a valuable service, as evident by their popularity, there are many questions regarding their scalability, efficiency, impact on equity, and negative externalities (e.g. congestion). On the other hand, traditional public transit systems provide affordable and community-oriented access to personal mobility, but have their own operational limitations. This talk will focus on the algorithmic foundations of integrating public transit operations with agile, demand-responsive services to enable personal mobility for all.

■ TC37

CC Room 210C

In Person: Military Applications

General Session

Chair: Gregory S Parnell, University of Arkansas, Fayetteville, AR, 72701, United States

1 - Using Neural Hidden Markov Models to Identify Insider Threat Behavior

David Elkind, Ephemer.ai

Threats originating inside of an organization can take the form of an individual experiencing distress. Emotional or psychological distress has an established mutual causality with a disrupted sleep pattern. We develop an approach using firewall logs to infer an individual's state (sleep, recreation, study, classroom instruction, etc.). Network traffic data powers a modified Hidden Markov Model that incorporates neural networks thereby creating a more flexible model not constrained by the Markov assumptions while simultaneously reflecting demographic data about individuals.

2 - Topology Optimization of Maritime Environmental Survey Operations

Danielle Morey, University of Washington, Seattle, WA, United States, Randall Plate, Cherry Yu Wakayama, Zelda B. Zabinsky

Topology optimization is a challenge for maritime environmental survey operations. Unmanned underwater vehicles (UUVs) are considered to collect and transport data from sensors to a centralized depot. Simulations exist to accurately model scenarios, but are computationally expensive for topology optimization. Two scenarios are defined: one uses UUVs to visit pre-defined locations for a single observation; the second involves sensors that collect data at a fixed rate to be sent to UUVs in a store-and-forward manner. We develop low-fidelity models for use in conjunction with a high-fidelity simulation to find a Pareto-optimal set of solutions with regards to latency and reliability.

3 - Optimization in Medium-term Planning for Military Aircraft Maintenance

Sergio Rebouças, Brazilian Air Force, Sao Jose dos Campos, Brazil, Dennys Wallace Imbassahy, Fernando Teixeira Abrahão

The assignment of military aircraft must be closely linked to the fleet maintenance plan. Optimization of maintenance activities and resources is crucial to maximize fleet availability and minimize the costs of air operations. Current optimization models generalize critical constraints that make their application in real-life difficult. This work proposes a new approach to medium-term optimization planning for military aircraft maintenance. Innovative constraints are defined and implemented through the Biased Random-Key Genetic Algorithm for optimization of the fleet maintenance plan, improving the model's adherence to the operational context.

■ TC38

CC Room 210D

In Person: Platforms, Networks, and New Markets

General Session

Chair: Fatemeh Navidi, University of Chicago, Chicago, IL, United States

Co-Chair: Rad Niazadeh, Chicago Booth School of Business, Stanford, CA, 94305-5008, United States

1 - Structuring Question and Answer Communities

Neha Sharma, Northwestern University Kellogg School of Management, Evanston, IL, United States, Achal Bassamboo, Gad Allon

Q&A communities started as a supplement to customer service but now most firms have their own community for customer engagement and support. Typically, in such communities, a user posts a question; other users with more knowledge can then answer her question. The asker sees all the answers and then chooses the best answer. The user who provided the best answer gets reward points, while the asker gains value from getting an answer to her question.We analyze how users decide to participate in the community. We then study the change in participation and network structure due to users' decisions and growth in knowledge. Finally, we study the number of questions asked and answered over time. We also find that a community designer faces a trade-off between generating traffic through increased participation and efficiency in terms of the number of answered questions.

2 - Food Delivery with Unknown Demand

Fatemeh Navidi, University of Chicago, Chicago, IL, United States, Rene A. Caldentey, Ozan Candogan, Rad Niazadeh

We model the service operation of a food delivery platform as an online decision making problem over discrete time horizon. At each time we need to jointly pick multiple restaurant rankings to show to the users based on their neighborhood and assign delivery routes to the drivers in a way that maximizes the generated revenue net routing cost. Given this model, we assume each restaurant is associated with an unknown attraction parameter, which captures the likelihood of generating an online order for the restaurant when is considered by a user. To learn these parameters, and therefore the demand, we can use the upcoming online orders over time as information feedback. Being equipped with this feedback mechanics, we design a polynomial time online learning algorithm that implicitly learns the attraction parameters and achieves a near-optimal multiplicative-additive regret.

■ TC39

CC Room 211A

In Person: Information Design and Incentive Management

General Session

Chair: Minjun Chang, Durham, NC, 27713, United States

1 - Engineering Social Learning: Information Design of Time-Locked Sales Campaigns for Online Platforms

Can Kucukgul, The University of Texas at Dallas, Richardson, TX, 75080, United States, Ozalp Ozer, Shouqiang Wang

Many online retailing platforms offer time-locked sales campaigns as an innovative selling mechanism, whereby third-party sellers sell their products at a typically discounted price for a fixed time horizon of pre-specified length. To incentivize purchases, platforms provide some information on up-to-date sales as campaigns progress, in the hope of influencing an upcoming customer's valuation of products. Using a dynamic Bayesian persuasion framework, we study how a revenue-maximizing platform should optimize its information policy for such a setting. We propose a heuristic policy that is easy-to-implement and numerically shown to perform well. Our policy yields significant profit improvement upon some naïve policies currently implemented in practice. Finally, we demonstrate the generality of our methodology by relaxing some informational assumptions.

2 - Containing the Outbreak of an Epidemic

Minjun Chang, Duke University, Durham, NC, United States

To contain the outbreak of an epidemic, public agencies need the population to take costly protective actions, such as vaccination or social distancing. Agencies track the origin of the disease on a network and inform individuals about their risks of being infected so as to persuade them to act. The more individuals protect themselves, the less likely the disease will spread to a particular node, which lower the incentive for one player to act. We study how public agencies should inform a population so as to mitigate such free riding incentive issues, and, ultimately minimize the impact of an outbreak.

■ TC40

CC Room 211B

In Person: Equilibrium and Games in Mathematical Finance

General Session

Chair: Moritz Voss, University of California, Los Angeles, Los Angeles

1 - Managing Projects in Virtual Settings: Information Exchange Networks and Project Performance

Sukrit Pal, Doctoral Candidate, Michigan State University, East Lansing, MI, United States, Anand Nair

Projects are increasingly being managed in virtual settings where project team members collaborate online. Collaborative information exchanges among team members result in the creation of complex communication network that can have non-trivial influence on the outcome due to the asynchronous nature of these exchanges and the lack of visual and non-verbal cues. We examine the impact of communication network characteristics on the number of issues closed within an open source software (OSS) development project. Additionally, the study examines the role of project managers' active participation in these communication networks on project outcome. We analyzed a panel dataset comprising of 1842 OSS development projects spanning 104 weeks from the time of project initiation was carefully compiled for this research.

2 - Equilibrium Asset Pricing with Transaction Costs: Theory and Numerics

Xiaofei Shi, Columbia University, New York, NY, United States

In a risk-sharing economy we study how the price dynamics of an asset depends on its "liquidity". An equilibrium is achieved through a system of coupled forward-backward SDEs, whose solution turns out to be amenable to an asymptotic analysis for the practically relevant regime of large liquidity. We also discuss how to leverage deep-learning techniques to obtain numerical solutions, and compare them with our asymptotic approximations.

3 - Trading With The Crowd

Moritz Voss, UC Los Angeles, Los Angeles, CA, United States

We study a multi-player stochastic differential game between financial agents who seek to liquidate their position in a risky asset in the presence of jointly aggregated transient price impact on the asset's execution price along with taking into account a general price predicting signal. The unique Nash-equilibrium strategies reveal how each agent's policy adjusts the predictive trading signal for the accumulated transient price distortion induced by all other agents' price impact; and thus unfolds a direct link in equilibrium between the trading signal and the agents' trading. We also formulate and solve the limiting mean field game and show how the finite-player Nash equilibrium strategies converge to the mean field game solution.

■ TC42

CC Room 212B

In Person: Environment, Energy, and Natural Resources

Contributed Session

Chair: Diwas Paudel, University of South Florida, Tampa, FL, United States

1 - Predictive Multi-microgrid Generation Maintenance, Formulation And Impact On Operations & Resilience

Farnaz Fallahi, GRA, Wayne State University, Detroit, MI, United States, Murat Yildirim, Jeremy Lin, Caisheng Wang

This work proposes a framework that builds a seamless integration between sensor data and operational & maintenance (O&M) drivers in a multi-microgrid setting and demonstrates the value of this integration for improving multiple aspects of microgrids operations. The framework offers an integrated stochastic optimization model that jointly optimizes O&M. Operational uncertainty from renewables, demand, and market prices are modeled through scenarios. We use the model structure to develop a decomposition-based solution algorithm to ensure computational scalability. The model provides significant improvements in terms of reliability, costs, generation availability, & resilience.

2 - Efficient EV Charging via Throughput Maximization

Yize Chen, University of Washington, Seattle, WA, United States

The proliferation of electric vehicles calls for reliable and efficient operations of EV charing stations, which are often limited by the charging capacity and electrical network constraints. In this talk, by taking the state-of-charge information into account, we formulate the EV charing problem as a throughput maximization problem. The resulting adaptive charing algorithm can not only serve the most charging sessions, it can only schedule the charing rate by respecting the charing rate and demand congestion constraints.

3 - Fleet Size and Charging Infrastructure Capacity for Ridehailing Services Using Autonomous EVS

Diwas Paudel, University of South Florida, Tampa, FL, United States, Tapas K. Das

We develop a robust stochastic mixed integer model which, for any given part (percentage) of the current demands in the city that the SAEV fleet might intend to serve, yields optimal SAEV actions and corresponding capacity plan (fleet size and charging infrastructure) that maximizes gross profit. The model solution yields optimal capacity plan, which varies depending on the decision makers choice of the level of conservatism towards robustness. Expansion of the existing capacity to meet an increased demand and sensitivities of battery capacity and power network configurations are also explored.

4 - Efficient Carpooling and Toll Pricing for Autonomous Transportation

Manxi Wu, Massachusetts Institute of Technology, Cambridge, MA, United States, Saurabh Amin, Patrick Jaillet

How can autonomous transportation technology be utilized to reduce road congestion? We analyze a carpooling market, where a transportation authority sets tolls on road segments, and riders are incentivized to organize autonomous carpooled trips and split toll prices. We characterize sufficient conditions on the network topology and riders' heterogeneous utilities, under which the market equilibrium implements a socially optimal trip assignment. We also propose an algorithm for computing the market equilibrium. These results enable efficient implementation of market-based autonomous carpooling services.

■ TC43

CC Room 213A

In Person: Innovation/ Entrepreneurship

Contributed Session

Chair: Marc Eulerich, University Duisburg-Essen, Hagen, 58099, Germany

1 - An Empirical Assessment of the Role of Multinational vs Entrepreneurial Firms in the Development of Markets: Evidence From African Mobile Telecommunications Industry

Mohammad Jahanbakht, Assistant Professor, University of Texas at Arlington, Fort Worth, TX, United States, Romel Mostafa, Soheil Hooshangi

Although the impact of pre-entry knowledge on firms' innovative decisions and performance is known in the industry evolution literature, the nature of relationship between firm-level innovations and market-level competitive outcomes is not well-established. Using GMM method with instrument on a panel data from African mobile telecom industry, we find that a small number of firms are capable of implementing trailblazing strategies which result in a disproportionally large impact on evolution of market-level outcomes, such as adoption, price, and industry capital expenditure. We discuss that a differentiating attribute of these firms is their superior pre-entry knowledge of local markets.

2 - Fundamental Limits of Learning: A Mathematical Framework

Yian Yin, Northwestern University, Evanston, IL, United States, Dashun Wang

A key aspect in human activities concerns how one learns from past experience. The learning curve literature has documented a robust relationship between experience n and unit cost c: cn ~ n- , with [0,1]. Yet rich empirical results across industries have consistently reported a typical ≈ 0.32 and lack of high > 0.5, raising a fundamental paradox: Is the limit = 1 achievable? Here we develop a general learning model and prove a fundamental limit of learning ≤ ≤ 0.5. We further show that both the technology landscape and strategic explorations of new technology are critical for achieving , which have direct implications for the diagnosis, improvement, and planning of many innovative activities.

3 - Do Elite Innovation Companies Need CSR? An Investigation of The Interactions Between Innovation And Ethical Pay, CSR, and Firm Profits

Patti Miles, Associate Professor of Management, University of Maine, Bangor, ME, United States, John N. Angelis

Companies that invest in CSR or Ethical Pay usually benefit from improved reputation and legitimization in the eyes of the public, investors, and their employees. However, a company that is highly rated by investors for its innovation may be less likely to need such investments. Using an elite sample of innovation companies created by Clay Christensen (Forbes Top 100 Innovative Companies list), we find that innovative companies are significantly more likely to pay median employees more and be more profitable. However, innovative companies do not necessarily spend more on CSR, and CSR does not successfully mediate the relationship between innovation companies and profits.

■ TC44

CC Room 213B

In Person: Data Mining & Machine Learning in Smart Manufacturing

General Session

Chair: Neng Fan, University of Arizona, Tucson, AZ, 85721, United States

1 - Robust Tensor Regression

Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL, 32608-1047, United States

We will extend tensor regression techniques to robust versions and will show their efficacy in detecting and removing outliers through simulations and case studies.

2 - Automated Metrology Planning for 3D Scanning of a Freeform Design Using Bayesian Optimization

Zhaohui Geng, Assistant Professor, The University of Texas Rio Grande Valley, Edinburg, TX, United States, Bopaya Bidanda

3D scanning is widely used for the dimension measurements of physical objects with freeform designs. The output point cloud is flexible enough to provide a detailed geometric description for these objects. However, geometric accuracy and precision are still debatable. Uncertainties are ubiquitous in measurement due to many physical factors. This presentation first investigates the geometric and spatial factors that could potentially influence the scanning variability. Their functional relationship is modeled as a 'black-box' model, which is later utilized to find the optimal scanning settings for variance reduction. A Bayesian optimization approach is proposed to solve this minimization problem. Case studies are presented to validate the proposed methodology.

3 - A Cloud SDN-enabled Network for Cyber-physical Infrastructure in Smart Manufacturing Systems

Lida Haghnegahdar, UNT, Denton, TX, United States

To improve predictability, security, and real-time performance in smart manufacturing, Software-defined network (SDN) needs to apply timing and secure criterion and detailed analysis in the software systems and network functions. SDN as a controller can run some applications such as intrusion detection systems (IDS), and central distribution systems (CDS) to monitor systems and devices to detect malicious nodes. This research intends to develop a secure and resilient SDN-based system for a smart manufacturing network. This approach by using controller security procedures will help to detect intrusions and provide reliability within SDN-based smart manufacturing.

4 - Evolutionary Optimization of FAB Dispatch Rule Parameters

Harel Yedidsion, Research Scientist, Applied Material, Austin, TX, United States, Derek Adams, Emrah Zarifoglu, David Norman

The semiconductor manufacturing process is an NP-hard job shop with re-entry problem. As a result, heuristic dispatch rules are commonly used in practice to schedule lots in semiconductor FABs. The dispatch rule logic has tens of parameters, and its performance relies heavily on the ability to fine-tune the parameter values according to the work-in-progress, and the station availability. In this work, we present a parameter tuning method based on Evolutionary Optimization combined with Simulated Annealing. Our empirical results indicate that the proposed approach outperforms other benchmarks, and can be successfully used to dynamically optimize the dispatch rule's parameter values.

Tuesday, 12:30PM-1:30PM

■ Amazon

Virtual Room 11

Innovation and Diversity at Amazon

Panel Session

1 - Innovation and Diversity at Amazon

Mallory Craker, Amazon, Seattle, WA, 98121, United States

Five senior leaders who work at Amazon host a panel discussion the importance of innovation and diversity in STEM during INFORMS 2021.

Tuesday, 1:30PM-2:30PM

■ Tuesday Keynote 01

CC Ballroom A /Virtual Theater 1

Keynote: Policy Modeling for SARS-CoV-2 Screening, Prevention, and Vaccination

Keynote Session

1 - Policy Modeling for SARS-CoV-2 Screening, Prevention, and Vaccination

A. David Paltiel, Professor, Yale School of Public Health, Dept of Epidemiology & Pub Health, New Haven, CT, 06520-8034, United States

In 2020, the SARS-CoV-2 pandemic repeatedly forced decision makers to confront the tradeoff between clinical, epidemiological, and economic considerations. More often than not, a policy response was demanded long before major uncertainties could be resolved via the traditional forms of health and medical investigation. I will present four dilemmas, each of which was the topic of front-page media coverage, and describe my personal experiences developing simple policy models to address them: How to reopen college campuses safely? How to trade vaccine efficacy against speed of implementation? How to choose between single- and two-dose vaccines? How to evaluate the costs and benefits of population-wide, home-based, rapid, antigen testing?

■ Tuesday Keynote 02

CC Ballroom E /Virtual Theater 2

Keynote: Lagrangian Control at Large and Local Scales in Mixed Autonomy Traffic Flow

Keynote Session

1 - Lagrangian Control at Large and Local Scales in Mixed Autonomy Traffic Flow

Alexandre Bayen, University of California-Berkeley, Berkeley, CA, United States

This talk investigates Lagrangian (mobile) control of traffic flow at local scale (vehicular level). The question of how will self-driving vehicles will change traffic flow patterns is investigated. We describe approaches based on deep reinforcement learning presented in the context of enabling mixed-autonomy mobility. The talk explores the gradual and complex integration of automated vehicles into the existing traffic system. We present the potential impact of a small fraction of automated vehicles on low-level traffic flow dynamics, using novel techniques in model-free deep reinforcement learning, in which the automated vehicles act as mobile (Lagrangian) controllers to traffic flow. Illustrative examples will be presented in the context of a new open-source computational platform called FLOW, which integrates state of the art microsimulation tools with deep-RL libraries on AWS EC2. Interesting behavior of mixed autonomy traffic will be revealed in the context of emergent behavior of traffic: https://flow-project.github.io/

■ Tuesday Keynote 03

CC Ballroom C /Virtual Theater 3

IFORS Distinguished Lecture

Keynote Session

1 - Using OR to Improve Emergency Vehicle Planning and Performance

Karen Aardal, Delft University of Technology, TU Delft, Mekelweg 4, Delft, 2628 CD, Netherlands

In life-threatening situations each second counts. It is therefore of utmost importance that emergency medical response vehicles are used efficiently. This involves determining ambulance location sites, and the number of vehicles that should be stationed at these sites, as well as using dispatch policies that keep sufficient coverage even when a subset of vehicles are dispatched to calls. In this talk we will review emergency medical response vehicle location models and dispatch algorithms with a focus on road ambulances and helicopters. The main body of the work presented here is an outcome of research projects involving university researchers in the Netherlands and Norway, and representatives from the National Institute for Public Health and the Environment in the Netherlands, the Norwegian Air Ambulance Foundation, and regional Health Trusts.

■ Tuesday Keynote 04

CC Ballroom D /Virtual Theater 4

2021 Wagner Prize Winner Reprise

Keynote Session

The Daniel H. Wagner Prize is awarded for a paper and presentation that describe a real-world, successful application of operations research or advanced analytics. The prize criteria emphasizes innovative, elegant mathematical modeling and clear exposition.

■ Tuesday Keynote 05

CC Ballroom E / Virtual Theater 2

Keynote: 2021 UPS George D. Smith Winner Reprise

Keynote Session

1 - University of Iowa, Department of Business Analytics

Ann Melissa Campbell, University of Iowa, Iowa City, IA, 52242-1994, United States

2021 The UPS George D. Smith Prize is created in the spirit of strengthening ties between industry and the schools of higher education that graduate young practitioners of operations research. INFORMS, with the help of the INFORMS Practice Section, will award the prize to an academic department or program for effective and innovative preparation of students to be good practitioners of operations research, management science, or analytics."

The UPS George D. Smith Prize is named in honor of the late UPS Chief Executive Officer who was a champion of operations researchers at a leading Fortune 500 corporation. UPS generously sponsors the award in his memory.2021The UPS George D. Smith Prize is created in the spirit of strengthening ties between industry and the schools of higher education that graduate young practitioners of operations research. INFORMS, with the help of the INFORMS Practice Section, will award the prize to an academic department or program for effective and innovative preparation of students to be good practitioners of operations research, management science, or analytics.

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Tuesday, 2:45PM 4:15PM

■ TD02

CC Ballroom B / Virtual Theater 2

Hybrid Location Models I

Sponsored: Location Analysis

Sponsored Session

Chair: Zvi Drezner, California State University Fullerton, Fullerton, CA, 92834, United States

Co-Chair: Pawel J. Kalczynski, California State University-Fullerton, Fullerton, CA, 92834-6848, United States

1 - A Sinkhorn Algorithm for the Quadratic Assignment Problem

Samhita Vadrevu, UIUC, University of Illinois at Urbana-Champaign, Champaign, IL, 61801, United States, Rakesh Nagi

A Sinkhorn based approach is proposed to solve the Quadratic Assignment Problem. Linear programs of the lifted formulations of QAP are considered formulated as an Optimal Transport Problem. By applying iterative projections, an approximate solution is found for the LP. A GPU accelerated algorithm is designed to find these approximate solutions and then a GPU based Branch and Bound technique is used to find integral solutions to QAP, thus achieving an accurate solution via an efficient and scalable algorithm.

2 - Optimal Placement of M Finite-size Rectangular Facilities in an Existing Layout: Exact Solution Methods, Lower Bounds, and Heuristics

Rakesh Nagi, U. of Illinois at Urbana-Champaign, Department Of Industrial Enterprise Systems Transp, Urbana, IL, 61801, United States, Ketan Date

In this paper we investigate a new problem of optimal placement of M finite-size rectangular facilities in presence of existing rectangular facilities. To find a solution, we divide the feasible region into sub-regions and prove that the candidates for the optimal placement of the new facilities can be drawn from the boundary of these sub-regions. We design a branch-and-bound algorithm suitable for navigating this highly degenerate search space. Heuristic procedures perform well for non-pathological cases with an acceptable optimality gap. Our

contribution is rigorous treatment of an important problem that unifies facility location and layout theories with minisum objective and rectilinear distance metric.

3 - A Directional Approach to Gradual Cover
Zvi Drezner, California State University Fullerton, Steven G. Mihaylo College of Business and Economic, Fullerton, CA, 92834, United States, Tammy Drezner, Pawel J. Kalczynski

The objective of classic cover location models is for facilities to cover demand within a given distance. The gradual (or partial) cover replaces abrupt drop from full cover to no cover by gradual decline in cover. We propose, analyze, and test a new rule for calculating the joint cover of a demand point which is partially covered by several facilities. Every facility covers points within a given radius. Each demand point is defined as a circle with a given radius. The proportion of the demand point covered by a facility is the fraction of the area of the demand circle covered by the facility. The total cover by several facilities is the union of the covered areas. The rule considers the directions of the facilities providing partial cover and not just the proportions of the partial covers. The new approach provided better total cover than the cover obtained by existing procedures.

■ TD03

CC Ballroom C / Virtual Theater 3

Hybrid - Business Analytics in the Age of AI

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Xinxue Qu, University of Notre Dame, Granger, IN, 46530-8209, United States

1 - Animated Live Streamers with AI Assistance on E-commerce Platforms
Si Xie, The University of Texas at Dallas, Richardson, TX, United States, Amit Mehra, Zehan Zhao

As live streams in e-commerce emerge, some vendors have chosen to deploy AI assisted animated live streamers to broadcast their brands and products. While AI live streamers could help attract consumers without human presence to increase sales, they are costly to develop and are perceived as less persuasive, which might lead to lower sales. In this research, we empirically examine the vendors with AI assisted animated live streamers with their key competitors without it and study the impact on sales and consumer engagement indicators. We also link our setting to Uncanny Valley to explore and understand the preferences of viewers based on cognitive dissonance related to whether the avatar is an actual human.

2 - Reward-Based Crowdfunding: Competition and Spillover
Maryam Rahmani Moghaddam

The spillover effects in crowdfunding campaigns have been identified as important issues in the literature. Blockbuster campaigns attract backers to their own category (positive effect) and drive away from the campaigns of other categories (negative effect). However, there is a lack of literature on the impact of concurrent campaigns (i.e., competition) on the outcome of the focal campaign. Contributing to the spillover and competition literature in the crowdfunding context, we introduce two new types of spillovers, namely, demand revelation spillover, ideation spillover. Using all US-based campaigns launched between February 2009 and April 2020 in the product design category on Kickstarter, we examine how a crowdfunding campaign is affected by the joint effects of (1) multiple spillovers and (2) competitions from both similar and different (type of products) campaigns. While we found significant impacts of blockbusters as in the received literature blockbusters positively (negatively) affect upcoming campaigns that sell similar (different) products these results failed our robustness checks. Our results show that while concurrent competitors negatively affect the success probability of the focal campaign, the negative effect of competitors selling similar products (within-cluster competition) is about 20 times larger than that of competitors selling different products (outside-cluster competition) due to the private good nature of these products. Moreover, our results indicate that campaigns that enjoy more R&D spillover are more likely to meet their funding goals. That is, a higher success rate is observed for campaigns launched in areas with more research and development activities. Furthermore, market demand plays a major role in determining the campaign's outcome, and one standard deviation increase in the demand size improves the campaign's chances of success by 8.67%. In addition, creators whose ideas are inspired by previous similar successful campaigns have significantly higher chances of success (ideation spillover). All these effects exert nonnegligible influences in crowdfunding campaigns after accounting for their measurements in our study. Lastly, we conclude this paper with implications and future directions.

3 - Shapley-value-based Feature Attribution for Data Privacy Protection
Francis Bilson Darku, Research Assistant Professor, University of Notre Dame, Notre Dame, IN, United States, Xinxue Qu, Hong Guo

With abundant consumer data, companies can offer better products to customers using AI tools. To protect consumer privacy, several methods have been proposed to reduce identity and disclosure risks. Considering intruders may use other variables in a dataset to infer confidential values, masking or removing the confidential variable(s) only may not be the most effective solution. To address this, we propose a unified framework of feature attribution for data privacy protection. We use a Shapley-value-based approach to fairly allocate the risk and utility of a dataset to the variables contained in that dataset, thereby identifying variables that pose higher risk but contribute less to utility.

4 - Examining the Impact of Yelp's Elite Squad on Users' Following Contribution
Xunyi Wang, Baylor University, Waco, TX, United States, Sean Sanders, G. Lawrence Sanders

As a leading online review platform, Yelp leverages a gamification design, Yelp Elite Squad (YES), to engage its users. A user needs to significantly contribute to the Yelp community to become a YES member. However, it is not clear how the YES members behave after they receive this status. In this study, we use a large volume of Yelp's data to answer this question. The results based on a dynamic panel analysis show that a YES member will produce more content after obtaining the YES. We further find that if a user receives the YES status for two consecutive years, the most current YES status has a positive effect on users' future contributions, but this effect is not as strong as the effect of a first-time status recipient. This research contributes to the online user engagement and gamification literature. We also provide practical implications for online community design.

5 - Digital Prophylaxis for Firm Resilience: A Study on Covid-19 Disruption
Yuanyang Liu, University of Tennessee, Knoxville, TN, 37934-4461, United States

This article examines whether digitalization increases firm resilience in the presence of a negative exogenous event. Using an extensive online database of job postings, we propose a new measure of firm digitalization that is based on its investment in IT-related human capital. We test the efficacy of firm digitalization as a prophylaxis against the disruption created by the COVID-19 pandemic. Our identification strategy relies on two-way fixed regression and the synthetic control method. We find that higher levels of firm digitalization result in greater firm resilience during COVID-19 disruptions. Our study has implications for managers, shareholders, and regulators as it provides evidence that higher levels of firm digitalization leads to greater firm resilience when faced with negative exogenous shocks.

■ TD04

CC Ballroom D / Virtual Theater 4

Hybrid Network Flow Algorithms in Covariate Balancing

Sponsored: Computing Society

Sponsored Session

Chair: Dorit Simona Hochbaum, University of California-Berkeley, Berkeley, CA, 94720-1777, United States

1 - Complexity and Algorithm of the Integer Minimum Cost Network Flow with Fractional Supplies Problem with an Application to Covariate Balancing
Xu Rao, University of California Berkeley (now at Google), Berkeley, CA, 94706, United States, Dorit Simona Hochbaum, Asaf Levin

We study the integer minimum cost network flow when some of the supplies are fractional. In the presence of fractional supplies it is impossible to satisfy the flow balance constraints, creating an imbalance. Assigning penalties to the imbalances, we present a polynomial time algorithm to find integer flow that minimizes the sum of the cost of the flow and the imbalance penalty. We also prove that in the presence of a constraint that bounds the imbalance the problem is NP-hard, but efficiently solvable for a fixed number of fractional supplies. This problem is motivated by the application of minimizing proportional imbalance of covariates.

2 - Network Flow Methods for the Minimum Covariate Imbalance Problem
Jason Sauppe, University of Wisconsin-La Crosse, La Crosse, WI, United States, Dorit Simona Hochbaum, Xu Rao

Given samples of treatment and control units in an observational study, we consider the problem of finding a subset of control units that has minimum imbalance with respect to the treatment sample on two nominal covariates. We present a minimum cost network flow (MCNF) formulation and a maximum flow formulation for solving the problem with the constraint that the control subset size equals the treatment sample size. For other control subset sizes, using a

proportional imbalance objective leads to non-integral supplies and demands in the MCNF formulation; we show an alternate MCNF formulation which has an optimal integer solution.

3 - Algorithms and Complexities of Matching Variants in Covariate Balancing

Dorit Hochbaum, University of California, Berkeley, Berkeley, CA, 94720, United States, Asaf Levin, Xu Rao

We present a comprehensive complexity study of variants of matching problems that arise in covariate balancing. In these problems we seek the largest possible selection of treatment samples to match, or to minimize the assignment costs, while meeting balance requirements. For these problems we provide polynomial time algorithms, or a proof of NP- hardness, where the polynomial time algorithms are combinatorial and use network flow techniques. We further present several fixed-parameter tractable results for problems where the number of covariates and the number of levels of each covariate are seen as a parameter.

■ TD05

CC Ballroom E / Virtual Theater 5

Hybrid Life as a PhD Student

Sponsored: Minority Issues Forum

Sponsored Session

Chair: Diana Gineth Ramirez-Rios, Rensselaer Polytechnic Institute, Troy, NY, 12180-2050, United States

1 - Life as a PhD Student

Diana Gineth Ramirez-Rios, Rensselaer Polytechnic Institute, Troy, NY, 12180-2050, United States

Making a decision to start a Ph.D. is not an easy task. Yet, many of us decide to trust our abilities and knowledge to take that step and enroll in the program of interest. Despite of the variety of experiences told to us, for the most part life as a Ph.D. is hard, requires sacrifice, and perseverance. But why do we make this decision? How do we overcome the challenges we face during these years? Is it worth the sacrifice? This panel is intended to cover all these questions about the life of a Ph.D. student. The panel consists of mostly Ph.D. students at the different stages of their research, and one faculty who will share us the lessons learned.

2 - Panelist

Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY, 12180-3522, United States

3 - Panelist

Yifei Sun, Dartmouth College, Lebanon, NH, 03766, United States

4 - Panelist

Martha Sabogal, Clemson University, Clemson, SC, United States

■ TD06

CC Room 303A

In Person: Diversity/PSOR/MIF Diversity, Equity and Inclusion in OR/MS/Analytics. Innovations in Research and Practice II

General Session

Chair: Michael P Johnson, University of Massachusetts Boston, Department of Public Policy & Public Aff Mccormack, Boston, MA, 02125-3393, United States

1 - Bringing STEM to underserved Communities

Phebe Vayanos, University of Southern California, OHE 310L, University Park Campus, Los Angeles, CA, 90089, United States, Aida Rahmattalabi, Caroline Johnston

Industry and academia suffer from lack of full participation in STEM fields, excluding those from traditionally marginalized groups. To help address this problem, we partnered with Code in the Schools, a non-profit in Baltimore city and STEM academy of Hollywood, a high school in Los Angeles to bring students from traditionally under-represented groups in STEM together and engage them in fun AI/OR projects for social good. To achieve this, we held the ExplOR event in November 2020. Guided by mentors from the INFORMS community, the students worked in teams to address a range of problems in areas including public health, conservation, etc. The goal was to raise students' interest in AI/OR and help them build a network with mentors and fellow students.

2 - Developing Principles for Dei-informed Research in Or/analytics Through an Analysis of Published Journal Articles

Michael P. Johnson, University of Massachusetts Boston, Department of Public Policy & Public Aff Mccormack, Boston, MA, 02125-3393, United States, Tayo Fabusuyi

We describe a project to develop principles by which researchers in OR/analytics may integrate ideas about diversity, equity and inclusion, racial and social justice and antiracism into research ideas that span application areas, disciplinary modes and analytic methods. These principles are derived from a mixed methods analysis of INFORMS journal publications including thematic analysis and author interviews. This project has the potential to improve the profession (how the work gets done, and the environment within which the work is done) as well as the discipline (the academic and scholarly place within which the work is situated).

■ TD08

CC Room 303C

In Person: Simulation, Learning and Queueing Theory

General Session

Chair: Qiaomin Xie, U-Wisconsin-Madison, Cornell University, Ithaca, NY, 14850, United States

1 - Online Learning and Pricing for Service Systems with Reusable Resources

Huiwen Jia, University of Michigan, Ann Arbor, MI, 48105-1181, United States, Cong Shi, Siqian Shen

We consider a price-based revenue management problem with finite reusable resources. The arrival and service rates depend on the posted price but the mappings are unknown. The firm makes adaptive pricing decisions to maximize the cumulative revenue. Compared with prior pricing and MAB literature, the salient difficulties are (i) unknown rate-and-price mappings, (ii) the dynamic nature of reusable resources being committed over time, (iii) the transient behavior of the system when price changes, and (iv) unbounded and heavy-tailed observed random variables. Our algorithms contain a Warm-up Phase to eliminate the heavy-tail effects and a Learning Phase to identify the optimal price. We prove that the cumulative regret is O(√PT log T), where T and P are the number of time periods and candidate prices, and this result matches the lower bound up to a logarithmic factor.

2 - Efficient Algorithms for Online Decision-making with Limited Action Changes

Yilun Chen, Cornell, Ithaca, NY, 14850-1854, United States

Many of today's online decision-making tasks (e.g. dynamic pricing, pandemic management) boil down to solving stochastic dynamic programs (DP) with high-dimensional / path-dependent underlying state, suffering from the ``curse of dimensionality". We propose a new approach that overcomes this computational barrier for a fairly general class of problems, subject only to a ``limited-action-change" constraint (translate to ``limited price change" for dynamic pricing). Our results come with strong theoretical guarantees (both runtime and accuracy) for models with arbitrary state transition and reward structures, guaranteeing an $(1-\epsilon)-$optimal policy in a runtime scaling polynomially in the time horizon and effectively independent of the dimension, The key building block of the approach is our recent algorithmic progress for optimal stopping.

3 - Decentralized Q-learning in Zero-sum Stochastic Games

Kaiqing Zhang, MIT, Cambridge, MA, 61801-2307, United States

We study reinforcement learning (RL) in infinite-horizon zero-sum stochastic games. We focus on the practical while challenging setting of decentralized multi-agent RL, where the agents are not coordinated by any central controller, and neither the actions nor the payoffs of the opponent agent can be observed. Each agent might be even oblivious to the presence of the opponent. Unlike many existing MARL algorithms, we aim to develop algorithms that are both rational and convergent the learning dynamics are natural to each agent, converging to the opponent's best-response when the opponent converges to a stationary policy; while the iterates converge to the Nash equilibrium when both agents adopt the learning dynamics. We develop a decentralized Q-learning, with provable convergence guarantees to the Nash equilibrium of the game.

■ TD09

CC Room 303D

In Person: Learning for Queueing and Beyond

General Session

Chair: Weina Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Learning While Playing in Mean-field Games: Convergence and Optimality

Qiaomin Xie, U. Wisconsin-Madison, Madson, WI, 14850, United States, Zhuoran Yang, Zhaoran Wang, Andreea Minca

We study reinforcement learning in mean-field games. To achieve the Nash equilibrium, which consists of a policy and a mean-field state, existing algorithms require obtaining the optimal policy while fixing any mean-field state. In practice, however, the policy and the mean-field state evolve simultaneously, as each agent is learning while playing. To bridge such a gap, we propose a fictitious play algorithm, which alternatively updates the policy (learning) and the mean-field state (playing) by one step of policy optimization and gradient descent, respectively. Despite the non-stationarity induced by such an alternating scheme, we prove that the proposed algorithm converges to the Nash equilibrium with an explicit convergence rate. To the best of our knowledge, it is the first provably efficient algorithm that achieves learning while playing.

2 - Average Cost Deep Reinforcement Learning for Queuing Networks

Mark Gluzman, Cornell University, Ithaca, NY, 14850-6311, United States, Jim Dai

In queueing control problems, the long-run average cost is a natural performance measure instead of commonly used discounted objectives. We propose a novel bound on the difference of the discounted returns for two policies and show that it converges to a bound for average costs. We further generalize the bound on MDPs with unbounded cost functions, infinite state spaces, and long-run average cost objectives. Our bound leads to a version of Proximal policy optimization algorithm that can monotonically improve controls of queueing networks. Numerical results for multi-class queueing networks, a ride-hailing model, and a hospital inpatient operation model will be provided.

3 - Fluid Limits for Shortest Job First with Aging

Yonatan Shadmi, Technion, Haifa, Israel

We investigate fluid scaling of single server queues operating under a version of shortest job first (SJF) where the priority level undergoes aging. That is, a job's priority level is initialized by its size and varies smoothly in time according to an ordinary differential equation. Linear and exponential aging rules are special cases of this model. This policy can be regarded as an interpolation between FIFO and SJF. We use the measure-valued Skorokhod map to characterize the fluid model and establish convergence under fluid scale. We treat in detail examples of linear and exponential aging rules and provide a performance criterion based on our main result.

4 - Fluid Limits of Queue-based CSMA, Homogenization and Reflection

Eyal Castiel, Technion, Haifa, Israel

In this talk, we will discuss the fluid limits of a queueing process with QB-CSMA scheduling policy for general interference graphs. Introduced in 2009, this algorithm aims at mimicking the behavior of the celebrated Max-Weight algorithm by Tassiulas and Ephremides in a fully distributed fashion. The key element of the analysis is a fully coupled stochastic averaging principle where the schedule evolves much faster than queue lengths and we can replace the service rates by an invariant measure 'adapted' to the current queue lengths. This approximation fails in a neighborhood of zero but we will be able to overcome this difficulty in the case of a complete interference graph through a coupling argument.

■ TD10

CC Room 304B

In Person: Analytics in Supply Chain Networks

General Session

Chair: Deniz Besik, University of Richmond, Richmond, VA, 23220, United States

1 - Vulnerability of Global Supply Chains: Impact of Industrial and Geopolitical Concentration of Upstream Industries

Jafar Namdar, University of Iowa, Iowa City, IA, 52246, United States, Gautam Pant, Jennifer Blackhurst

In addition to the well-known notion of concentration due to the dominance of a few firms within an industry (i.e., industrial concentration), our study highlights the role of a relatively under-recognized dimension of geopolitical concentration. Using a large data set of firms, we find that the sales growth of firms whose suppliers are operating in high concentrated industries saw a relative drop of 5 percentage points during the pandemic. Our robust findings provide insights for both policy makers and managers for mitigating the supply chain risks stemming from industrial concentrations.

2 - Enhancing a Multi-commodity Supply Chain Network Resilience Through Fairness-based Distribution During Disruptions

Andres David Gonzalez, University of Oklahoma, Norman, OK, 73019, United States, Osamah Y. Moshebah

The flow of multi-commodities in supply chain networks SCNs can be significantly impacted by any sort of disruption in the network, in particularly the road transportation network. Enhancing the SCN performance can be ensured by implementing a fair-based distribution of commodities while restoring the SCN resilience and maintaining higher satisfaction rate at most of the demand nodes.

3 - An Integrated Multitiered Supply Chain Network Model of Competing Agricultural Firms and Processing Firms

Deniz Besik, University of Richmond, Richmond, VA, 23220, United States, Anna B. Nagurney, Pritha Dutta

The COVID-19 pandemic has created many disruptions in the agricultural supply chain networks, encompassing production, processing, packaging, storage, and distribution, affecting many stakeholders in the agriculture industry. This presentation shows an integrated multitiered competitive agricultural supply chain network model in which agricultural firms and processing firms compete to sell their differentiated products at the demand markets. The competition among agricultural firms and processing firms at the demand markets is formulated and studied via game theory, where the governing Cournot-Nash equilibrium conditions correspond to a variational inequality problem. We use an algorithm to test our modeling framework through a numerical study consisting of several supply chain disruption scenarios, including ones relevant to the Covid-19 pandemic.

■ TD11

CC Room 304C

In Person: Economics and Computation III

Award Session

Chair: Young-San Lin, Perdue University

Co-Chair: Alexander Wei, UC Berkeley

1 - Revenue Maximization under Unknown Private Values with Non Obligatory Inspection

Ali Makhdoumi, Duke University, Durham, NC, United States, Azarakhsh Malekian, Saeed Alaei

We consider the problem of selling k units of an item to n unit-demand buyers to maximize revenue, where the buyers' values are independently distributed according to publicly known distributions but unknown to the buyers themselves, with the option of allowing buyers to inspect the item at a cost. This problem can be interpreted as a revenue-maximizing variant of Weitzman's Pandora's problem with non-obligatory inspection. We present an approximation mechanism that achieves 1-\frac{1}{\sqrt{k+3}} of the optimal revenue. Our mechanism continues to work in an online setting where buyers arrive in an arbitrary unknown order.

2 - Allocation with Weak Priorities and General Constraints

Young-San Lin, Purdue University, West Lafayette, IN, United States, Hai Nguyen, Thanh Nguyen, Kemal Altinkemer

With COVID 19 prevalent in the world, efficient social distance seating becomes an option for sport venues, which allows only a fraction of the capacity and necessitates reassigning spectators to games. We model this as a resource allocation problem and develop a mechanism based on a new concept called Competitive Stable Equilibrium. Its novelty is the combination of three features: complex resource constraints, weak priority rankings over the agents, and ordinal preferences over bundles of resources. We empirically apply our mechanism to reassign season tickets to families and show that our method outperforms existing ones in both efficiency and fairness measures.

3 - Data Tracking under Competition
Ilan Morgenstern, Stanford University, Stanford, CA, United States, Kostas Bimpikis, Daniela Saban

We explore the implications of data tracking technologies that enable firms to collect consumer data and use it for price discrimination. We find that the absence of data tracking may lead to a decrease in consumer surplus, even if consumers are myopic. Importantly, this result relies on competition: consumer surplus is higher with data tracking only when multiple firms offer substitutable products to consumers. Our results contribute to the debate of whether to regulate firms' use of data tracking technologies by illustrating that their effect on consumers depends not only on their level of sophistication, but also on the degree of competition in the market.

■ TD12

CC Room 304D

In Person: New Frontiers in Behavioral OM

General Session

Chair: Evgeny Kagan, Johns Hopkins Carey Business School, Johns Hopkins Carey Business School, Baltimore, MD, 21202-4673, United States

1 - Seeing the Bigger Picture? Ramping Up Production with the Use of Augmented Reality
Enno Siemsen, University of Wisconsin-Madison, Wisconsin School of Bus., Madison, WI, 53706-1324, United States, David Wuttke, Ankit Upadhyay, Alexandra Wuttke-Linnemann

Firms increasingly use augmented reality (AR) devices to improve their production ramp-up processes. Our field experiment provides empirical evidence related to the strengths and weaknesses of AR in the ramp-up of production. When faced with a new task, workers instructed by AR smart glasses achieve a 74% higher flow rate compared with a control group. However, workers that use AR glasses consistently perform 21% slower than the control group when both groups repeat the task, without either AR or paper-based instructions. After the devices have been removed, workers instructed based on paper improve their productivity faster through learning than those instructed by AR. In addition, the former group suggests better process improvements than the latter.

2 - Understanding Donors' Preferences in Charitable Giving
Hasti Rahemi, University of Colorado Boulder, Boulder, CO, United States, Sebastian Villa, Gloria Urrea

Charities depend on donors for funding to run their operations. However, it is not clear how donors' preferences affect donors' contributions. We propose that to fully understand donors' decisions, it is necessary to account for two types of donors' preferences: their predilection for programs and their own self-serving bias. We investigate these two types of preferences in an online experiment with over 350 participants. Our results provide guidance for charities to improve their fundraising strategies.

■ TD13

CC Room 201A

In Person: Confluence of Data Mining and Business Analysis

General Session

Chair: Arif Ansari, University of Southern California, Los Angeles, CA, 90089-0809, United States

Co-Chair: Dariush Khezrimotlagh, Pennsylvania State University Harrisburg, Middletown, PA, 17057-4846, United States

1 - Visual Programming: Teaching for Business Analytics Best Practices
Dursun Delen, Professor & Research Director, Oklahoma State University, Tulsa, OK, United States

A proven way to make learning of the foundational concepts and best practices more intuitive for students is to utilize a visual modeling and workflow-driven analytics platform. The goal is to reduce the syntactic nature of data science so that more time and mental capacity can be spent on concepts. KNIME Analytics Platform (a free and open-source software environment) is an excellent candidate for such an intuitive teaching, learning, and practicing tool. The current presentation will provide evidence and a short tutorial to illustrate the ease use of the KNIME Analytics Platform.

2 - Data Mining and Business Analysis for Efficient Search Engine Marketing
Arif Ansari, University of Southern California, Los Angeles, CA, 90089-0809, United States

In this presentation, we will provide a novel approach to find Search Engine Marketing keywords using multiple datamining methods, like clustering, text explorer, Tree Maps, Probabilistic Simulation, Estimation of Customer Acquisition Cost etc., This presentation will show the confluence of Business Analysis, Analytics and Data Mining to get Competitive Edge.

3 - Introducing the Multivariate Returns to Scale Technology
Dariush Khezrimotlagh, Pennsylvania State University Harrisburg, Middletown, PA, 17057-4846, United States

In this study, the motivation and construction of the multivariate returns to scale technology (MRTS) are presented. A linear programming data envelopment analysis (DEA) model is suggested as a data-driven tool to measure the corresponding production function and measure the corresponding efficiency score of units. The corresponding technology includes the corresponding variable returns to scale (VRS) technology and is a subset of the constant returns to scale (CRS) technology. As a result, the proposed score is neither less than that of the corresponding CRS DEA model nor greater than that of the corresponding VRS DEA model. The method should be considered for real-life applications when datasets include more than one input and/or more than one output. The process to justify the returns to scale for a dataset is also illustrated.

4 - Irrational Exuberance: Correcting Bias in Probability Estimates
Bradley Rava, University of Southern California, Los Angeles, CA, United States, Peter Radchenko

We consider the common setting where one observes probability estimates for a large number of events. Selecting events corresponding to the most extreme probabilities can result in systematically underestimating the true level of uncertainty. We develop an empirical Bayes approach "Excess Certainty Adjusted Probabilities" (ECAP), using a variant of Tweedie's formula, which updates probability estimates to correct for selection bias. ECAP directly estimates the score function associated with the probability estimates, so it does not need to make any restrictive assumptions about the prior on the true probabilities. ECAP also works well in settings where the probability estimates are biased. We demonstrate through theoretical results and empirical analysis that ECAP can provide significant improvements over the original probability estimates.

5 - Integrating INFORMS CAP/aCAP Into Your Academic Program
Matthew A. Lanham, Purdue University, Lafayette, IN, 47905-4803, United States

We discuss how we are making a proactive attempt to get every future graduate of Purdue's M.S. in Business Analytics & Information Management (BAIM) program and many program alumni to become INFORMS Certified Analytics Professionals (CAPs/aCAPs). We discuss why most programs have not achieved this, why we believe we can, how we are going about it, and challenge any academic program to partner with us to create additional incentives to push our graduates and program outcomes to the next level.

■ TD14

CC Room 201B

In Person: Data and Modeling Applications in Response to COVID-19 Pandemic

General Session

Chair: Yuan Zhou, University of Texas at Arlington, Arlington, TX, 76019-1000, United States

1 - An Agent-based Modeling Approach for Planning COVID-19 Reopening Activities
Yuan Zhou, University of Texas at Arlington, Arlington, TX, 76019-1000, United States

With mass distributions of vaccines, COVID-19 cases and fatalities have been reduced significantly in the US. However, it remains unclear when communities can return to the pre-pandemic normalcy completely, where the effectiveness of reopening strategies plays a critical role at both community- and individual-level. To derive an effective reopening plan, this study develops an agent-based simulation. The proposed model mimics the underlying transmission dynamics under different intervention scenarios and enables joint investigations of the timing and magnitude of lifting interventions used currently, such as social distancing precaution, mandatory mask wearing order, and online working requirement.

2 - Optimizing Pandemic Policy Decisions Accounting for Economic And Epidemiologic Impact
Leili Soltanisehat, University of Oklahoma, Norman, OK, 73019-1027, United States

While different COVID-19 controlling strategies (e.g., lockdown, school, and business closures) helped with decreasing the number of infections, they have had an adverse economic impact. Conversely, loosening such strategies led to new waves of cases. Therefore, the optimal timing and scale of closure and reopening strategies are required to balance pandemic growth with economic impacts. This work proposes a novel mathematical model for mitigating the economic and epidemiologic impact of a pandemic by combining SIRD and MNFP models into a linear mixed-integer program to explore state- and industry-level strategies.

3 - COVID-19 ResNet: Residual Neural Network for COVID-19 Classification with Bayesian Data Augmentation
Javier Sebastian Balseca Zurita, Universidad San Francisco de Quito, Quito, Ecuador, Martin Alejandro Cruz Patino

In this work a Residual Convolutional Neural Network (ResNet) for COVID-19 medical image (CXR) classification with a personalized data augmentation strategy is presented. The ResNet is a very deep network that progressively learns high level and complex feature representations from the CXR images. To overcome the data scarcity of covid-19 images, a data augmentation approach was implemented and hyperparameters were optimized using a Bayesian optimization approach. Experimental results show the proposed method obtains a competitive classification accuracy.

4 - Multi-criteria Course Mode Selection and Classroom Assignment under Sudden Space Scarcity
Mehran Navabi, ISyE Georgia Tech, Atlanta, GA, United States, Mohamed El Tonbari, Boland Natashia, Dima Nazzal, Lauren N. Steimle

Social distancing dramatically reduces the effective capacity of classrooms. During the COVID-19 pandemic, this presented a unique problem to campus planners: (1) Assigning a mode to each offered class as either remote, residential (in-person) or hybrid (2) Reassigning classrooms under reduced capacities to the non-remote classes. We solve a flexible integer program and use hierarchical optimization to handle the trade off between various administrative priorities. We generate optimal classroom assignments for all classes at the Georgia Institute of Technology, and quantify the impact of our results, particularly on in-person contact hours and mode preference satisfaction.

5 - Impact Assessment of Full and Partial Stay-at-home Orders, Face Mask Usage, and Contact Tracing: An Agent-based Simulation Study Of Covid-19 for an Urban Region
Shalome Hanisha Anand Tatapudi, University of South Florida, Tampa, FL, United States, Rachita Das, Tapas K. Das

Social intervention strategies to mitigate COVID-19 are examined using an agent-based simulation model. The simulation model mimics daily social mixing behavior of the susceptible and infected and data representing demographics of the region, virus epidemiology, and social interventions shapes model behavior. Results show that early implementation of complete stay-at-home order is effective in flattening the infection growth curve in a short period of time. Universal use of face masks reduced infected by 20%. A further reduction of 66% was achieved by adding contact tracing with a target of identifying 50% of the asymptomatic and pre-symptomatic.

■ TD15

CC Room 201C

In Person: Data Analytics in Semiconductor Manufacturing

General Session

Chair: Kim Dohyun, Korea, Republic of

1 - A Framework for Process Parameter Optimization Based on Deep Generative Model
YoungGeun Ahn, Myongji University, Yongin-si, Korea, Republic of, Dohyun (Norman) Kim, Minyoung Park

There are many process parameters that affect the process yield in the semiconductor process, and it is very important to find an optimized value of parameters to maximize the process yield. However, complex nonlinear correlations between parameters make their optimization difficult. Therefore, in this study, we propose a framework for optimizing the process parameters that maximize the process yield using deep generative model.

2 - Deep Learning-based Clustering Algorithm Considering Outliers
Somi Ha, Myong-ji Univ., Gyeonggi-do, Korea, Republic of, Sungwoo Kim, Dohyun (Norman) Kim

Most clustering algorithms perform clustering without considering outliers. However, when performing clustering, outliers often degrade performance. Therefore, in this study, a clustering algorithm that simultaneously performs clustering and outlier detection has been proposed. The proposed deep learning-based algorithm identifies outliers using the predicted class distribution and performs clustering based on only normal data.

3 - Analysis of Tabular Data Based on Graph Neural Network
Seungyeon Lee, Myongji University, Yongin-si, Korea, Republic of, Minyoung Park, Dohyun (Norman) Kim

In many applications in the industry, tabular data are the most commonly used data type. Machine learning methods for dealing with tabular data are classified into two categories: similarity-based approach and feature-based approach. Feature-based models are easy to understand and intuitive to use and deploy but generally cannot utilize the relationships between observations. Similarity-based models are most suited for exploiting the relationships among observations, but their availability is usually limited. In order to take advantage of both aspects of tabular data, we propose an algorithm to combine feature-based and similarity-based approaches using graph neural network. Experimental results show that the proposed method provides more precise results for classification tasks, implying that it may improve the generalization capability.

4 - Competing Streaming Platforms: The Impact of Exclusive Content
Emily A. Meigs, MIT, Cambridge, MA, 02139-4204, United States

We develop a model to study the joint problem of designing the subscription fee and amount of original content a streaming platform should generate. In our model, the users are heterogeneous in their usage rate and depending on the content on the platforms and their subscription fee decide whether they want to subscribe to a platform or not. The two competing platforms, each choose the subscription fee that they want to offer for (unlimited) access to their content and the investment level they put into their content. The investment in their own content is costly, but higher quality content can potentially be offered at a higher subscription fee to the users. We fully characterize the equilibrium in both the monopolistic and competitive settings. We characterize under what conditions the platforms separate the two types of customers.

5 - A New Cluster Validity Index for Non-hierarchical Clustering Analysis
Youngseon Jeong, Chonnam National University, Industr, Gwangju, 61186, Korea, Republic of, Changwan Ko

This paper proposes new cluster validity indexes (CVIs) in feature space for non-hierarchical clustering analysis in which the proposed CVIs transform arbitrary shape of clusters into elliptical or circular shaped clusters by using kernel functions of Support Vector Data Description (SVDD). The experimental results show that the proposed CVIs have a good performance to estimate the optimum number of clusters for lower-dimensional and unique characteristic dataset.

■ TD16

CC Room 201D

In Person: Optimization Methods for Learning from Data

General Session

Chair: Paul Brooks, Virginia Commonwealth University, Richmond, VA, 23284-4000, United States

Co-Chair: Jose H. Dula, University of Alabama, Tuscaloosa, AL, 35487, United States

1 - Nearest Convex Hull Classification with Linear Programming
Jose H. Dula, University of Alabama, School of Business,, Tuscaloosa, AL, 35487, United States, Anatoly Nemirko

The multi-class classification problem aims at assigning a test point to one of several classes that partition a data set. Nearest Convex Hull Classification uses the point's distance to the convex hulls of the class's data for this assignment. This presents a special challenge when the test point is interior to two or more hulls. We propose a lazy supervised machine learning method based on linear programming that locates internal and external test points and approximates distances. Advantages include that the same formulation is used for interior or exterior points, necessary and sufficient conditions for classification, the absence of user-defined parameters, and excellent scalability. Tests on health care data show the method performs well.

2 - Processing Large Scale DEA: The State-of-the-art
Jose H. Dula, University of Alabama, School of Business,, Tuscaloosa, AL, 35487, United States, Dimitris K. Despotis, Gregory Koronakos

Dula's 2012 algorithm, BuildHull, was the fastest way to process DEA when it came out. Since then there has been an interest in analyzing and testing the algorithm's performance. We report on a study comparing BuildHull with a recent competing approach for DEA using a well-structured data suite which includes massive data sets and allows insights into the effects of dimensionality, cardinality, and extreme-efficient DMU density.

3 - Dynamic L1 Regression
Botan Citil, University of Alabama, Tuscaloosa, AL, United States, Jose Dula

The objective of this project is to apply L1 regression to streaming data. L1 regression is considered to be more robust than ordinary least squares and is indicated when the data contain outliers such demand spikes, etc. We report on results that enhance and accelerate resolving the special LP formulation for this problem. We present numerical results from our tests.

■ TD17

CC Room 202A

In Person: Decision Analysis

General Session

Chair: Tim Marler, PhD, RAND Corporation, Santa Monica, CA, United States

1 - Presenter
Jack Soll, Duke University, Fuqua School Of Bus., Durham, NC, 27708-9972, United States

I will serve as a discussant for the papers presented in this session.

2 - Analysis of Cyber-attacks and Cost-effective Methods of Cybersecurity
Einstina Wang, Oxford Academy, Cypress, CA, United States, Gabriel Han, Hannah Jang, Won Jang

Increasing cybersecurity risks can cause data breaches that expose personal and sensitive information, damaging the reputation of targeted companies and hurting their clients. We test various preventative security methods, including employee education, firewalls, encryption, and software updates, with consideration of costs to determine practical solutions to mitigate the risks of cybersecurity data breaches for companies of various sizes. We determine that the most important action a company could take would be through behavioral changes such as securing passwords and using multi-factor authentication.

3 - The Role of Overconfidence on Personal Attitude Toward Covid-19 and Risk Mitigating Factors
Dominik Piehlmaier, Assistant Professor, University of Sussex, Brighton, United Kingdom

The experimental study sheds light on the impact of overconfidence on a person's attitude toward COVID-19 as well as the likelihood of wearing face masks, getting vaccinated, utilizing contact tracing apps, and following mandatory quarantine rules by conducting a randomised controlled trial data from 600 UK panellists. Building on the theory of correlation neglect, we show that respondents who are overconfident in their knowledge about infectious diseases illustrate a laxer attitude toward the current outbreak. The study provides evidence to help inform public health officials to focus on a subpopulation who would benefit from a nudge to follow official COVID-19 guidance and regulations.

4 - A Game Theory Approach for Engineering Optimization and Decision-making
Tim Marler, RAND Corporation

Groups of decision-makers, interacting in a design process, can be modeled using game theory, which in turn can be solved as a multi-objective optimization problem. From this perspective, decision-makers rarely cooperate completely in a theoretical sense; rather, the exchange of information is iterative. Ultimately, this can result in a non-optimal solution or design. Given multiple decision-makers, each managing a separate objective function and controlling unique variables, this paper presents a new algorithm for modeling design process as a non-cooperative game theoretic scenario. This algorithm is then used in the context of a broader novel multi-objective optimization approach for resolving such non-cooperative situations, thus yielding a Pareto optimal solution. This approach provides not only a mathematical method for extending a Nash equilibrium point (non-cooperative solution) towards the Pareto optimal set, but also a means for modeling how decision-makers actually interact. This, in turn provides significant insight into engineering project management and decision-making. The proposed approach is demonstrated with two illustrative design problems.

■ TD19

CC Room 203A

In Person: Information, Technology, and Analytics in Healthcare

General Session

Chair: Mehmet U.S. Ayvaci, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - Does EMR Adoption by Nursing Homes Decrease Hospitalization Costs ?
Atiye Cansu Erol, University of Pennsylvania, Philadelphia, PA, United States, Lorin Hitt, Prasanna Tambe

Electronic Medical Records (EMR) have the potential to decrease medical expenditures by increasing communication between healthcare providers and by reducing unnecessary tests and medical errors. Using a three–year panel of Medicaid spending for long–term care patients in nursing homes, we find evidence that EMR adoption by nursing homes reduces hospitalization costs for residents by 3.5–14 percent. We also find a further reduction of hospitalization costs for residents when hospitals and nursing homes both adopt EMR: an average savings of 13 percent of Medicaid expenditure and as much as 35 percent for system–member hospitals. Given the interdependent nature of healthcare delivery for long–term care patients or patients with chronic conditions, our findings underscore the importance of looking outside the adopting institution when accounting for health IT value.

2 - Nursing Home Staff Networks and Covid-19
Elisa F. Long, UCLA Anderson School of Management, Gold Hall 110 Westwood Plz # B-508, Los Angeles, CA, 90024-5055, United States, Keith Chen, Judith Chevalier

Skilled nursing homes (SNFs) accounted for a disproportionate share of COVID-19 fatalities worldwide, with outbreaks persisting despite the March 2020 nationwide ban on visitors. Using device-level geolocation data for 50 million smartphones, we analyze SNF connections via shared staff and observe 500,000 individuals entering at least one SNF, with 5.1% entering two or more facilities. Nursing homes share connections with 7.1 other facilities, on average. Network measures of connectivity, including node degree, strength and Eigenvector centrality, are highly predictive of COVID-19 cases, whereas traditional regulatory quality metrics are unimportant in predicting outbreak size.

3 - A Multi-treatment Forest Approach for Analyzing the Heterogeneous Effects of Team Familiarity
Minmin Zhang, The University of Texas at Dallas, Richardson, TX, 75252, United States, Wallace J. Hopp, Guihua Wang, Michael Mathis

We study the heterogeneous effects of team familiarity on surgery duration. We develop a multi-treatment forest consisting of multiple tree models that divide patients into different subgroups based on their features and estimate the effects of familiarity within each subgroup. The results show that the effects of familiarity are different for different types of patients. Our results can help hospital administrators to improve operational efficiency by matching patients with surgery team members using patient-specific information.

4 - A Tool to Inform Global Hepatitis C Elimination in Developing Countries
Huaiyang Zhong, Harvard Medical School, Massachusetts General Hospital, Boston, MA, United States, Madeline Adee, Lindsey Hiebert, John Ward, Jagpreet Chhatwal

The World Health Organization (WHO) recently launched a global campaign for eliminating hepatitis C virus (HCV) as a public health threat by the year 2030. However, most countries do not have a national strategy for HCV screening and treatment that can lead to HCV elimination. We developed a microsimulation model to assess various combinations of screening and treatment strategies, and built an online, publicly accessible tool to help policy makers identify a path to HCV elimination.

■ TD20

CC Room 203B

In Person: Pharmaceutical Supply Chains

General Session

Chair: Minje Park, Boston University, Boston, MA, 02215-1704, United States

1 - Changing Standards and Drug Shortages in the Pharmaceutical Industry

Ivan Lugovoi, The Ohio State University, Columbus, OH, United States

Matching supply and demand is a fundamental task of supply chain management. Failure to supply a product is painful for consumers, but particularly so in the pharmaceutical industry, where the product is often necessary for the treatment of life-threatening diseases. Drug shortages, therefore, pose significant public health threats. One important manufacturing quality issue is a drug's non-compliance with quality standards. Our research examines changes in such quality standards. A change of a quality standard can lead to a compulsory change in the manufacturing or testing technology, and such technological change can, in turn, lead to manufacturing quality issues or the decision to completely cease production. As a result, the total manufacturing capacity for a drug in a market can be adversely impacted by a quality standard change.

2 - The Impacts of a Non-profit Organization on Drug Shortages

Junghee Lee, University of Notre Dame, Notre Dame, IN, 70118-5669, United States, Hyoduk Shin, Daewon Sun

The ongoing shortage of pharmaceutical drugs critically threatens public health. To mitigate the drug shortages, philanthropies and hospital systems founded a non-profit organization that "better" sources and even manufacturers essential medicines. We investigate how the advent of the non-profit entity reshapes the competition and impacts the performance of each entity in a pharmaceutical drug supply chain.

■ TD21

CC Room 204A

In Person: Robust and Stochastic Decision-making under Uncertainty

General Session

Chair: Meng Qi, University of California, Berkeley, Chicago, IL, 60614, United States

1 - The Power of Adaptivity for Stochastic Submodular Cover

Rohan Ghuge, University of Michigan, Ann Arbor, MI, 48105-2542, United States, Anupam Gupta, Viswanath Nagarajan

In the stochastic submodular cover problem, the goal is to select asubset of stochastic items of minimum expected cost to cover a submodular function. Solutions in this setting correspond to a sequential decision process that selects items one by one "adaptively" (depending on prior observations). While such adaptive solutions achieve the bestobjective, the inherently sequential nature makes them undesirable in many applications. We ask: how well can solutions with only a few adaptive rounds approximate fully-adaptive solutions? We consider both cases where the stochastic items are independent, and where they are correlated. For both situations, we obtain nearly tight answers, establishing smooth tradeoffs between the number of adaptive rounds and the solution quality, relative to fully adaptive solutions.

2 - Models and Methods for Ambulance Dispatch

Anton J. Kleywegt, ISyE Georgia Tech, School of Ind and Systems Eng, Atlanta, GA, 30332-0205, United States, Vincent Guigues

Ambulances are controlled by dispatch decisions. First, when an emergency call arrives, a decision is made which ambulance to dispatch, or whether to place the call in queue to wait for a later dispatch. A number of factors should be taken into account when making this dispatch decision, including the following: (a) Ambulance type and crew. Ambulance services operate different types of ambulances, and ambulance crews have different levels of skills. (b) Ambulance location. At any point in time, different ambulances are at different locations and in different states of readiness. (c) Future coverage. The ambulances that remain available should provide good coverage for future emergencies. Second, when an ambulance completes a task and becomes available, a decision is made regarding the call in queue that the ambulance should serve next, or the location where the ambulance should go and wait. Future coverage also plays a role in this decision. We present a number of stochastic optimization models and methods to support ambulance dispatch decisions.

3 - Integrated Conditional Estimation-Optimization

Meng Qi, University of California, Berkeley, Berkeley, CA, 60614, United States, Paul Grigas, Zuo-Jun Max Shen

Many real-world optimization problems have an objective function defined by a random parameter whose probability distribution depends on a contextual feature vector. In contrast to the standard way of first estimating the uncertainty then optimizing the objective based on estimation, we propose an Integrated Conditional Estimation-Optimization (ICEO) method that estimates the underlying conditional distribution of the random parameter while considering the structure of the optimization problem. This allows us to fundamentally capture the correlation between the contextual features, especially when the distribution of contextual features varies. We prove the asymptotic consistency and finite performance guarantees in the form of generalization bounds. We also provide computational methods and numerical studies.

■ TD22

CC Room 204B

In Person: Empirical and Behavioral Research in Healthcare

General Session

Chair: Hyun Seok (Huck) Lee, Korea University Business School, Seoul, 97333-3235

Co-Chair: Junghee Lee, Tulane University, New Orleans, LA, 70118-5669, United States

1 - Learning in Drug Shortages

Hyun Seok (Huck) Lee, Korea University Business School, Seoul, 97333-3235, Korea, Republic of, Junghee Lee, In Joon Noh

In this study, we investigate whether pharmaceutical manufacturing plants learn from their own drug shortage instances. Specifically, we examine if more drug shortages recovery at a plant lead to quicker recovery from its subsequent shortages. We also investigate factors that might affect this learning. Our findings will have policy implications for the FDA and will also contribute to the academic literature on learning.

■ TD24

CC Room 205A

In Person: Supply Chain & Operational Risk Management

General Session

Chair: Na Rea Cho, University of Alabama, Tuscaloosa, AL, 35405, United States

1 - Concurrent Sourcing under Supply and Demand Uncertainty

Bryant Cassidey, University of Alabama, Tuscaloosa, AL, United States, Nickolas K. Freeman, Sharif Melouk

A central question in the supply chain strategy literature related to Supply Chain Risk Management (SCRM) asks how a firm should delineate its boundary with respect to goods composing a product or service it offers. We investigate the setting in which a firm may choose to make and buy components used to manufacture finished goods (concurrent sourcing), and determine the optimal decision strategy under uncertain supply and demand. For simplicity, we assume supply is uncertain in an all-or-nothing manner: either the supply is totally disrupted or not. We show that the optimal strategy follows a threshold structure defined by problem parameters. We also investigate the effect of concurrent sourcing on the supplier's optimal pricing strategy. Our analysis highlights the conditions under which a manufacturer and a supply chain system benefit the most from concurrent sourcing.

2 - Managing Residential Energy Storage

Na Rea Cho, University of Alabama, Tuscaloosa, AL, 35405, United States, Karthik Murali, Youngsoo Kim, Mesut Yavuz

In this paper, we examine a homeowner's battery management policy when they have access to intermittent renewable energy and are connected to a grid with feed-in tariffs and time-of-use electricity prices. The cost-minimizing battery operating policy depends on the configuration of electricity prices in the market. When electricity sellback prices are lower than purchase prices from the grid, we show that a simple heuristic with a charge up to level in the off-peak period and a discharge down to level in the peak period performs extremely well relative to the optimal solution. We compare the performance and emissions reductions resulting from this recommended policy against other commonly utilized heuristics (full charge/discharge, no battery, do nothing).

■ TD25

CC Room 205B

In Person: Optimization in Julia

General Session

Chair: Chenyang Yuan, Massachusetts Institute of Technology

1 - Conic Formulation Choice in Interior Point and Outer Approximation Algorithms

Chris Coey, Massachusetts Institute of Technology, Cambridge, MA, United States, Juan Pablo Vielma

Any (mixed-integer) convex problem can be reformulated as a (mixed-integer) conic problem. We introduce a variety of proper cones, which we use to write simple, natural formulations for many applied examples. We generate a diverse set of continuous and mixed-integer benchmark instances. We solve these instances using our new generic implementations of interior point and outer approximation algorithms. Our results may be helpful for practitioners deciding how to formulate conic models.

2 - Recent Advancements in Hypatia

Lea Kapelevich, Massachusetts Institute of Technology, 238 Prospect St Apt 2, Cambridge, MA, 02139-1784, United States, Chris D. Coey, Juan Pablo Vielma

We will discuss recent advancements in our interior point solver, Hypatia. In particular, we will look at some new cones, their barrier functions, and oracles.We will show that many advanced oracles that make our interior point algorithm more efficient are available in analytic form, which reduces the gap in the efficiency of oracles between standard and exotic cones.

3 - A Method for Large Scale Sum of Squares Optimization

Chenyang Yuan, Massachusetts Institute of Technology, Cambridge, MA, United States, Benoît Legat, Pablo A. Parrilo

Determining if a polynomial is a sum of squares involves solving a large semidefinite program, which quickly runs into scalability issues. We propose applying the Burer-Monteiro method to a sampled version of the problem, where equality constraints are enforced by evaluating the polynomial at random points. This method is easily parallelizable and scalable, and the problem can be solved using stochastic gradient descent.

■ TD26

CC Room 206A

In Person: Binary Decision Diagrams for Optimization

General Session

Chair: Yatharth Dubey, Georgia Institute of Technology, Atlanta, GA, 30318, United States

1 - Graph Coloring with Decision Diagrams: An Analysis of Variable Ordering

Anthony Karahalios, Carnegie Mellon University, Pittsburgh, PA, United States, Willem-Jan van Hoeve

A decision diagram approach was recently introduced to generate lower bounds for the graph coloring problem. It uses compilation via iterative refinement, which requires a variable ordering to be specified in advance. Oftentimes no single variable ordering dominates all others for a set of problem instances. This work provides an analysis and experimental evaluation of different variable ordering strategies including using portfolios of variable orderings.

2 - Deepest Cuts for Benders Decomposition

Mojtaba Hosseini, Paul Merage School of Business, UCI, Irvine, CA, United States, John G. Turner

Benders Decomposition (BD) has been successfully applied to a wide range of large-scale mixed-integer (linear) problems. We introduce deepest Benders cuts, a new unifying Benders cut selection technique based on a geometric interpretation of cut "depth", and provide a comprehensive study of their properties. We further propose a generalization of the Benders separation problem that brings several well-known cut selection strategies under one umbrella. We propose the Guided Projections Algorithm for producing deepest Benders cuts and demonstrate their effectiveness in improving the convergence of the BD algorithm.

3 - Lower Bounds on the Size of General Branch-and-Bound Trees

Yatharth Dubey, Georgia Institute of Technology, Kendall Park, NJ, 08824-1486, United States

A general branch-and-bound tree is a branch-and-bound tree which is allowed to use general split disjunctions to create child nodes. We construct a packing instance, a set covering instance, and a Traveling Salesman Problem instance, such that any general branch-and-bound tree that solves these instances must be of exponential size. We also verify that an exponential lower bound on the size of general branch-and-bound trees persists when we add Gaussian noise to the coefficients of the cross polytope, thus showing that polynomial-size ``smoothed analysis" upper bound is not possible. The results in this paper can be viewed as the branch-and-bound analog of the seminal paper by Chvatal et al., who proved lower bounds for the Chvatal-Gomory rank.

■ TD27

CC Room 206B

In Person: Advances in Nonlinear and Stochastic Optimization I

General Session

Chair: Baoyu Zhou, Lehigh University, Bethlehem, PA, 18015, United States

1 - A Smoothing-based Decomposition Algorithm for Nonlinear Two-state Problems

Andreas Waechter, Northwestern University, Department Of Industrial Eng. The Technological In, Evanston, IL, 60208-0834, United States, Shenyinying Tu, Ermin Wei

A decomposition algorithm for nonlinear two-stage optimization problems is presented. The second-stage value function is smoothed by means of a barrier term. As a result, the first-stage problem can be solved directly with a nonlinear optimization algorithm. Fast local convergence is achieved by lifting second-stage constraints to avoid ill-conditioning near the optimal solution.

2 - A One-Bit Gradient Estimator for Comparison-Based Optimization

Daniel Mckenzie, University of California, Los Angeles, Los Angeles, CA, United States, HanQin Cai, Wotao Yin, Zhenliang Zhang

Comparison-based optimization is a particularly restrictive form of derivative-free optimization. Instead of having access to function evaluations one only assumes access to an oracle which, given two points x and y, returns a single bit of information indicating which is larger, f(x) or f(y). This paradigm arises frequently in practice in optimization problems where humans are providing the feedback, e.g. website AB testing, as asking humans to compare two options is typically more reliable than asking them to assign a numerical score of "goodness".In this talk we will survey recent progress on making comparison-based optimization more query efficient, with an emphasis on a recent work by the listed authors that exploits gradient sparsity to construct an algorithm with query complexity sub-linear in the problem dimension.

■ TD28

CC Room 207B

In Person Technology Tutorial: New Developments in AMPL: Solver Callbacks, Spreadsheet Interfaces, and Cloud Licensing

Technology Tutorial

1 - New Developments in AMPL: Solver Callbacks, Spreadsheet Interfaces, and Cloud Licensing

Robert Fourer, AMPL Optimization Inc., Evanston, IL, 60201-2308, United States

Built on the concept of model-based optimization, AMPL's intuitive algebraic modeling language and prototyping environment give you a fast start on prescriptive decision-making projects. AMPL's APIs for popular programming languages then help you build completed optimization models into your applications. Now AMPL's APIs also help you get more functionality from widely-used MIP solvers, by providing access to a variety of solver callbacks. This presentation introduces AMPL's generic solver callback features through two Python notebook examples: implementation of custom-designed solver stopping rules, and dynamic generation of cuts (constraints) during the solution process. Our presentation concludes with summaries of other notable developments in AMPL, including improved interfaces to spreadsheets and databases, and flexible licensing for deployment in virtual environments such as cloud services and containers.

■ TD29

CC Room 207C

In Person: Applied Machine Learning for a Two-Sided Marketplace

General Session

Chair: Nathaniel Burbank,

1 - Algorithmic Contact Management in Sales & Service
Luke Winslow, Wayfair, Boston, MA, United States, Akritee Shrestha

Contact center operations must balance demand and supply to achieve target service levels. Lack of an integrated framework for forecasting, traffic balancing, and routing decreases overall efficiency. In this presentation, we outline a three-level approach for contact optimization: 1. improving contact forecasting through machine-learning to enable advance scheduling, 2. shaping traffic in real-time to encourage or defer contacts based on existing staffing levels, and 3. routing contacts to the right team/agent based on predicted customer needs to maximize outcomes. This integrated framework helps us increase overall efficiency and improve service levels and outcomes on sales and service contacts.

2 - Bayesian Product Ranking for Multiple Objectives
Tom Croonenborghs, Wayfair, Boston, MA, 02111, United States

One of the most important aspects of a successful e-commerce business, especially one with the scale and breadth of products like Wayfair, is to make it easy for customers to find the perfect product for their need, right when they need it. Our catalog size presents a significant curation challenge: we need to balance exposing popular products with surfacing newer products that we believe can be successful, but have not yet received significant customer traffic. To this end, we have developed and deployed a Bayesian recommender system which not only finds opportunities for all of our customers, but at the same time maximizes benefits for our suppliers and Wayfair.

3 - Power Up Geo Experimentation at Wayfair With Integer Optimization
Chenhao Du, Wayfair, Wayfair, Boston, MA, 02111, United States

In Wayfair we run numerous experiments to evaluate the ad efficiency, optimize the UI interface and understand users' preference. Comparing to the most popular user-level A/B experiments, Geo experiment is more privacy robust and able to handle the situations when user-level data is unavailable. In this talk, we will introduce how we improve the design and measurement on Geo experiment at Wayfair using the integer optimization.

4 - Share Of Voice: Optimizing Wayfair's Marketing Content by Maximizing Customer Relevancy with Business Constraints
Kurt Zimmer, Wayfair, 4 Copley Place, Boston, MA, 02111, Boston, MA, 02111, United States

While Wayfair's various ML models and pipelines provide us an algorithmic way to find the most relevant content for a given customer, there may be instances where we want to deviate from the most optimal short term strategy. In particular, this is often the case with new and emerging product categories, where we'd like to increase the Share of Voice of these categories by finding who are the most optimal customers to show these categories to. This is encoded as a Generalized Assignment Problem where we are aiming to assign each customer to a product category optimally given our constraints. We set the optimization objective to maximize the relevancy of the category to each customer as determined by our Customer Need Models and solve after adding the Share of Voice constraints from the business. Tests have shown a lift in engagement across both traditional and emerging categories.

■ TD30

CC Room 207D

In Person: Adaptive Online Learning of High-Dimensional Data

General Session

Chair: Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL, 32608-1047, United States

1 - Deep Learning-based Critical Event Prediction using Time-dependent Representations
Ye Kwon Huh, University of Wisconsin-Madison, Madison, WI, United States, Minhee Kim, Kaibo Liu

In reliability analysis, event sequence data are commonly used in system monitoring, diagnosis, and critical event prediction. While many deep learning-based event prediction models have been proposed, they rely on representations (e.g., one-hot encoding) that do not fully incorporate the temporal information contained in the event sequence. To overcome this limitation, this study proposes a novel time-dependent representation of the event sequence by generating event embeddings that leverage both occurrence time (continuous) and event type (categorical). For better interpretability and accuracy, we further introduce an attention layer that considers the criticalness of different events and a regularizer based on the time between consecutive events. We conduct numerical studies on simulated data and Computerized Tomography log data to evaluate our method.

2 - Active Sequential Change-point Detection under Sampling Control
Qunzhi Xu, Georgia Tech, Atlanta, GA, United States

This paper considers the active monitoring of multiple data streams for changes under the sampling control constraint. Here the sampling control constraint means that we are allowed to access only one local stream per time step. Under the scenario when the post-change distributions involve unknown parameters, we develop an efficient active sequential change-point detection algorithm: the greedy-cyclic-sampling-cumulative-sum (GCS-CUSUM) algorithm. It is surprising that our proposed GCS-CUSUM algorithm is asymptotically optimal to minimize the detection delay up to o(log) subject to the average run length to false alarm constraint of when the dimension M= o(log( )) and goes to ∞. Simulation studies are then conducted to illustrate the performance of the proposed algorithm.

3 - A Bayesian Deep Learning Framework for Interval Estimation of Remaining Useful Life in Complex Systems by Incorporating General Degradation Characteristics
Minhee Kim, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53706-1539, United States

Abstract is not available

■ TD31

CC Room 208A

In Person: Platforms, Data, and Algorithms

General Session

Chair: Ali Makhdoumi, Duke University, Durham, NC, 27708-9972, United States

1 - Misinformation: Strategic Sharing, Homophily, and Endogenous Echo Chambers
James Siderius, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Daron Acemoglu, Asuman Ozdaglar

We present a model of online content sharing where agents can "fact-check" to determine if this content contains misinformation. While agents value shares, they simultaneously fear getting caught sharing misinformation. With little homophily in the social network, misinformation is often quickly identified and brought to an end. However, when homophily is strong, whereby agents anticipate that only those with similar beliefs will view the article, misinformation spreads more rapidly because of echo chambers. We use this to show that a social media platform that wants to maximize engagement should propagate extreme articles amongst extremist users. This creates an endogenous echo chamber, or "filter bubble," that is highly conducive to viral misinformation. We conclude with a few policy suggestions to combat platform incentives to recommend misinformation.

2 - Passing Data Directly into Prescriptive Analytics
Lennart Baardman, University of Michigan, Ann Arbor, MI, 48103, United States

Analytics has seen an increase in use to solve operational problems. Often, data-driven algorithms take a two-stage approach involving predictive and prescriptive analytics. Predictive analytics is used to develop models of uncertain quantities, which can then be used in mathematical optimization models of prescriptive analytics. In this work, we propose a framework that can directly translate data into decisions using only a single mathematical optimization model. Using a single model avoids any errors due to overfitting on predictions in a sequential approach or the misspecification of a predictive model. Additionally, our approach can deal with highly non-linear objective functions. We show the strength of our model both in theory and practice, and solves complex problems quickly.

3 - Optimal Data Acquisition with Privacy-Aware Agents
Juba Ziani, Georgia Institute of Technology, Atlanta, GA, United States, Rachel Cummings, Hadi Elzayn, Vasilis Gkatzelis, Emmanouil Pountourakis

We look at a data analyst that must optimally buy data from individually rational, privacy-aware agents, to compute a statistic. Agents derive utility from the output of the statistic, and trade-off the privacy costs they incur from revealing their data with the utility they get from the statistic. They may decide to opt out if their privacy costs are high. The analyst provides differential privacy guarantees to her computation, and adjusts the level of noise she offers to affect the agents' privacy costs. She does so to optimize the accuracy of her computation, and must take into account the trade-off between i) adding more noise to incentivize participation and data collection through lower privacy costs and ii) adding less noise to obtain more accurate data points. We provide near-optimal algorithms for the optimization and mechanism design problems faced by the analyst.

■ TD32

CC Room 208B

In Person: Innovative Business Models and Platforms

General Session

Chair: Longyuan Du, University of San Francisco, San Francisco, CA, 94117-1080, United States

1 - The Important Role of Time Limits When Consumers Choose Their Time in Service

Pnina Feldman, Boston University, Questrom School of Business, 595 Commonwealth Aven, Boston, MA, 2215, United States, Ella Segev

We examine ways to manage congestion in services when customers choose their service time. We find that time limits are very attractive levers. They are optimal for revenue and social welfare maximization and are nearly optimal to maximize consumer surplus.

2 - Sales Effort Management under All-or-nothing Constraint

Longyuan Du, University of San Francisco, San Francisco, CA, 94117-1080, United States, Ming Hu, Jiahua Wu

We consider a sales effort management problem under an all-or-nothing constraint. The seller will receive no bonus/revenue if the sales volume fails to reach a predetermined target at the end of the sales horizon. Throughout the sales horizon, the sales process can be moderated by the seller through costly effort. We show that the optimal sales rate is non-monotonic with respect to the remaining time or the outstanding sales required to reach the target. We then study easy-to-compute heuristics. We show that when the profit-maximizing rate is lower than the target rate, the performance loss of any static heuristic is of an order greater than the square root of the scale parameter. To address the poor performance of the static heuristic, we propose a modified resolving heuristic and show that it is asymptotically optimal and achieves a logarithmic performance loss.

■ TD33

CC Room 209A

In Person: Data-driven Learning in Revenue Management

General Session

Chair: Yuexing Li, Duke University, Durham, NC, 27703-6548, United States

1 - Provably Optimal Reinforcement Learning for Online Inventory Models With Cyclic Demands

Xiao-Yue Gong, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States, David Simchi-Levi

Motivated by a long-standing gap between inventory theory and operations practice, we study online inventory models with unknown cyclic stochastic demands. We design efficient reinforcement learning algorithms with provable theoretical guarantees that cater to the specific structures of inventory management problems. We apply a standard performance measure in online learning literature, regret, defined as the difference between the expected total cost of a policy and that of the optimal policy with full knowledge of the demand distributions.This paper first introduces an easier family of models—episodic models—where inventory is discarded at the end of every cycle. Our policies achieve ~O(\sqrt{T}) regret for both the episodic lost-sales model with zero lead time, and the episodic multi-product backlogging model with lead times, fixed joint-ordering costs and order limits. The regret bounds of our policies match the regret lower bounds that we prove for these models. Next, we build upon these policies for episodic models to devise meta algorithms for the more difficult non-discarding models with cyclic demands. Our policies achieve ~O(\sqrt{T}) regret for both the lost-sales model with zero lead time and the backlogging model with zero lead time, again matching the regret lower bounds for these models. We achieve ~O(T^{5/6}) regret for the multi-product non-discarding backlogging model with lead times, fixed joint-ordering costs and order limits. Our policies allow the input of expert advice to further improve their performance in real applications. Importantly, some of our algorithms apply more generally to a variety of operations research problems beyond inventory management.

2 - Quality Learning in a Dynamic Mutual Data Exchange Model

Ebru Kasikaralar, University of Chicago, Chicago, IL, United States, John R. Birge

Advances in storing and processing big data have transformed how digital platforms learn about product quality, user preferences and make pricing decisions accordingly. Due to the increase in data privacy concerns, policies restricting access to consumers' data are expected to become more prevalent. However, personal data is essential in generating successful matching algorithms and enhancing the customers' purchase experience. Hence, we introduce a model where the buyers and a firm directly interact with each other in two different markets: product and data market. There is a costly dynamic data exchange between the firm and the consumers, where the firm offers incentives to buyers to sell data. The firm uses acquired data from consumers to learn the underlying product quality, and consumers use the acquired data from the firm to make strategic purchase decisions.

3 - Data-driven Newsvendor: Algorithms and Optimal Performance

Omar Mouchtaki, Columbia University, New York, NY, United States, Omar Besbes

We study the classical newsvendor problem in which the decision-maker must make decisions to trade-off underage and overage costs. In contrast to the typical setting, we assume that the decision-maker does not know the underlying distribution driving uncertainty but has only access to past data drawn from the underlying distribution (e.g., past demand). In turn, the key question is how to map existing data to an optimal decision. We evaluate the performance of any algorithm through its worst-case relative expected regret, compared to an oracle with knowledge of the distribution. We provide the first finite sample exact analysis of the classical Sample Average Approximation (SAA) algorithm for this class of problems across all data sizes. We further derive an optimal algorithm and its associated performance. It yields significant improvements over SAA for small data sizes.

4 - Deep Learning For Visual Advertising on Digital Platforms

Yuexing Li, Duke University, Durham, NC, 27703-6548, United States, N. Bora Keskin, Shaoxuan Liu, Jing-Sheng Jeannette Song

We consider a digital platform that aims to crop and display N images to its customers to help with their purchasing decisions. For each image, the platform chooses a cropping window and observes the resulting conversions, i.e., the customer purchasing decisions. The platform does not know how cropped images influence conversions. We design a neural network policy that dynamically learns this relationship and adjusts images to maximize conversion. We derive a theoretical performance guarantee proving the asymptotic optimality of our policy. Using real-life data from a large online travel platform, we show that our policy achieves considerable improvement over the incumbent policy of the platform. The results also reveal that our policy exhibits good performance even if the functional relationship between images and conversion is misspecified.

■ TD36

CC Room 210B

In Person: Emerging Themes in Urban Transportation Planning

General Session

Chair: Bingqing Liu, New York University, New York, NY, United States

1 - Ridesharing Morning Commute in Monocentric City Networks an Equilibrium Model and the Analytical Solutions

Rui Ma, University of Alabama in Hunstville, Owens Cross Roads, AL, 35763, United States

The ridesharing morning commute traffic in a many-to-one network where commuters from different origins commute to the central business district (CBD) is studied. It is found that the common parking disutility connects departure-time choice behavior and traffic flow patterns on all corridors.Seemingly counter-intuitive, a demand paradox and a corridor expansion paradox are found, which have significant implications for both urban traffic management and infrastructure planning for concentric cities.

2 - Ridesharing and Fleet Sizing for On-demand Multimodal Transit Systems

Ramon Auad, ISyE Georgia Tech, Atlanta, GA, 30318-5499, United States, Pascal Van Hentenryck

This work considers the design of On-Demand Multimodal Transit Systems (ODMTS) that combine fixed bus/rail routes between transit hubs with on-demand shuttles to serve the first/last miles to/from the hubs. The design problem aims at finding a network design for the fixed routes to allow a set of riders to travel from their origins to their destinations while minimizing the sum of the travel costs, the bus operating costs, and rider travel times. Using MIP models, the paper generalizes prior work by including ridesharing in the shuttle rides and proposes a novel fleet-sizing algorithm for determining the number of shuttles needed to meet the performance metrics of the ODMTS design. The methodological contributions are evaluated on a real case study in Michigan to illustrate the potential of ridesharing for ODMTS.

3 - An Electric Vehicle Charging Station Access Equilibrium Model with M/D/C Queueing
Bingqing Liu, New York University, New York, NY, United States, Theodoros Pantelidis, Stephanie Tam, Joseph Y. J. Chow

The use of electric vehicle (EV) fleets is highly dependent on charging infrastructure. Three contributions are made. First, we propose an EV-to-charging station equilibrium assignment model with a nonlinear objective to evaluate charging station configurations. Queueing is modeled as M/D/C queue. Second, to address the non-differentiability, we propose a solution algorithm based on the Method of Successive Averages. Third, the model is calibrated to the NYC DCAS fleet and charging station configuration as of July 8, 2020, and applied to evaluate hypothetical charging station investments based on two alternative strategies. Results are promising for a policy based on high utilization ratio.

■ TD37

CC Room 210C

In Person: Systems Engineering in Support of National Security

General Session

Chair: Isabella Sanders, United States

1 - Military Readiness Modeling: An Actionable Data Framework
Connor McLemore, CANA Advisors, Reno, NV, 89509-2342, United States

Although the purpose of the Department of Defense (DoD) is accepted broadly to be "to provide ready and sustainable military forces to protect the nation's vital interests," the meaning of that statement is largely reliant upon the definition of the word "ready." Yet it is generally unclear what it means to be ready. Ready for what? How ready? By when? To address this problem, we recommend the DoD adopt a simple, interpretable, and actionable data framework using stochastic scenario libraries. If implemented by the military, such a framework could allow mathematically coherent readiness estimates to better communicate "how ready for what" combinations of military assets are. Additional details can be found in MOR Journal 2021 Vol. 26, #1, "Military Readiness Modeling: Changing the Question from 'Ready or Not?' to 'How Ready for What?

2 - Hybrid Supplier Risk Assessment and Identification Methodology for the Defense Industry
Isabella Sanders, United States

This paper aims to present a supplier risk identification and assessment framework that rigorously examines the financial outlook of firms and their respective plants, focusing on disruption and disaster risk factors. This hybrid data-driven risk analysis methodology is practical to implement and can be used proactively by firms to improve the stability of their supplier base through risk assessment and reduction.

■ TD38

CC Room 210D

In Person: Blockchain in OM

General Session

Chair: Dmitrii Sumkin, INSEAD, Singapore, 138676, Singapore

1 - Pricing in Service Platforms: Who Should Set the Prices?
Tolga Dizdarer, Wharton School of Business, Philadelphia, PA, 19104-3615, United States, Gerard P. Cachon, Gerry Tsoukalas

Motivated by emergence of blockchain-based decentralized service platforms and Uber's recent driver-pricing practice in California, we investigate how a platform with large supply should set its fares when service providers are heterogeneous in costs. We use a stylized model to compare two prevalent methods in practice: platform-pricing, where the platform sets the prices for all servers, and server-pricing, where prices are defined by the competitive equilibrium of server decisions. We, then, compare these methods to an optimal contract.

2 - On the Financial Inclusion and Sustainability Benefits of Blockchain Adoption in Agriculture
Basak Kalkanci, Georgia Institute of Technology, Atlanta, GA, 30308-1149, United States, Saed Alizamir, Foad Iravani

An emerging financial innovation enabled by the Blockchain technology in agricultural supply chains is the capability to "tip the farmers." This innovation empowers socially-conscious customers to identify the individual farmers of their sustainably-sourced products and reward them by sending them direct payments. We examine the implications of this new capability on farmers' and consumers' welfare, and agricultural firm profits. We find that tipping capability can make farmers and consumers worse off in expectation, or may increase income disparity among farmers.

3 - Optimal Cash Management with Payables Finance
Xiaoyue Yan, Cornell University, Ithaca, NY, United States, Li Chen, Xiaobo Ding

Payables finance provides a supplier with the option to receive a buyer's payables early while allowing the buyer to extend its payment due date. Its recent adoption of blockchain technology has made the process more efficient and secure. In this paper, we study the supplier's optimal cash management policy under such a "frictionless" payables finance arrangement, based on which we quantify the value of payables finance to the supplier and also determine the equilibrium payment term extension for the buyer. Our work extends the classic cash management models to allow all interest gains and costs to accrue together with the cash balance. Our analysis reveals that the optimal cash policy has a cash balance-dependent (L, M, U) structure. We show that it is the cash liquidity enabled by payables finance to hedge cash flow uncertainty that generates value to the supplier.

4 - Designing the Supply of Digital Collectibles Markets Using NFTS
Pavel Kireyev, INSEAD, 12 Boulevard Richard Lenoir, Paris, 75011, France, Dmitrii Sumkin, Serguei Netessine

Many organizations, such as Formula One and the NBA, issue digital collectibles traded on blockchain-based marketplaces to attract new customers. For some products, traders can create a limited number of new assets from the assets they already have. It affects reselling price and market liquidity and ambiguously impacts the expected gain from reselling. Given the recent growth of some markets and the rapid shutdowns of others, we find the optimal design of the market supply, where there is enough gain from trade and enough liquidity on the market. We estimate a structural model of trade of digital assets and infer how varying transaction costs, the possibility to create new collectibles from existing ones, and the production rate of the new collectibles affect the competition in the market, customer's surplus from trade, and the firm revenue.

■ TD39

CC Room 211A

In Person: Models to Inform Health Policy and Disease Control

General Session

Chair: Sze-chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States

1 - Inverse Fractionation In Radiotherapy
Archis Ghate, University of Washington, Seattle, WA, 98155-5917, United States

The objective in cancer radiotherapy is to maximize tumor-kill while limiting toxic effects of radiation dose on nearby organs-at-risk. Given a fixed number of treatment sessions, planners thus face the problem of finding a dosing sequence that achieves this goal. This is called the fractionation problem. Mathematical formulations utilize the linear-quadratic (LQ) framework to characterize radiation dose-response of tumors and organs-at-risk. The optimal dosing plan in this forward problem depends on the parameters of the LQ model. Unfortunately, these parameters are difficult to estimate. Current debates thus focus on the following question: what parameter values will make specific dosing plans effective? I will present an inverse optimization approach to answer this question.

2 - Optimizing Social Distancing Policies: A Dynamic Programming Approach for Coupled High and Low Risk Populations
Peng Dai, Industrial and System Engineering University of Southern California, Los Angeles, CA, United States, Sze-chuan Suen

Reducing transmission may be an effective way to control disease, but it is not clear when and who needs to social distance in a pandemic scenario, particularly when policies are allowed to change dramatically over time and population subgroup. We construct a Markov decision process model and build an age-stratified SEIR model to identify the optimal policy to maximize social utility for COVID-19. We compare our optimal policies across several regimes and assess differences in resultant utility, number of infections, and deaths over the time horizon. Our results show that the additional flexibility of policies varying over time and population could generate substantial utility gain.

3 - Finding the Optimal Screening Policy for Chronic Kidney Disease among Diabetics using a POMDP Framework

Chou-Chun Wu, University of Southern California, Los Angeles, CA, 90007-4221, United States, Sze-chuan Suen

The US CDC estimates that up to 90% of those with chronic kidney disease are undiagnosed, resulting in 30+ million unmanaged cases. To encourage timely diagnosis of at-risk patients, we develop screening guidelines stratified by age, proteinuria status, and prior test history among diabetics by race and gender. To do this, we adopt a Partially Observed Markov Decision Process (POMDP) framework to identify the optimal action (screen or wait) to take every three months from ages 30-85 that maximizes a patient's discounted lifetime net monetary benefit. We draw some of our POMDP model inputs from a microsimulation which estimates disease progression, lifetime quality-adjusted life years, and medical expenses. We find that the optimal policy recommends more frequent screening in all race and gender groups compared with the annual screening recommended in the status quo.

■ TD40

CC Room 211B

In Person: OR/MS in Industry Practice I

General Session

Chair: Daniela Aguilera, Sr. Manager Inventory Strategy and Optimization, AEO Inc, Pittsburgh, PA, United States

1 - Omni-channel Inventory Placement for Regional Fulfillment

Paulie Anne Williams, American Eagle Outfitters, PA, United States

As e-commerce business grows at an unprecedented rate, it is increasingly important for retailers to increase delivery speed to customers while minimizing shipping costs by balancing inventory in a multi-node network. At American Eagle Outfitters (AEO), we have found that optimal inventory placement across the network is challenging due to high variability of demand in the fashion industry, which reduces the effectiveness of even state-of-the-art predictive models. We will discuss how we decide assortment and stock levels in each node, as well as how we constantly re-balance inventory to respond to unpredictable demand and ensure regional fulfillment in our network.

2 - Prime Radiant: A System for Evaluating EVTOL Configurations and Vertiport Networks

Mike D. Prince, Archer Aviation, Seattle, WA, 76244, United States

Archer's mission is to advance the benefits of sustainable urban air mobility (UAM). Archer is creating the world's first electric airline that moves people throughout the world's cities in a quick, safe, sustainable, and cost-effective manner.Prime Radiant is a suite of in-house developed tools used to inform key strategic decisions related to Archer's business operating model. In this session we will discuss two core optimization models built for this purpose — one for determining vertiport network design in a given city and a fleet routing optimization model used to evaluate vehicle size and configuration.

3 - How Inventory Segmentation and Being Agile Adjusting Inventory Policies Can Leverage Your Supply Chain Performance

Daniela Aguilera, Sr. Manager Inventory Strategy and Optimization, AEO Inc, Pittsburgh, PA, United States

In 2020, American Eagle Outfitters (AEO) initiated an Inventory Productivity program. One of the pillars involved analyzing Inventory segmentation and evaluating legacy Inventory policies. The initiative shows how applying universal Inventory principles can be easily suited to any environment and help your supply chain organization remain adaptable and increasing working capital efficiency. Implementation challenges, change management, market changes, data issues as part of the roadmap. *How implementing Inventory Segmentation can help to determine proper Inventory policies *Using data to leverage Inventory optimization and adjust Inventory policies in a fast-changing RTL and E-comm environment *Monitor your Safety Stock Inputs to ensure proper days of inventory and optimize service levels. *Measuring and tracking Inventory productivity

■ TD41

CC Room 212A

In Person: Electrical Markets

Contributed Session

Chair: Santiago Maiz, CIUDAD REAL, 13071, Spain

1 - Computation of Convex Hull Prices using Dantzig-wolfe Decomposition

Panagiotis Andrianesis, Boston University, Brookline, MA, United States, Dimitris Bertsimas, Michael C. Caramanis, William W. Hogan

Several US ISOs have recently considered Extended Locational Marginal Prices as approximation to Convex Hull (CH) prices, mainly because determining exact CH prices is computationally challenging, while providing little intuition about the price formation rationale. We describe the CH price estimation problem by relying on Dantzig-Wolfe decomposition and Column Generation as a tractable, highly parallelizable, and exact method, with finite convergence, which provides intuition on the underlying price formation rationale. We provide several stylized examples and realistic ISO-scale datasets to support scalability and validate proof-of-concept.

2 - Variable Renewable Generation Participation in U.S. Ancillary Services Markets

James Hyungkwan Kim, Lawrence Berkeley National Laboratory, Berkeley, CA, United States, Fredrich Kahrl, Andrew Mills

Rising penetrations of variable renewable generation (VRG) are reducing VRG value and creating new challenges for system operators. Enabling VRG participation in ancillary services (AS) markets could provide additional revenue and allow system operators to access lower-cost integration solutions. Using profit-maximizing dispatch against 2015-2019 energy and AS prices in all seven U.S. ISOs/RTOs, we found that the average incremental value of AS market participation to hybrid (storage-paired) VRG owners is significantly higher than for standalone VRG. The value to system operators can be high, suggesting the need to consider expanding eligibility to participate in AS markets.

3 - Expansion Planning of a Price-maker Virtual Power Plant in Energy And Reserve Markets

Santiago Maiz, Universidad de Castilla-La Mancha, Ciudad Real, Spain, Raquel García-Bertrand, Luis Baringo

We address the expansion planning problem of a virtual power plant (VPP) considering the possibility of building new assets such as conventional, renewable, and storage units. The VPP is modeled as a price-maker player that participates in energy and reserve markets altering the prices of these markets to its own benefit. Uncertainties in production levels of renewable units and up/down reserve deployment requests are addressed using a stochastic programming approach. Numerical results show the influence of the behavior of the VPP in the expansion decisions.

■ TD42

CC Room 212B

In Person: Energy Policy and Planning

Contributed Session

Chair: Carlos Olivos, Auburn University, Auburn, AL, 36830, United States

1 - Co2 Infrastructure Planning for Fossil- and Bio-energy with Carbon Capture and Storage

Emma JAGU, IFP School, Rueil-Malmaison, France, Olivier Massol

BioEnergy with Carbon Capture and Storage (BECCS) is a critical technology to limit global warming. However, its up-scaling requires the installation of a costly CO2 transportation infrastructure, which will likely be shared between BECCS plants and fossil Carbon Capture and Storage (CCS) plants. We examine the conditions for the deployment of such an infrastructure using an adapted cooperative game theoretic framework. We then apply this model to a contemporary project in Sweden. Our results support pragmatic policy recommendations to organize the deployment of the BECCS technology.

2 - Sensitivity Analysis of the Market Penetration in China's Passenger Vehicle Market Through Monte Carlo Method

Mohamed Ali Saafi, Lab Scientist, Aramco Services Company, Novi, MI, United States, Shiqi Ou, Zhenhong Lin, Xin He

This study uses the python version of the New Energy and Oil Consumption Credits (NEOCC) model a tool integrated consumer discrete choice and optimization methods to quantify the impact of fuel price, battery cost, markup and fast-charging power on the electric vehicle market success as well as the industry profit in 2020-2050. Through integrating the Monte Carlo Simulation, it tests the robustness of the NEOCC model, and highlights the parameters that could affect the market penetration projection. The results show that markup affects the market the most, while the market becomes more sensitive to the fuel price and battery cost after 2035 which is explained by less policy constraints.

3 - Economic Analysis Approach to Critical Infrastructure Resiliency Investment

Jeffrey Lineberry, University of Oklahoma Gallogy College of Engineering, Annapolis, MD, 21402, United States

Critical infrastructure resiliency is an imperative global concern. The consideration of critical infrastructure interdependencies complicates the identification of resilience optimality. Many nations are faced with budgeting constraints and the need to optimally determine infrastructure resilience investment. The ability to identify critical infrastructure essential node vulnerability is paramount to decision makers. Determining overall economic impacts associated with critical infrastructure disruptions is a desirable approach. Real data consisting of Sweden's rail network, power supply network, and associated economic commodity data is implemented in a tri-level model approach utilized to pinpoint vulnerability considering critical infrastructure interdependencies. This Defender-Attack-Defender model representative of vulnerability reductions, network disruptions, and recoverability enhancements is used to determine vital interdependent nodes associated with the rail and power supply networks. The analysis from this model gives insight into associated economic impacts, thus providing the framework necessary to link economic sectors to critical infrastructure interdependencies in order to determine optimal resilience investment. This model results in an overall ability to guide resilience investment based on overall economic sector considerations.

4 - Stochastic Unit Commitment Problem, An Analytical Approach

Carlos Olivos, Auburn University, Auburn, AL, United States, Jorge F. Valenzuela

The stochastic unit commitment problem has been modeled using different approaches such as scenario generation, chance-constrained, and robust optimization. These methods tend to provide conservative solutions resulting in higher dispatching and commitment costs. We propose an analytical formulation of the expected dispatch and commitment costs resulting from the probability distribution function of the random load. The model is linearized through a piece-wise linear approximation and solved as a Mixed Integer Linear Program (MILP). The solution is verified by simulating and computing analytically the expected cost. Results, algorithms, and conclusions will be presented.

■ TD43

CC Room 213A

In Person: Statistical Learning for Decision Analytics in Complex Systems

General Session

Chair: Victoria C. P. Chen, The University of Texas at Arlington, Arlington, TX, 76019-0017, United States

1 - Machine Learning Framework Fornonlinear and Interaction Relationships Involving Categorical and Numerical Features

Shirish Rao, University of Texas-Arlington, Arlington, TX, 76019, United States, Victoria C. P. Chen, Jay Michael Rosenberger, Shouyi Wang, Atefe Makhmalbaf

Certain applications like sustainability assessment in green building have a mix of categorical and numerical features. The relation between response and features in these applications can be highly nonlinear in behavior. Moreover, interactions between features impact sustainability metrics, and addressing interaction modeling for this mix of feature types is another challenge. While some of these challenges have been addressed individually in the literature, there is no methodology which handles these complexities simultaneously. We propose a method combining multivariate adaptive regression splines with group LASSO to screen relevant features and model terms. Using experimental design, we uncover causal understanding and show that models fitted with our methodology have improved prediction capability

2 - Lasso Based State Transition Modeling with Interactions in Adaptive Interdisciplinary Pain Management

Amith Viswanatha, University of Texas-Arlington, Arlington, TX, 76013, United States, Victoria C. P. Chen, Jay Michael Rosenberger

The McDermott Center for Pain Management at The University of Texas (UT) Southwestern Medical Center at Dallas provides a two-stage interdisciplinary pain management program, where a holistic, integrated approach is employed in treating patients with chronic pain to improve their pain outcomes. Patient data from the McDermott Center includes state variables related to the patient's past and current health, treatment history, and current treatments. It is important to identify the true underlying features and the interactions between the state and treatment variables for building state transition and outcome models that are employed within a two-stage stochastic programming-based treatment optimization. In this study, we evaluate different LASSO based interaction modelling approaches on a simulated case study in identifying the true features and interactions.

3 - Fast and Reliable Metamodeling of Large-scale Nonlinear Time-dependent Problems

Xinchao Liu, University of Arkansas, Fayetteville, AR, United States

This research proposes a reduced-order surrogate learning framework for nonlinear structural dynamics governed by unequivocal physics principles. Motivated by the nonlinear spatio-temporal surface displacement process due to aircraft-UAV collisions, this paper shows (i) how the reduced-order physics models (including physics of motion ,fundamental material laws and finite element framework) can be obtained from the Proper Orthogonal Decomposition; (ii) how the reduced-order physics models can be accelerated by gradient boosted ensemble trees; (iii) how the input (force) uncertainty in nature is incorporated into deterministic finite element results; and (iv) how the error is controlled and modelled for governing-equation-based reduced-order models."

Tuesday, 4:30PM-6:00PM

■ TE02

CC Ballroom B / Virtual Theater 2

Hybrid Location Models II

Sponsored: Location Analysis

Sponsored Session

Chair: Zvi Drezner, California State University-Fullerton, Fullerton, CA, 92834, United States

Co-Chair: Pawel J. Kalczynski, California State University-Fullerton, Fullerton, CA, 92834-6848, United States

1 - Computational Results for Primal and Dual Algorithms for the Min-Max Location Problem with Weighted Euclidean Distances in N-Dimensions

Mark Cawood, Clemson University, Clemson, SC, United States, Lin Dearing

Numerical results are presented for primal and dual algorithms for the min-max location problem with weighted distances. During each iteration, the algorithms use a search-path method, where the path is determined by the intersection of bisectors of a set of active points; complementary slackness is maintained for points on this path; primal feasibility is maintained for the primal algorithm; and dual feasibility is maintained for the dual algorithm. The step size is computed explicitly. Computational results are presented for each algorithm for up to 10,000 points, in up to 1000 dimensions.

2 - A Closed Form Solution for the K-centra Location Problem on an Unbalanced Binary Tree

Trevor Hale, Mays Business School, College Station, TX, United States, Ryan Pepper, Faizul Huq

This research delineates a heuristic that solves the k-centra location problem on a unbalanced binary tree. This treatise differs from most location research in that we employ a novel, graph theoretic based k-centra approach that seeks to find the location that minimizes the sum of the distances to the k furthest existing facilities. The k-centra problem generalizes the classic minimax and minisum location problems: If k = 2, the problem reduces to the center (minimax) location problem; whereas if k = n, the problem reduces to the median (minisum) location problem. This research has direct application to the location of a distribution center on a simple origin-to-destination distribution network to improve service levels.

3 - Obnoxious Facility Location: The Case of Weighted Demand Points

Atsuo Suzuki, Nanzan University, Dept of Systems and Mathematical Sciences, Nagoya, 466-8673, Japan, Pawel J. Kalczynski, Zvi Drezner

The problem considered in this paper is the weighted obnoxious facility location in the convex hull of demand points. The objective function is to maximize the smallest weighted distance between a facility and a set of demand points. Three new optimal solution approaches are proposed. Two variants of the "Big Triangle Small Triangle" global optimization method, and a procedure based on intersection points between Apollonius circles. We also compared the results with a multi-start approach using the non-linear multi-purpose software SNOPT. Problems with 1,000 demand points are optimally solved in a fraction of a second of computer time.

4 - The Obnoxious Facilities Planar P-median Problem with Variable Sizes

Pawel J. Kalczynski, California State University-Fullerton, Fullerton, CA, 92834-6848, United States, Zvi Drezner

The obnoxious facility location problem is to locate facilities that have a negative impact on communities (being "obnoxious"), and being farther from communities is preferred. However, such facilities also serve the communities. Our goal is to minimize the system's operating cost subject to a minimum distance requirement from communities. The multiple obnoxious facility problem is usually defined as locating several facilities maximizing the minimum distance between facilities and communities. However, not all facilities have the same impact on communities. We assume that the size of a facility depends on the volume of service provided by it. The problem is extremely non-convex. We designed a special starting solution for non-linear solvers that provides a much better objective (in some cases cutting it by half) in a very small fraction of the run time.

■ TE03

CC Ballroom C / Virtual Theater 3

Hybrid Data Mining in Networks

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Sulyun Lee, The University of Iowa, Iowa City, IA, 52240, United States

1 - HIPED: Heterogeneous Interaction-based Dynamic Embedding of Patients

Hankyu Jang, University of Iowa, Iowa City, IA, 52246, United States, Sulyun Lee, Hasib Hasan, Sriram Pemmaraju, Bijaya Adhikari

Representation learning of patients gained attention recently due to its applicability in meaningful prediction tasks in the healthcare setting. In this work, we propose Heterogeneous Interaction-based Dynamic Embedding of Patients (HIDEP), an unsupervised embedding approach that learns latent representations of patients from their temporal, heterogeneous interactions at hospitals. We model patient interaction with medications, doctors, and rooms over time during the course of their inpatient visit to the hospital. We evaluate the learned patient embeddings on various prediction tasks such as early detection of healthcare-associated infection, patient transfer into medical intensive care unit, mortality risk prediction, and severity risk prediction. Our results show that HIDEP outperforms the state-of-the-art methods in all the prediction tasks.

2 - Predicting NFL Team Performance via Hierarchical Team Embeddings

Sulyun Lee, University of Iowa, Iowa City, IA, 52240, United States, Kang Zhao, Changze Han

Collaboration is a fundamental part of teams where individuals form groups to reach the common goals of assigned tasks. In networks such as academic collaboration networks, sports teaming networks, or online gaming networks, exploring the aspects of collaborations is essential in predicting team performances. This work focuses on collaborations of coaches in NFL teams, which is the American professional football leagues. We observed the collaborations among coaches in the same team and proposed a model that predicts the team performance given the coach information and collaborations. Specifically, we focused on the hierarchical collaborations among the NFL coaches, where coaches are at different levels in the command structures.

3 - Understanding the Spread of Misinformation on Social Media - the Effects of Topics and a Political Leader's Nudge

Xiangyu Wang, University of Iowa, Iowa City, IA, 52246-5104, United States, Min Zhang, Weiguo Fan, Kang Zhao

The spread of misinformation on social media has become a major societal issue. In this work, we used the ongoing COVID-19 pandemic as a case study to investigate factors associated with the spread of multi-topic misinformation based on the Heuristic-Systematic Model. Among factors related to systematic processing of information, we showed that the topics of a misinformation story matter, with conspiracy theories being the most likely to be retweeted. As for factors related to heuristic processing of information, when citizens look up to their leaders during such a crisis, our results demonstrated that behaviors of a political leader, former U.S. President Donald Trump may have nudged people's sharing of COVID-19 misinformation. Outcomes of this study help social media platform and users better understand and prevent the spread of misinformation on social media.

4 - Firm Profiling and Competitiveness Assessment: A Heterogeneous Occupation Network Embedding Approach

Howard Zhong, ESCP Business School, Paris, France, Chaunren Liu

Extensive efforts have been made by both academics and practitioners to understand interfirm competitiveness due to its profound significance in multiple key business objectives. However, it is not an easy task to fully depict the landscape of competitiveness owing to its heterogeneity, multiformity, and dynamicity. To mitigate these issues, we design a novel firm profiling and competitiveness assessment system following the structured procedure defined by Information System Design Theory (ISDT). The efficacy and competency of our proposed system are validated by performance comparisons of multiple models in different settings as well as by formal statistical testing analyses. Overall, our solutions shed new light on interfirm competitiveness assessment problem and are potentially beneficial to academic scholars as well as practitioners and decision makers.

■ TE04

CC Ballroom D / Virtual Theater 4

Hybrid Methodological Advances in MINLP

Sponsored: Computing Society

Sponsored Session

Chair: Aleksandr Kazachkov, University of Florida, FL "

1 - Formulations Comparison for Piecewise Convex Relaxation of the Sequential Convex MINLP Method

Claudia D'Ambrosio, LIX, CNRS, École Polytechnique, Institut Polytechnique de Paris, Route de Saclay, Palaiseau, France, Antonio Frangioni, Claudio Gentile, Renan Spencer Trindade

The Sequential Convex Mixed Integer Non Linear Programming (SC-MINLP) method is an exact approach to solve problems with non convexities arising in separable functions. It is based on lower and upper bounds computed by solving a sequence of piecewise convex relaxations and non convex restrictions, respectively. In this talk, we focus on the comparison of different ways to formulate the piecewise convex relaxations, inspired by classic piecewise linear approximations. While in the linear case the continuous relaxations of the formulations are equivalent, this is not true for the convex case. Computational results on a few classes of problems are presented as proof-of-concept.

2 - Intersection Cuts for QCQPs via Maximal Quadratic-free Sets

Gonzalo Munoz, Universidad de O'Higgins, Rancagua, 2820000, Chile, Antonia Chmiela, Felipe Serrano

The generation of strong linear inequalities for QCQPs has been recently tackled by a number of authors using the intersection cut paradigm a highly studied tool in integer programming whose flexibility has triggered these renewed efforts in non-linear settings. In this talk, we consider intersection cuts using the recently proposed construction of maximal quadratic-free sets. We describe the construction of these sets and show how to obtain closed-form formulas from them to compute intersection cuts using an arbitrary quadratic inequality being violated by a vertex of an LP relaxation. We evaluate this approach with extensive computational experiments.

3 - Solving the Pooling Problem at Scale with Extensible Quadratic Optimizer Galini

Ruth Misener, Imperial College London, South Kensington Campus, London, United Kingdom, Francesco Ceccon

GALINI is an open source solver for non-convex quadratic optimization problems formulated with Pyomo. We have also built a Python library to model pooling problems, a class of network flow problems with many engineering applications. We demonstrate GALINI's extensible characteristics by using the pooling library to develop two GALINI plug-ins: 1) a cut generator plug-in that adds valid inequalities in the GALINI cut loop and 2) a primal heuristic plug-in that uses the mixed-integer linear restriction. We show that, thanks to the good upper bound provided by the mixed-integer linear restriction and the good lower bounds provided by the convex relaxation, GALINI obtains optimality gaps competitive with Gurobi 9.1 on large instances.

4 - Quantum-inspired Formulations for the Max K-cut Problem

Ramin Fakhimi, Lehigh University, Bethlehem, PA, 18015, United States, Hamidreza Validi, Illya V. Hicks, Tamás Terlaky, Luis F. Zuluaga

The max k-cut problem is a challenging combinatorial optimization problem with multiple well-known optimization formulations. However, its mixed-integer linear optimization (MILO) formulations and mixed-integer semidefinite optimization formulation are all time-consuming to be solved. Motivated by recent progress in classic and quantum solvers, we study a binary quadratic optimization (BQO) formulation and two quadratic unconstrained binary optimization (QUBO) formulations. First, we compare the BQO formulation with the MILO formulations. Further, we propose an algorithm that converts any feasible fractional solution of the BQO formulation to a feasible binary solution whose objective value is at least as good as that of the fractional solution. Finally, we find tight penalty coefficients for the proposed QUBO formulations.

■ TE06

CC Room 303A

In Person: Community-Based Operations Research

General Session

Chair: EunSu Lee, New Jersey City University, Jersey City, NJ, 07304-4048, United States

Co-Chair: Michael P Johnson, University of Massachusetts Boston, Boston, MA, 02125-3393, United States

1 - Procurement Policies for Emergency Relief Operations
Mahyar Eftekhar, Arizona State University, Tempe, AZ, 85287-4706, United States, Scott Webster

The aftermath of rapid-onset disaster is a chaotic period when emergency responders' goal is to distribute critical items at the fastest possible time. This study proposes a few policies to minimize supply—demand mismatch in presence of multiple sources of uncertainty, and demonstrates the value of emergency funds.

2 - Designing a Community-engaged Learning Using Public OR
EunSu Lee, Ph.D., New Jersey City University, Jersey City, NJ, 07311, United States

This presentation discusses the community-engage learning (CEL) using the public OR. The case studies will be presented and introduce a sample syllabus and student project. The key takeaways include how to design CEL utilizing the public OR, lessons learned from the cases, and things to consider. The audience will be able to actively participate in the discussion during the presentation.

3 - Robust Multi-stakeholder Preference Elicitation and Aggregation for Treatment Prioritization During the Covid-19 Pandemic
Caroline Johnston, University of Southern California, Los Angeles, CA, 90007, United States, Simon Blessenohl, Phebe Vayanos

During the COVID-19 pandemic, triage committees must make ethically difficult decisions that are complicated by diverse stakeholder interests. We propose an automated approach to support group decisions by recommending a policy to the group a compromise between potentially conflicting individual preferences. To identify a policy to best aggregate individual preferences, our system elicits preferences by asking a moderate number of strategically selected queries, each taking the form of a pairwise comparison posed to a specific stakeholder. We propose a novel multi-stage robust optimization formulation of this problem. Formulating this as an MILP, we evaluate our approach on the issue of recommending policies for allocating ICU beds to patients with COVID-19. We show that our method recommends a policy with higher utility than various methods from the literature.

■ TE07

CC Room 303B

In Person: Novel Behavioral Models in Social Networks

General Session

Chair: Tauhid Zaman, Yale University, Boston, MA, 02114, United States

1 - Social Media Sentiment and Cryptocurrencies
Khizar Qureshi, MIT, San Francisco, CA, 94104, United States

We conduct a study of social media activity surrounding cryptocurrencies. We collect tweets from Twitter for multiple cryptocurrencies. We also construct measures to quantify the sentiment of the tweets using transformer neural networks. We model social media interactions surrounding tweets of the coin and then fit a Poisson Regression to this data and use the estimated model parameters to construct features that quantify the virality of the coin and its long-term potential for growth. Finally, we attempt to predict which coins have massive future price movements using these virality features.

2 - The Impact of Bots in the (First) Impeachment of Donald Trump
Michael J. Rossetti, Adjunct Professor, Georgetown University, Washington, DC, United States, Tauhid Zaman

We study manipulation of the social media discussion surrounding the first impeachment of U.S. President Donald Trump by automated accounts, known as bots. Our dataset includes 50 million posts from 2.7 million Twitter users, covering a 60 day period from impeachment to acquittal. We identify 24,000 bots using an algorithm based on the Ising model from statistical physics. Analysis shows the bots are 100 times more active than normal users, and their follower network structure is polarized along political lines. Language analysis shows pro-Trump bots using terms related to the Qanon conspiracy theory. After quantifying bot impact using a network centrality measure we developed known as generalized harmonic influence centrality, we find that although pro-Trump bots are more numerous and active than anti-Trump bots, the anti-Trump bots have a larger daily impact.

3 - Inviting Celebrities to Live Commerce: More Sales or More Returns?
Qi Yan, University of California, Irvine, Irvine, CA, United States, L. Robin Keller

Live commerce, a new popular way of shopping, is a combination of e-commerce and live streaming. Professional sellers introduce and make sales of products during live streaming. Sometimes, they invite celebrities to join the live video stream because of various reasons. Fans of the celebrities will follow the stream and make purchases in real time to validate their popularity. The large flow to the streaming channel helps the streamer become more acknowledged. However, more returns may occur after the event because of the cancellations of transactions from the fans. The net effect of inviting celebrities joining live commerce and how fit they are to the products need to be examined.

■ TE08

CC Room 303C

In Person: Applications of Markov Decision Processes

General Session

Chair: Daniel F Silva, Auburn University, Auburn, AL, 36849, United States

1 - Analysis of Overdiagnosis in Cervical Cancer Screening Using an Incidence-based Personalized POMDP
Raha Akhavan, Sabanci University, Istanbul, Turkey, Malek Ebadi

Population level screenings with a fixed frequency assumes homogeneity of the patients in different risk factors. This assumption causes unnecessary screenings and follow ups and impose considerable burden on the patients and healthcare systems. In this study, we consider different cohorts of patients with different prevalence and age-specific incidence rate of the infection, and aim to study the overdiagnosis of cervical infections and low grade lesions using a POMDP model tailored to incorporate incidence rate for each cohort. Our primary analysis confirms the presence of overdiagnosis in low and medium risk cohorts.

2 - Revisiting Linear Programming to Solve Markov Decision Processes under the Long-run Average Reward Criterion
Daniel F. Silva, Auburn University, Auburn, AL, 36849, United States

We compare the computational performance of Linear Programming and the Policy Iteration Algorithm for finding optimal solutions to discrete time, infinite-horizon, unichain Markov decision processes under the long-run average reward criterion. We compare the computational performance of the linear programming method and the policy iteration algorithm over test instances with varying sizes of state space, action space, as well as different sparsity and structure of the transition probability matrices. The results of our experiments show that linear programming methods are faster than the policy iteration algorithm for problems with relatively small action spaces and large state spaces, while the policy iteration algorithm is faster for problems with small state spaces and large action spaces.

■ TE09

CC Room 303D

In Person: Recent Advances in Load Balancing

General Session

Chair: Martin Zubeldia, Eindhoven University of Technology, Eindhoven, 5611 SJ, Netherlands

1 - Load Balancing System in the Many-server Heavy-traffic Regime
Daniela Hurtado Lange, Georgia Institute of Technology, GaTech, Atlanta, GA, United States

We study the load balancing system in the many-server heavy-traffic regime. We consider a system with N servers, and we parametrize the arrival rate so that the arrival rate per server is N-a, where a>0 is a parameter that represents how fast the load grows with respect to the number of servers. In this talk, we show conditions on a so that the average queue length scaled by N1-a behaves similarly to the classical heavy-traffic regime. We provide two proofs to our result: one based on Transform methods and one based on Stein's method. In the second proof, we also compute the rate of convergence in Wasserstein's distance. We additionally compute the rate of convergence in expected value. All of our proofs are powered by state space collapse.

2 - Job Dispatching Policies for Queueing Systems with Unknown Service Rates

Weina Wang, Carnegie Mellon University, Pittsburgh, PA, United States

In multi-server queueing systems where there is no central queue holding all incoming jobs, job dispatching policies are used to assign incoming jobs to the queue at one of the servers. Classic job dispatching policies such as join-the-shortest-queue and shortest expected delay assume that the service rates and queue lengths of the servers are known to the dispatcher. In this work, we tackle the problem of job dispatching without the knowledge of service rates and queue lengths, where the dispatcher can only obtain noisy estimates of the service rates by observing job departures. This problem presents a novel exploration-exploitation trade-off between sending jobs to all the servers to estimate their service rates, and exploiting the currently known fastest servers to minimize the expected queueing delay. We propose a bandit-based exploration policy that learns the service rates from observed job departures. Unlike the standard multi-armed bandit problem where only one out of a finite set of actions is optimal, here the optimal policy requires identifying the optimal fraction of incoming jobs to be sent to each server. We present a regret analysis and simulations to demonstrate the effectiveness.

■ TE10

CC Room 304B

In Person: AI for Cybersecurity

General Session

Chair: Tung Cu, Northeastern Illinois University, Chicago, IL, 60625-4625, United States

1 - How we Browse: Measurement and Analysis of Digital Behavior

Yuliia Lut, Columbia University, New York, NY, United States, Michael Wang, Elissa Redmiles, Rachel Cummings

In this work, we design and conduct a user study to collect browsing data ($n=31$) continuously for 14 days and self-reported browsing patterns. We combine self-reports and observational data to provide an up-to-date measurement study of online browsing behavior. We use these data to empirically address the following questions: (1) Do structural patterns of browsing differ across demographic groups and types of web use?, (2) Do people have correct perceptions of their behavior online?, and (3) Do people change their browsing behavior if they are aware of being observed? In response to these questions, we find significant differences in level of activity based on user age, but not based on race or gender. We also find that users have significantly different behavior on Security Concerns websites, which may enable new behavioral methods for detection of security concerns online.

2 - AI-Driven Cybersecurity: An Assessment of Cybersecurity Defense Systems

Tung Cu, Northeastern Illinois University, Chicago, IL, 60625-4625, United States

Cybersecurity is simply classified into four popular categories including Data Security, Information Security, Network Security, and Internet/IoT Security. To solve these cybersecurity problems, people usually use popular AI techniques involving machine learning and deep learning methods, the concept of natural language processing, knowledge representation and reasoning, as well as the concept of knowledge or rule-based expert systems modeling. Based on these AI methods, in this paper, I present a comprehensive assessment on how these AI Cybersecurity methods can play an important role in cybersecurity defense systems. In conclusion, I also highlight several research directions within the scope of our study, which can help researchers do future research in the area.

■ TE13

CC Room 201A

In Person: Parameter Optimization in Modeling and Complex Systems

General Session

Chair: Mayank Kejriwa, University of Southern California, CA, University of Southern California, CA

1 - Identifying Climate Action Language in News to Predict Firm Environmental Performance

Nima Safaei, University of Iowa, Iowa City, IA, United States, Gautam Pant

Firms are increasingly engaged in meaningful actions to mitigate climate change effects and reduce greenhouse gas (GHG) emissions. Information on a firm's actions to address environmental challenges, i.e., its environmental performance is critical to its stakeholders (e.g., investors, consumers, government, community). However, the currently available data about firms' climate actions[1] is sparse and unreliable. Hence, there is a gap between the importance of firms' climate action data and the availability of such data to their various stakeholders. To close this gap, we develop a textual model using machine learning to derive a climate action vocabulary. The vocabulary is subsequently used for measuring the extent to which news stories about a firm are related to climate action. Specifically, we propose several text-based metrics that capture the intensity of media attention on climate action related to a given firm. We validate the effectiveness of our methodology for deriving the climate action vocabulary and the proposed text-based metrics by demonstrating that they effectively predict the future environmental performance of firms.

2 - Building Domain-specific Knowledge Graphs from Text

Mayank Kejriwal, University of Southern California

Domain-specific knowledge graph (KG) construction is an active and interdisciplinary research area that has recently witnessed impressive advances due to machine learning techniques like deep neural networks and word embeddings. Today, there is a vast amount of text data available, including text extracted from webpages, natural language documents, social media 'documents' such as tweets and memes, and even free-text descriptions in spreadsheets and CSV files. Constructing KGs over raw text data is a challenging problem that requires techniques from multiple fields, most notably Natural Language Processing. This talk will provide a high-level overview of KG construction from text, and promising directions for future research.

3 - Identifying User Needs from Online Reviews with Albert and a Cluster Based Algorithm

Yi Han, Northeastern University, Malden, MA, United States

Sentiment analysis has been widely applied in product design processes. Various rule-based and deep learning-based methods have been proposed in the literature to collect, analyze, and predict potential user needs from online reviews. Pre-trained language models like BERT are proven effective in different NLP tasks such as sentiment classification with over 90% accuracy. This paper utilizes ALBERT, a light improved version of BERT, with integrated domain knowledge and syntax rules to identify user needs from unstructured reviews. The ALBERT model achieves a 91.3% F1 score on a large review dataset. A cluster-based algorithm has been designed for the post-training of the model.

4 - Quantifying Risks of Food Insecurity by Analyzing the News

Ananth Balashankar, Ph.D Candidate, New York University, New York, NY, United States, Samuel Fraiberger, Lakshminarayanan Subramanian

Existing food security early warning systems rely on sparse data, usually available with a considerable lag, impeding the efficacy of humanitarian efforts. In this work, we propose a novel framework to extract early indicators reported in news articles, which are both causally grounded and highly predictive of food insecurity events. Using predictive causal early indicators from news, we reduce the error in forecasting the average Famine Early Warning System rating in 20 fragile states by 37% as compared to using on-the-field data alone. Analyzing news from 30 years, we also show that early detection of certain social and political causes of famine, improves the AUC-PR of crisis events by 20%.

■ TE14

CC Room 201B

In Person: Machine Learning for Spatio-temporal Data Modeling and Analysis

General Session

Chair: Shixiang Zhu, Georgia Institute of Technology, Atlanta, GA, 30318-2990, United States

1 - Equivariant Neural Networks for Learning Spatiotemporal Dynamics

Robin Walters

Applications such as climate science and transportationrequire learning complex dynamics from large-scale spatiotemporal data.Existing machine learning frameworks are still insufficient to learnspatiotemporal dynamics as they often fail to exploit the underlyingphysics principles. Representation theory can be used to describe andexploit the symmetry of the dynamical system. We will show how to designneural networks that are equivariant to various symmetries for learningspatiotemporal dynamics. Our methods demonstrate significantimprovement in prediction accuracy, generalization, and sampleefficiency in forecasting turbulent flows and predicting real-worldtrajectories. This is joint work with Rose Yu, Rui Wang. and Jinxi Li.

2 - An Adaptive Sampling Strategy for Online Monitoring and Diagnosis of High-dimensional Streaming Data

Kamran Paynabar, ISyE Georgia Tech, Georgia Tech, H. Milton Stewart School of Isye, Atlanta, GA, 30332-0205, United States

This research proposes an adaptive sampling strategy for online monitoring and diagnosis of high-dimensional streaming data. It integrates two novel ideas: (i) the recursive projection of the high-dimensional streaming data onto a low-dimensional subspace to capture the spatio-temporal structure of the data while performing missing data imputation, and (ii) the development of an adaptive sampling scheme, balancing exploration and exploitation.

■ TE17

CC Room 202A

In Person: Game Theory

Contributed Session

Chair: Krista J. Li, Indiana University, Bloomington, IN, 47405, United States

1 - Social Welfare Maximization and Conformism via Information Design in Linear-quadratic-gaussian Games

Furkan Sezer, PhD Student, Texas A&M University- College Station, College Station, TX, United States, Hossein Khazaei, Ceyhun Eksin

We consider linear-quadratic-gaussian (LQG) games in which players have quadratic payoffs that depend on the players' actions and an unknown payoff-relevant state, and signals on the state that follow a Gaussian distribution conditional on the state realization. An information designer decides the fidelity of information revealed to the players in order to maximize the social welfare of the players or reduce the disagreement among players' actions. Leveraging the semi-definiteness of the information design problem, we derive analytical solutions for these objectives under specific LQG games.

2 - Illegal Fishing in Congested Maritime Environments

Michael M. Perry, George Mason University Volgenau School of Information Technology and Engineering, Fairfax, VA, United States

A maritime environment is modeled where two countries in close proximity must delineate fishing rights. Countries issue fishing quotas and its shown one can benefit significantly from issuing excessive quotas, inducing illegal fishing in the other's legal waters. The costs imposed by patrol craft serve as a way of deterring this behavior, but patrols can be offset by employing martial assets onboard fishing vessels, a phenomenon of increasing regularity. The cost-effectiveness of each of these measures is assessed. The paper concludes that even if the countries can agree to cooperative combat illegal fishing, the potentiality of illegal fishing will significantly alter the terms of such a deal.

3 - A Proof of the Optimality of the E-patrolling Strategy for the Continuous Patrolling Game

Thuy Bui, Rutgers Business School, Newark, NJ, United States, Thomas Lidbetter

We consider the continuous patrolling game introduced in Alpern et al. (2016). This is a zero-sum game between an Attacker, who attacks a network at a particular time and place, and a Patroller, who patrols the network with the aim of intercepting the attack. Recently, Alpern et al. (2020) conjectured that a patrolling strategy called the E-patrolling strategy is optimal for all tree networks, and they proved this to be true in some special cases. In this paper, we settle the conjecture by providing -optimal strategies for the Attacker. We also give precisely optimal Attacker strategies for some previously unsolved star networks.

4 - Product Innovation with Customer Recognition

Krista J. Li, Associate Professor, Indiana University, Bloomington, IN, United States

We examine how customer recognition affects brands' incentives to invest in product innovation. We find that when brands have similar equity, customer recognition increases brands' incentives to invest in product innovation. However, when brands have sufficiently different equity, customer recognition leads the stronger brand to invest more and the weaker brand to invest less in product innovation. In addition, customer recognition can increase the weaker brand's profit but decreases it more for the stronger brand. Thus, collecting customers' purchase history data for customer recognition can be beneficial for weaker brands but detrimental for stronger brands.

■ TE18

CC Room 202B

In Person: Advances in Mining

General Session

Chair: Alexandra M Newman, Colorado School of Mines, Golden, CO, 80401-1887, United States

1 - Characterizing Heat and Diesel Emissions in an Underground Mine for a Production Scheduling Model

Aaron Swift, BS, Colorado School of Mines, Golden, CO, 80401, United States

Current production scheduling models for underground mines do not consider real-time heat or emissions from diesel equipment, which can lead to unsafe conditions as heat or emissions accumulate in the working areas. Based on thermodynamic principles, this research develops a transient model for heat, emissions, and ventilation that can be infused into a short-term production scheduling model for near-term operational planning.

2 - Incorporating Ventilation, Heat, and Emissions in a Short-term Underground Mine Production Scheduling Model

John Ayaburi, MS, Colorado School of Mines, Golden, CO, 80401, United States

Mine planners utilize production schedules to determine when blocks of ore should be extracted. However, the accumulation of heat in an underground mine not only disrupts the schedule but also affects the health and safety of mine workers. We propose a large-scale, short-term production scheduling model that minimizes deviation between i) medium-and short-term schedules and ii) production goals. We correspondingly present novel techniques to improve the model tractability. Constraints such as precedence, mill and extraction capacities, heat, and diesel emissions are considered. The model produces a consistent schedule while ensuring the safety of the work environment.

■ TE19

CC Room 203A

In Person: Healthcare

General Session

Chair: Zilong Wang, Atlanta, GA, 30318, United States

1 - An Analysis of Incentive Schemes for Participant Retention in Clinical Studies

Xueze Song, University of Illinois-Urbana-Champaign, Champaign, IL, United States, Mili Mehrotra, Tharanga K. Rajapakshe

Patient retention is one of the critical issues that haunt clinical studies. This paper analyzes two interventions—incentive payment and effort—and identify their optimal combination for retaining desired number of participants. Also, we examine several commonly observed payment schemes in practice and compare their relative performances under different settings.

2 - Regret Analysis for Adaptive Model Predictive Control

Ilgin Dogan, Ph.D. Candidate, University of California, Berkeley, Berkeley, CA, 94707-2017, United States, Zuo-Jun Max Shen, Anil Aswani

The exploration/exploitation trade-off is an inherent challenge in data-driven and adaptive control. Though this trade-off has been studied for multi-armed bandits, reinforcement learning for finite Markov chains and linear control systems; it is less well-studied for adaptive control of nonlinear systems. A significant challenge in nonlinear setting is that there is no explicit characterization of an optimal policy for a given set of parameters. We propose a new regret notion with respect to a finite-horizon oracle controller with full knowledge of parameters and develop a new class of learning-based policies in the context of adaptive model predictive control. We conduct statistical analyses to prove finite sample concentration bounds for the estimation step, and then we perform theoretical analyses to show the closed-loop stability and low regret of our policy.

3 - Estimating Heterogeneous Treatment Effects with Modern Mixed Integer Programming Formulations

Zilong Wang, Georgia Institute of Technology, Atlanta, GA, United States, Zhaowei She, Turgay Ayer, Shihao Yang

The recent data driven approach paradigm at identifying and solving problems has reignited interest amongst policy makers, businesses, and physicians in shifting away from a "one-size-fits-all" mentality to a more tailored approach. Estimating heterogeneous treatment effects (HTEs) is thus of great import in many fields such as personalized medicine, marketing, and policy evaluation. State of the art techniques, are either based on highly restrictive classifiers or too complex to interpret. In this paper, we unify and generalize these approaches under a Generalized Method of Moments (GMM) estimation framework, and formulate it as a Mixed Integer Program (MIP). This estimation framework presents a "best-of-both-worlds" approach which simultaneously achieves interpretability and flexibility in classification problems based on treatment effect heterogeneity.

■ TE20

CC Room 203B

In Person: Emerging Topics in Agricultural Supply Chains

General Session

Chair: Somya Singhvi, MIT, Cambridge, MA, 02139-4230, United States

1 - Yield Improvement Through Smallholder Farmer Certifications: Price and Profit Implications

Utku Serhatli, Nova School of Business and Economics, Lisbon, Portugal, Guillaume Roels

In agricultural-intensive economies, manufacturers often help smallholder farmers improve their yields through training and certification programs. However, and perhaps paradoxically, some farmers feel that these programs can lower their profit, in part due to a decrease in commodity prices. Using a Cournot model, we show that a) certification programs can push prices down, which may indeed decrease profits of some farmers, b) the objectives of minimizing market prices and protecting farmer well-being might be conflicting and c) certifying low-cost farmers performs well in terms of both individual and aggregate farmer well-being.

2 - Restricting Mobile Data Can Accelerate Digital Development Evidence From a Smartphone Experiment

Kamalini Ramdas, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, Alp Sungu

This paper identifies a significant and heretofore unnoticed barrier to digital development: data shortages. Low-income smartphone users in Mumbai who were randomly assigned to a data plan with daily usage caps increased late-plan access of WhatsApp invites to health camps, increased attendance at these camps, and reduced social media checking; without compromising sleep or subjective well-being. Our novel smartphone usage tracking app reveals why. Absent usage caps, participants binge on YouTube and social media, resulting in subsequent data shortages. Consequently, access to information significantly reduces later in a data plan. Participants with low self-control and high fear of missing out are more likely to prefer this data-saving mechanism, even at a higher price. Data caps present a non-obvious and inherently cost-saving path to alleviating poverty.

3 - Designing Payment Models for the Poor

Sasa Zorc, University of Virginia, Charlottesville, VA, United States, Bhavani Shanker Uppari

Some life-improving technologies for the poor are unaffordable to them, as their limited liquidity puts the purchase costs out of reach. Thus, business models have emerged where the consumers pay a fraction of price upfront to acquire the technology, and make a series of payments for continued access, at the end of which the ownership of the technology may be gained by the consumers. This offers flexibility to sometimes pay low/no amounts (alleviating cash constraints), and at the same time, disciplines consumers by remotely turning off the technology when they lag behind on payments (reducing default risk). Using the optimal contracting approach, we investigate the payment mechanisms that balance flexibility, discipline, and ownership incentives. Several implementable features that improve both the firm's profits and the consumers' welfare emerge from our analysis.

■ TE21

CC Room 204A

In Person: Equity and Social Justice in Health Care Operations

General Session

Chair: Michele Samorani, Santa Clara University, Santa Clara, CA, 95053, United States

Co-Chair: Amin Khademi, Clemson University, Clemson, SC, 29634, United States

1 - Fair Allocation Decisions in Multi-stakeholder Healthcare Scenarios

David Rea, Lehigh University, Bethlehem, PA, 45221-0211, United States, Leonardo Lozano, Craig Froehle

Healthcare is rife with difficult multi-stakeholder tradeoffs. Decisions have direct implications for the well-being of patients, providers, and healthcare systems. In such scenarios, inter-stakeholder fairness is a natural concern. Importantly, stakeholder groups are not monoliths. Individual patients and providers differ in their needs, preferences, and expectations. Simultaneously management of these intra-stakeholder and inter-stakeholder tradeoffs is further complicated by the discrete nature of healthcare allocation decisions. This research proposes a framework for incorporating fairness into algorithmic objectives. The generalizability of the framework is shown through examples from teleradiology and inter-hospital transport.

2 - Implicit Racial Bias in Healthcare Scheduling Delays

Michele Samorani, Santa Clara University, Leavey School Of Business, Santa Clara University, Santa Clara, CA, 95053, United States, Nan Liu, Shannon Harris, Haibing Lu

We show that the traditional objective of minimizing patients' waiting time and provider overtime leads to scheduling the patients at higher risk of no-show farther into the future than other patients. The reason is that by doing so, the clinic increases the show probability of the patients that are more likely to show up while decreasing the show probability of the patients that are less likely to show up. This strategy will consequently reduce the variability in number of shows, and ultimately decrease the schedule cost. However, because no-show probabilities are often correlated with race, this scheduling strategy results in unintended racial disparities in terms of access to care.

3 - Adaptive Design of Personalized Dose-finding Clinical Trials

Saeid Delshad, Clemson University, Clemson, SC, 29630, United States, Amin Khademi

A key step toward personalized medicine is redesigning dose-finding clinical trials and finding the right therapeutic dose for each patient type. This work studies a problem of fully response-adaptive Bayesian design of Phase II dose-finding trials with patient information, where the decision maker seeks to identify the right dose for each patient type by minimizing the overall expected variance of the target dose over all patient types. We formulate this problem by a SDP and exploit its properties. Since the optimal solution is intractable, we propose an approximate policy by an adaptation of a one-step look-ahead framework. We show the optimality and asymptotic rate of sampling of the proposed policy for a case with homogeneous patients and two doses. We also adapt other policies such as posterior adaptive sampling and test their performance against our proposed policy.

■ TE22

CC Room 204B

In Person: Healthcare Operations Management

General Session

Chair: Alex Mills, Baruch College, City University of New York, New York, NY, 10010-5585, United States

Co-Chair: Masoud Kamalahmadi, University of Miami, Bloomington, IN, 47405-1701, United States

1 - Optimization of Pediatric Vaccines Distribution Network Configuration under Uncertainty

Zahra Azadi, University of Miami Herbert Business School, Coral Gables, FL, 33158, United States, Sandra D. Eksioglu, Harry Neil Geismar

Millions of young people are not immunized in low- and middle-income countries because of low vaccine availability resulting from inefficiencies in cold supply chains. We create supply chain network design and distribution models to address the unique characteristics and challenges facing vaccine supply chains in these countries. The models capture the uncertainties of demand and the resulting impacts on immunization, the unique challenges of vaccine administration, the interactions between technological improvements of vaccines and immunizations, and the trade-offs between immunization coverage rates and available resources. The objective is to maximize the percentage of fully immunized children and the vaccine availability in clinics. We tested the model using Niger's Expanded Program on Immunization, which is sponsored by the World Health Organization.

2 - Telehealth Expansion and Patient Demand in Acute Care

Ozden Engin Cakici, American University, Washington, DC, 20016, United States, Alex Mills

Many healthcare providers have recently expanded telehealth services where patients can see a doctor online. In theory, increasing capacity of telehealth services should expand the provider's panel size because telehealth is more convenient, but the drawback of telehealth is that it may require a follow up visit for a physical exam. We model the patient's strategic choice for acute care among balking, telehealth, and walk-in office visit using a game theoretic model, as a function of the provider's capacity allocation to telehealth. We find that too much expansion of telehealth can decrease the provider's panel size, and we discuss policy implications that emerge from this result.

3 - Planning Follow-up Capacity to Reduce Hospital Readmissions

Alex Mills, Baruch College, City University of New York, New York, NY, 10010-5585, United States, Jonathan Eugene Helm

Many hospitals now schedule patients for follow-up care at the time of discharge, in an effort to reduce readmissions. Using analytical models and a case study with real hospital data, we show that careful capacity planning in a post-discharge follow-up program can increase the number of patients with timely follow-up appointments by about 30% without increasing the cost of the program.

■ TE23

CC Room 204C

In Person: Managing Behaviors in Healthcare/Behavior in Waiting Lines

General Session

Chair: Brett Hathaway, Johns Hopkins University, MD, 21784, United States

1 - Intra-day Dynamic Rescheduling under Patient No-shows
Aditya Shetty, University of Rochester, Rochester, NY, 14620-4436, United States, Henri Groenevelt, Vera Tilson

Existing work on appointment scheduling assumes that appointment times cannot be updated once they have been assigned. In this paper, we describe an intra-day dynamic rescheduling model that takes into account the observed no-shows and service times as the day goes on, to makes adjustments to subsequent appointment times. We find that, unlike optimal static schedules, optimal dynamic schedules do not follow some seemingly intuitive characteristics making it computationally intensive to solve the problem using brute force. We propose a more efficient approach to compute the optimal scheduling policy and find the conditions under which switching from static to dynamic scheduling is most beneficial.

2 - The Impact of Procedural Justice on Patient Flow in Hospitals
Galit Bracha Yom-Tov, Technion Israel Institute of Technology, Technion City, Haifa, 32000, Israel, Anat Rafaeli, Matias Kohn, Michal Medan

We investigate the impact of procedural justice in routing patients between ED and inpatient wards on patient LOS. Using diff-in-diff analysis we show a huge reduction (of more than 20%) in patient's LOS after implementing equalized routing. We investigate the mechanisms that drive this reduction.

3 - Personalized Priority Policies in Call Centers Using Past Customer Interaction Information
Brett Hathaway, Johns Hopkins University, Baltimore, MD, 21784, United States, Seyed Emadi, Vinayak V. Deshpande

We show how call centers can improve customer service using personalized priority policies, where managers use customer contact history to predict individual-level caller abandonment and redialing behavior and prioritize them based on these predictions to improve operational performance. We provide a framework for how companies can use individual-level customer history data to capture the idiosyncratic preferences and beliefs that impact caller abandonment and redialing behavior, and quantify the improvements to operational performance of these policies by applying our framework using caller history data from a real-world call center. We achieve this by formulating a structural model that uses a Bayesian learning framework to capture how callers' past waiting times and abandonment/redialing decisions affect their current abandonment and redialing behavior.

■ TE24

CC Room 205A

In Person: Emerging Topics in Technology and Innovation Management

General Session

Chair: Esma Koca, Imperial College London, London, SW10 9JH, United Kingdom

Co-Chair: Esma Koca, Imperial College London, London, SW10 9JH, United Kingdom

1 - Search in the Dark: The Normal Case
Manel Baucells, University of Virginia, Darden School Of Bus. Charlottesville, VA, 22903-1760, United States, Sasa Zorc

Search problems where the reward is equal to the highest sampled value are ubiquitous in real life. We tackle the important unresolved case of sampling from a normal distribution with unknown mean and unknown variance. We find that single threshold stopping rules—-prevalent to search theory—-are no longer optimal. Instead, the optimal stopping region consists of up to two bounded intervals. We may stop if the current value is near the previous sampling mean (a signal of low variance and reduced search profitability), or if it improves on the previous best (future samples must now exceed a higher hurdle to be of value), but not by much (very high or very low values signal high variance, and recommend more sampling). After two draws, it is optimal to discontinue search if the two draws are sufficiently similar.

2 - Managing Projects in Virtual Settings: Information Exchange Networks And Project Performance
Sukrit Pal, Doctoral Candidate, Michigan State University, East Lansing, MI, United States, Anand Nair

Projects are increasingly being managed in virtual settings where project team members collaborate online. Collaborative information exchanges among team members result in the creation of complex communication network that can have non-trivial influence on the outcome due to the asynchronous nature of these exchanges and the lack of visual and non-verbal cues. We examine the impact of communication network characteristics on the number of issues closed within an open source software (OSS) development project. Additionally, the study examines the role of project managers' active participation in these communication networks on project outcome. We analyzed a panel dataset comprising of 1842 OSS development projects spanning 104 weeks from the time of project initiation was carefully compiled for this research.

3 - Double Utilization of Consumer Appreciation: Is the Ecosystem Linkage the New Leverage?
Esma Koca, Imperial College London, London, United Kingdom, Robert Peach, Hang Ren

In this paper, we model the release of a new product category when two asymmetric firms engage in price and quality competition. The asymmetry is because one of the firm can strategically link a new good with a previous product category (ecosystem leverage). We examine whether the ecosystem leverage enables the ecosystem firm to keep its rival at bay or discourage firms to innovate in the new product category, as some industry experts argue. We conclude that the effect of the ecosystem leverage on its rival or the innovation is not necessarily adverse, but under some conditions, even facilitates the welfare of the rival.

■ TE25

CC Room 205B

In Person: Practical Optimization: What it Takes to Make Optimization Succeed in Real Life

General Session

Chair: Richard Oberdieck, Gurobi Optimization, Hvidovre, 2650, Denmark

1 - Deploying a Hybrid MILP Solution for Highly Complex Semiconductor Scheduling Problems
Semya Elaoud, Flexciton Limited, London, United Kingdom, Dionysios Xenos, Ioannis Konstantelos

Job scheduling in semiconductor factories is an NP-hard problem. It is a non-identical parallel machines job shop problem with secondary resources. Practical applications typically resort to the use of approximate techniques. Many factors render the use of MILP optimisation challenging: problem complexity, high uncertainty, multiple objectives. We present a novel solution strategy that combines MILP optimisation with heuristic techniques to schedule thousands of wafers. Flexciton has been deployed in semiconductor fabs and shown to outperform existing approaches. Using case studies we showcase how we can accommodate complex problem features and provide high quality schedules

2 - Tools and Processes for Rapid Prototyping of Optimization Applications
Richard Oberdieck, Gurobi Optimization, Nordlundsvej 27, Hvidovre, 2650, Denmark

Ideally, projects involving optimization start out with the business problem for which a decision strategy is needed. Based on this, a mathematical model is designed, implemented and validated against a set of test data, before it is encoded in an optimization application which solves the business problem.Unfortunately, most projects do not follow this path, for example due to complicated business logic, stakeholder management and data quality issues. Therefore, it is crucial to be able to iterate through each step quickly in order to quickly identify and resolve any blocking issues.In this talk, we will share some of the tools and processes used inside Gurobi that we have found to work well in these situations. In addition, we will provide recommendations to OR experts, developers and project managers on common pitfalls we see and several strategies on how to mitigate them.

■ TE26

CC Room 206A

In Person: Integer Programming and Combinatorial Optimization

General Session

Chair: David Bernal Neira, Carnegie Mellon University, Pittsburgh, PA, 15206-4367, United States

1 - Cross-dock Truck Scheduling with Workforce Constraint in Freight Transportation

Ritesh Ojha, PhD Student, ISyE Georgia Tech, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Alan Erera

Freight transportation companies operate cross-docking terminals to enable freight transfer between trailers throughout their consolidation network. This research addresses the integrated truck and workforce scheduling problem at unloading doors in a cross-dock. The objective is to minimize the total violation of fixed deadlines at the loading doors. We develop an optimization-based methodology, equipped with an iterative time refinement exact algorithm, for creating a timed schedule of trailer unloading activities with worker assignments. The algorithm solves small integer programs in each iteration to yield the optimal solution. A computational study demonstrates the utility of the model and effectiveness of the algorithm to solve practical instances based on data, representative of a large cross-dock, provided by our research partner.

2 - A Chance-Constrained Two-Echelon Vehicle Routing Problem With Stochastic Demands

Natasja Sluijk, Eindhoven University of Technology, Eindhoven, Netherlands, Alexandre Florio, Joris Kinable, Nico P. Dellaert, Tom Van Woensel

Two-echelon distribution systems are often considered in city logistics to maintain economies of scale and satisfy the emission zone requirements in the cities. In this work, we formulate the two-echelon vehicle routing problem with stochastic demands as a chance-constrained stochastic optimization problem, where the total demand of the customers in each second-echelon route should fit within the vehicle capacity with high probability. We propose two efficient solution procedures based on column generation. To ensure that the chance constraints are met, we use statistical inference techniques. Additionally, we employ feasibility bounds on the stochastic demands to reduce the number of times we have to verify the chance constraints. The results show the value of the stochastic formulation in terms of improved solution cost and guaranteed feasibility of the routes.

3 - Easily Solvable Convex MINLP Derived from Generalized Disjunctive Programming using Cones

David E. Bernal Neira, Carnegie Mellon University, Pittsburgh, PA, United States, Ignacio E. Grossmann

We model problems where discrete choices enforce convex constraints via Generalized Disjunctive Programs (GDP). GDP can be solved as MINLP through reformulations, eg the Hull reformulation (HR). We derive a convex GDP representation by modeling constraints in disjunctions with conic sets. These problems' reformulations can be efficiently tackled using solvers which take advantage of their conic structure. The HR of conic GDP is described exactly, leading to a tight formulation that avoids perspective function approximations. Our results, obtained from solving over 400 convex GDP arising from Process Systems Eng. and ML, show how the conic modeling of GDP leads to performance improvements.

■ TE27

CC Room 206B

In Person: Efficiency in Distributed ML Environments: Data Parallel, Model Parallel and Federated Learning Solutions

General Session

Chair: Liam Collins, Austin, TX, United States

1 - The Benefit of Heterogeneity in Collaborative Learning: Federated and Distributed Best-Arm Identification

Hamed Hassani, University of Pennsylvania, Philadelphia, PA, 19104, United States

We study a federated variant of the best-arm identification problem in stochastic multi-armed bandits: a set of clients, each of whom can sample only a subset of the arms, collaborate via a server to identify the best arm (i.e., the arm with the highest mean reward) with prescribed confidence. For this problem, we propose \texttt{Fed-SEL}, a simple communication-efficient algorithm that builds on successive elimination techniques and involves local sampling steps at the clients. To study the performance of \texttt{Fed-SEL}, we introduce a notion of arm-heterogeneity that captures the level of dissimilarity between distributions of arms corresponding to different clients. Interestingly, our analysis reveals the benefits of arm-heterogeneity in reducing both the sample- and communication-complexity of \texttt{Fed-SEL}. As a special case of our analysis, we show that for certain heterogeneous problem instances, \texttt{Fed-SEL} outputs the best-arm after just one round of communication. Our findings have the following key implication: unlike federated supervised learning where recent work has shown that statistical heterogeneity can lead to poor performance, one can provably reap the benefits of both local computation and heterogeneity for federated best-arm identification. As our final contribution, we develop variants of \texttt{Fed-SEL}, both for federated and peer-to-peer settings, that are robust to the presence of Byzantine clients, and hence suitable for deployment in harsh, adversarial environments.

2 - Model Aggregation in Federated Learning: Security and Efficiency

Salman Avertimehr, University of Southern California, Los Angeles, CA, United States

Model aggregation is a critical component of federated learning. In this talk, I will discuss several shortcomings in the state-of-the-art approaches for model aggregation, in terms of their security and efficiency, and propose new techniques to overcome those barriers.

3 - Exploiting Shared Representations for Personalized Federated Learning

Liam Collins, University of Texas at Austin, Austin, TX, United States

Neural networks have shown the ability to extract universal feature representations from data such as images and text that have been useful for a variety of learning tasks. However, the fruits of representation learning have yet to be fully-realized in federated learning (FL). In this talk, we propose FedRep: a novel federated learning framework and algorithm for learning a shared data representation across clients and unique local heads for each client. We prove that FedRep learns the ground-truth representation with per-user sample complexity that diminishes with the number of users in a linear setting, demonstrating that FedRep harnesses the benefits of collaboration in FL. Finally, we discuss experimental results showing that FedRep outperforms a variety of personalized FL methods on multiple data-heterogeneous FL benchmarks.

■ TE28

CC Room 207B

In Person: Decision-making under Multistage Uncertainty

General Session

Chair: Eojin Han, Southern Methodist University, Dallas, TX, 75205, United States

1 - Dynamic Capacity Management for Deferred Surgeries

Kartikey Sharma, Zuse Institute Berlin, Berlin, 60208-0834, Germany, Eojin Han, Omid Nohadani, Kristian Singh

The COVID-19 pandemic necessitated sweeping deferrals of elective surgeries. These deferrals led to deterioration of patients' conditions due to delayed procedures and potential departures. Current policies are ad-hoc, i.e., either all surgeries are deferred or capacities are extended by pre-determined factors. We develop an optimization framework to optimally manage the expansion of surgical capacity under uncertain backlog. Given that the model contains nonlinear products of uncertainties, we provide tractable policies for realistic problems. Numerical experiments on claims data from a large fraction of US hernia patients demonstrate sizable improvements over competing methods.

2 - Optimal Transportation Mode Selection and Capacity Allocation under Uncertainty

Avnish K. Malde, Graduate Research Assistant, Clemson University, Clemson, SC, 31405, United States, Tugce Isik

We consider the overseas supply chain of a manufacturing company with long lead-times and multiple transportation modes, where orders are placed using forecasted demand. The forecast error, which is the difference between forecasted and actual demand quantity, is considered an uncertain parameter. We also assume that the amount of excess inventory at the beginning of each period is uncertain. Order quantities for each transportation mode must be determined. We model this problem using a two-stage stochastic programming approach to minimize the overall expected order procurement, inventory holding, and backorder costs under demand and inventory uncertainty. Further, we use scenario decomposition based method, Progressive Hedging Algorithm, to solve the problem under consideration. We evaluate the performance of our solution algorithm via a numerical study.

■ TE29

CC Room 207C

In Person: Frontier of Optimization and Machine Learning

General Session

Chair: Yuri Fonseca, New York, NY, 10027, United States

1 - Offline and Online Learning from Optimal Actions

Yuri Fonseca, Columbia University, New York, NY, 10027, United States, Omar Besbes, Ilan Lobel

We study the offline and online problem of contextual optimization where instead of observing the loss, we observe the optimal action an oracle with full knowledge would have taken. At each period, the decision-maker has access to a new set of feasible actions to select from and to a new contextual function that affects that period's loss function. In the offline setting, the decision-maker has already collected information from multiple periods. We aim to minimize regret, which is defined as the difference between our losses and the ones incurred by an all-knowing oracle. Through our offline analysis, we tightly connect the type of performance that can be achieved as a function of the underlying geometry of the information induced by offline data. For the online setting, we leverage this tight link to optimize regret.

2 - Finite Sample Analysis of Minimax Offline Reinforcement Learning: Completeness, Fast Rates and First-order Efficiency

Masatoshi Uehara

We offer a theoretical characterization of off-policy evaluation (OPE) in reinforcement learning using function approximation for marginal importance weights and q-functions when these are estimated using recent minimax methods. Under various combinations of realizability and completeness assumptions, we show that the minimax approach enables us to achieve a fast rate of convergence for weights and quality functions, characterized by the critical inequality \citep{bartlett2005}. Based on this result, we analyze convergence rates for OPE. In particular, we introduce novel alternative completeness conditions under which OPE is feasible and we present the first finite-sample result with first-order efficiency in non-tabular environments, i.e., having the minimal coefficient in the leading term.

■ TE30

CC Room 207D

In Person: Featured Session: Reflection on the Opportunities and Challenges of COVID-19

Panel Session

Chair: Abdallah A Chehade, University of Michigan-Dearborn, Dearborn, MI, 48128-2406, United States

Chair: Xiao Liu, University of Arkansas, Fayetteville, AR, 72701, United States

1 - Moderator

Abdallah A. Chehade, University of Michigan-Dearborn, HPEC, Dearborn, MI, 48128-2406, United States

Distinguished panelists from the National Science Foundation and Academia will discuss the impacts of COVID-19 on academic research, teaching, and service. The discussion will be focused on the challenges, practices, and opportunities during and post COVID-19.

2 - Panelist

Kamran Paynabar, ISyE Georgia Tech, Georgia Tech, H. Milton Stewart School Of Isye, Atlanta, GA, 30332-0205, United States

■ TE31

CC Room 208A

In Person: Learning Algorithms in Revenue Management

General Session

Chair: Anyan Qi, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - A Joint Pricing and Capacity Decision Problem in Railways

Seetharama Chandrasekhar Manchiraju, University of Texas-Dallas, Naveen Jindal School of Man., Richardson, TX, 75080-3021, United States, Milind Dawande, Ganesh Janakiraman, Arvind Raghunathan

We study a joint pricing and capacity decision problem in the railway industry. Unlike in industries such as aviation, capacity in the railway industry can be decided at the end of the sales horizon due to the flexibility in choosing the number of coaches used on a train. The flexibility in varying capacity and a unique structure of the cost function distinguish this problem from the traditional RM pricing problems. Similar to the dynamic-pricing problems in RM literature, this problem is not tractable in general. Therefore, we obtain an easily implementable static policy and show that this policy is asymptotically optimal when the demand and capacity are proportionally scaled. We also obtain a dynamic policy which converges to optimality, faster than the static policy, as the scaling factor is increased.

■ TE32

CC Room 208B

In Person: Ridesharing

General Session

Chair: Peter Frazier, Cornell University, Ithaca, NY, 14853, United States

Co-Chair: Dmitry Mitrofanov, Boston College, New York, NY, 10012-1106, United States

1 - Pricing Fast and Slow

Daniel Freund, MIT, Cambridge, MA, 02139-4165, United States, Garrett J. van Ryzin

Ride hailing platforms update prices dynamically to efficiently balance supply and demand. But rapidly changing prices create incentives for riders to wait for high prices to drop. When supply builds up and prices do eventually drop, these patient customers may request en masse, causing a sharp drop in supply that triggers the pricing algorithm to increase prices. We present a simple fluid model that shows how dynamic pricing inherently creates such oscillations in supply and prices when riders are patient and strategic. Moreover, we show that these oscillations in supply levels are inherently inefficient due to the convexity of pickup times as a function of "open" (dispatchable) supply. We then show that by changing the service model to allow riders to enter a formal queue for low prices this inefficiency can be overcome.

2 - Dynamic Spatial Marching

Yash Kanoria, Columbia Business School, Columbia Business School Uris Hall, New York, NY, 10027-6945, United States

We consider demand and supply which arise i.i.d. uniformly in the unit hypercube [0,1]^d in d dimensions, and need to be matched with each other while minimizing the expected average distance between matched pairs (the "cost"). We characterize the achievable cost in three models as a function of the dimension d and the amount of excess supply (M or m): (i) Static matching of N demand units with N+M supply units. (ii) A semi-dynamic model where N+M supply units are present beforehand and N demand units arrive sequentially and must be matched immediately. (iii) A fully dynamic model where there are always m supply units present in the system, one supply and one demand unit arrive in each period, and the demand must be matched immediately. We show that cost nearly as small as the distance to the nearest neighbor is achievable in all cases except models (i) and (ii) for d=1 and M = o(N).

3 - Lyft and Uber IPOs: Before and After

Dmitry Mitrofanov, Boston College, Chestnut Hill, MA, 02467, United States, Maxime Cohen

The year 2019 witnessed two unicorn IPOs from ride-hailing platforms: Lyft filed its IPO on March 1 at a $24.3 billion valuation, and Uber filed its IPO on April 11 at a $82.4 billion valuation. Did these platforms adjust their operational decisions in anticipation of their IPOs? To answer this question, we use a comprehensive panel dataset with more than 13 million rides completed by more than 250,000 consumers between January 2018 and July 2019. We treat each IPO filing day as a natural experiment and examine how these two events have affected the operational strategies of Lyft and Uber, performance metrics, and consumers. The richness of our dataset allows us to account for various sources of heterogeneity including market penetration, loyalty, customers' past riding frequency and sharing propensity, riders' deal-seeking behavior, and tip amount.

■ TE33

CC Room 209A

In Person: Online Resource Allocation: New Models and Algorithms

General Session

Chair: Vineet Goyal, Columbia University, New York, NY, 10027, United States

1 - Online Resource Allocation With Time-flexible Customers

Evan Yao, Massachusetts Institute of Technology, Canton, MO, United States

We study an online resource allocation model where certain arriving agents are time flexible, meaning that they are willing to wait a short period of time to receive the resource. For flexible agents, we must make an immediate and irrevocable commitment to accept them, but how exactly we allocate resources to satisfy their demand can be made in an offline manner after we have seen more of the input sequence. When there are 2 or 3 types of agents, we present algorithms that achieve the maximum possible competitive ratio, while for 4+ types, we present a simple algorithm which achieves at least 80% of the maximum competitive ratio.

2 - Spatial Elasticity

Bobby Nyotta, UCLA Anderson School of Management, 25369 Avenida Ronada, Los Angeles, CA, 91355-3203, United States, Fernanda Bravo, Keith Chen

Using transactions data from a popular downtown neighborhood in a large metropolitan city's mobile phone application for parking payments, we analyze customer behavior from a natural pricing experiment to estimate the "spatial elasticity," a measure of how individuals quantify the cost of walking an additional mile, in an urban mobility setting.We find that customers require approximately $81 to walk an additional mile to their intended destination. The results are robust against several varying assumptions and when considering factors such as weather and time of day.Our estimates can be used in ride-sharing, bike-sharing, e-scooter-sharing settings to incentive users to end their trips at key locations to either ensure future availability or reduce congestion.

3 - Discrete Choice via Sequential Search

Aydin Alptekinoglu, Pennsylvania State University, University Park, PA, 16802-3603, United States, Natalia Kosilova

This work considers the sequential search process of the consumer and derives the resulting choice probabilities. While the optimal search strategy was characterized by Weitzman (1979), to the best of our knowledge there is no work deriving the choice probabilities that result from the optimal search strategy.

■ TE35

CC Room 210A

In Person: Freight Transportation I

General Session

Chair: Zhijie Sasha Dong, Texas State University, San Marcos, TX, 78666-4684, United States

Co-Chair: Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States

1 - The Middle Mile Consolidation Network Design Problem with Fixed Origins And Destinations: A Time-constrained Continuous Rate Model

Lacy Greening, Georgia Institute of Technology, 878 Peachtree St Ne Apt 716, Atlanta, GA, 30309-4469, United States, Alan Erera

The focus of the talk is on continuous rate load planning for large-scale middle mile order fulfillment of time-sensitive bulky items. We will demonstrate how to explicitly incorporate service time requirements within a flat network and how to solve realistically-sized problems using an IP-based local search heuristic.

2 - A Stochastic Prepositioning Model for Distribution of Disaster Supplies Considering Lateral Transshipment

Zhijie Sasha Dong, Texas State University, San Marcos, TX, 78666-4684, United States, Yusheng Wang, Shaolong Hu

This work focuses on addressing uncertainties in disasters when considering lateral transshipment opportunities for pre-positioning relief supplies. To deal with uncertain demands the problem is formulated as a two-stage stochastic programming model, which decides simultaneously on the locations of relief facilities and the allocations of relief supplies to demand nodes. Meanwhile, different damage levels caused by disasters are considered and reflected by a survival rate of usable stocked relief items. Multiple types of supplies with various priorities, values and spaces are explored. A real-world case study based on the Gulf Coast region of the United States is conducted to illustrate the application of the developed model. By comparison with the direct shipment solution, the lateral transshipment solution is demonstrated to be more cost-effective and flexible. The sensitivity analysis of out-of-stock penalty cost and maximum travel distance provides managerial insights for relief agencies.

3 - A Policy and Infrastructure Evaluation Model of Commodity Flows Through Inland Waterway Ports

Sanjeev Bhurtyal, University of Arkansas, Fayetteville, AR, United States, Sarah Vavrik Hernandez, Sandra D. Eksioglu, Manzi Yves

The purpose of the study is to formulate the two-stage stochastic optimization model to determine which inland waterway ports to invest in to provide expanded commodity-specific handling capacity given changes to commodity-specific demand. Calibration and validation of the two-stage optimization model is carried out in Arkansas River. To overcome the computational burden from large size mixed-integer linear programming model, Benders decomposition algorithm is used. The results from the model serve to prioritize inland waterway port infrastructure and equipment capacity expansion investment decisions under scenarios of commodity growth/decline.

4 - Load Plan Scheduling Problem

Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States, Fabien Lehuede

We introduce a new optimization problem, the Load Plan Scheduling Problem that is relevant to Less-than-truckload freight transportation carriers. This problem seeks to determine a schedule for a given set of shipment paths that minimizes transportation costs by achieving high levels of consolidation. We present different integer programming formulations of this problem. One formulation is based on a time-space network. We illustrate how the size of that network can be reduced through a filtering procedure and propose multiple classes of valid inequalities. Another formulation does not involve a time-space network but instead is an extended formulation, which we propose solving with a branch-and-price solution approach. We report on the effectiveness of these techniques with a computational study.

■ TE36

CC Room 210B

In Person: Analytics in eBusiness

General Session

Chair: Bryce Mclaughlin, Palo Alto, CA, 94306, United States

1 - Service Quality and Wage Differentiation in Two-sided Ridesharing Platforms

Haozhao Zhang, University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Chenglong Zhang, Srinivasan Raghunathan

We examine the quality differentiation strategy for a two-sided platform that matches drivers with riders. The riders have different valuations for waiting time, which is one measure of service quality. Unlike product markets, the ridesharing platform faces a self-scheduled supply and they may also be strategic in accepting a ride request. In the presence of strategic drivers, offering differential wages to control driver supply leads to adverse effects from driver-side cannibalization. An increase in the driver-side cannibalization diminishes the platform's incentive to practice wage differentiation as well as quality-differentiated services.

2 - Optimizing Machine Learning to Assist a Human Decision-Maker
Bryce McLaughlin, Stanford University, Stanford, CA, United States

Many decision systems have begun to incorporate predictions built off of large quantities of past data in an attempt to improve the quality of the decisions. In many such applications, machine-learning algorithms are trained to take an optimal decision based on this data. However, in high-stakes applications such as judicial decisions, medical diagnosis, or fraud detection many decisions will continue to be taken by humans, with machine predictions merely providing one of many inputs. In this work, we therefore ask how machine-learning predictions should change when they are designed to support, rather than replace, a human decision-maker who holds the decision authority. Our work aims to move the focus on AI-driven decisions from substituting human decisions to complementing them. A general take-away is that the optimal solutions to these problems are strikingly different, with optimal assistance focusing on instances that the human gets wrong, while optimal substitution focuses on cases humans typically also get right. As a specific take-away, we provide theoretical results that can guide the implementation of machine-learning algorithms in high-stakes decisions where human decision-makers have the decision authority.

■ TE37

CC Room 210C

In Person: Empirical Healthcare Operations Management

General Session

Chair: Masoud Kamalahmadi, University of Miami, Bloomington, IN, 47405-1701, United States

1 - A Field Experiment on Wait Time Information Provision
Danqi Luo, Stanford University, Stanford, CA, 94305-7216, United States, Mohsen Bayati, Erica Plambeck

In an ongoing field experiment, we trial three different wait time information provision schemes to low-acuity patients (LAP), patients with ESI level 3, 4, and 5. Through an incentivized text-based survey, patients can electronically self-report their real-time satisfaction on wait time and pain level throughout their stay in the ED. Matching patients' responses with their electronic medical records (EMR) and the NRC health data (a survey collected by SMMC), we can measure the impact of different wait time information on patients' waiting satisfaction, outcomes concerning the behavior of left-without-being-seen by a physician, length of the stay in the ED, and pain level. In the first stage of results, we identified that LAPs are less likely to leave the ED without being seen by a physician compared to the baseline when no information is provided.

2 - Nudging Patient Choice by Messaging: A Field Experiment
Jiayi Liu, Emory University, Atlanta, GA, 30322, United States, Diwas S. KC

To examine the drivers of patient no-shows at outpatient clinics, we conduct a series of field experiments where the messaging regarding their upcoming appointment is randomly assigned. We find that the type of messaging has a significant effect on the queuing behavior of individuals, most notably their no-show behavior.

■ TE39

CC Room 211A

In Person: Doing Good with Good OR: I

Award Session

Chair: Paul Gölz, Pittsburgh, PA, 15206, United States

1 - Learning, Optimization, and Planning under Uncertainty for Wildlife Conservation
Lily Xu, Harvard University, Cambridge, MA, United States

In collaboration with conservation NGOs, our project helps plan effective ranger patrols to protect endangered animals from poaching. Algorithmically, the problem is to optimize limited resources to maximize the number of snares confiscated. Given limited and incomplete data, we leverage linear programming, multi-armed bandits, and game theory to handle uncertainty about poacher behavior. Our approaches are supported with theorems, experiments, and real-world field tests. Our system is being integrated into existing conservation software to become available to 800 protected areas worldwide.

2 - Data-Driven COVID-19 Vaccine Development for Janssen
Michael Lingzhi Li, Massachusetts Institute of Technology, Boston, MA, 02111, United States

The COVID-19 pandemic has spurred extensive vaccine research worldwide. Phase III vaccine trials' success highly depends on future COVID-19 incidence rates at trial sites. To accurately predict these rates, we created DELPHI, a novel data and policy driven epidemiological model. DELPHI is the centerpiece of site selection for the Phase III trial of Ad26.COV2-S, the leading Janssen vaccine candidate. DELPHI-driven site selection accelerated the trial by 6-8 weeks while reducing the necessary size from 60k to 45k individuals, allowing millions of people earlier access to a life-saving vaccine.

3 - Fair Algorithms for Selecting Citizens' Assemblies
Paul Gölz, Carnegie Mellon University, Pittsburgh, PA, 15206, United States

Globally, there has been a recent surge in citizens' assemblies, which are panels of randomly-selected citizens weighing in on a policy question. Since these panels must proportionally represent many demographic groups, the selection algorithms currently used for choosing panels select different agents with highly unequal probabilities. We develop selection algorithms that satisfy quotas while choosing pool members with probabilities as close to equal as possible. We have implemented one such algorithm, which has been adopted by a number of organizations around the world.

■ TE40

CC Room 211B

In Person: Forecasting, Ordering and Allocation under Strategic Behavior

General Session

Chair: Minseok Park, PhD, Salisbury University, Salisbury, MD, 21801, United States

1 - Spatial Information-sharing on On-demand Service Platforms: A Behavioral Examination
Swanand Kulkarni, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Basak Kalkanci

We examine how the spatial characteristics of demand-supply mismatch information sharing influence a platform's matching efficiency. We compare public information sharing mechanisms (where all drivers have the same information) with local information sharing (where only nearby drivers learn about a surge opportunity). We examine drivers' relocation decisions under competition theoretically and test predictions experimentally. Experiments reveal that local information sharing can be highly effective despite being dominated theoretically.

2 - Accountability and the Starvation Cycle in the Nonprofit Sector
Iman Parsa, Arizona State University, Tempe, AZ, 85287, United States, Mahyar Eftekhar, Charles J. Corbett

Donors to nonprofit organizations are sensitive to overhead expenses and support charities with lower administration and fundraising costs. This can lead to under-investments in essential organizational and operational infrastructure, or misleading financial reports, and an increasing expectation of donors for low overhead costs. In this paper, we empirically investigate whether the IRS policy change in 2008 has helped in breaking this cycle by providing additional information about nonprofits' accountability. This empirical study is based on a large dataset containing information of nonprofits in different sectors in the time period 2009-2017.

■ TE41

CC Room 212A

In Person: Decision Analysis Game Theory Applications, Stochastic Dynamic Programming, and Public Policy

General Session

Chair: Manel Baucells, University of Virginia, Charlottesville, VA, 22903-1760, United States

1 - Optimal Incentives to Mitigate Epidemics: A Stackelberg Mean Field Game Approach
Gokce Dayanikli, Princeton University, Princeton, NJ, United States, Alexander Aurell, Rene A. Carmona, Mathieu Lauriere

Motivated by the models of epidemic control, we consider a Stackelberg mean field game between a principal and a mean field of agents whose states evolve in a finite state space. The agents play a noncooperative game in which they control their transition rates between states to minimize an individual cost. The principal influences the Nash equilibrium through incentives to optimize its own objective. We show an application to an epidemic model of SIR type in which the agents control their contact rates, and the principal is a regulator acting with non pharmaceutical interventions. We propose a numerical approach based on Monte Carlo simulations and machine learning tools for stochastic optimization.

2 - Sequential Search with Bidding
Cagin Uru, Duke University, Durham, NC, United States, David Brown

We consider a sequential search problem in which a decision maker sequentially explores and bids on a set of disappearing alternatives with a priori unknown values to obtain the best alternative. This problem can be formulated as a stochastic dynamic program, but it is difficult to solve as the state space is both high-dimensional and continuous. In this paper, we study a relaxation with an infinite number of alternatives and obtain a threshold policy that does not recall any previously explored alternative. Analyzing its performance in the original problem, we not only show that the threshold policy is asymptotically optimal for problems with many alternatives but also characterize the convergence rate. For problems where calculating the threshold is challenging, we propose an approximation scheme based on the discretization of the state space and prove its convergence.

3 - A Real Options Approach to Risk Management for a Small Business Innovation Research Portfolio
Jeremy Eckhause, RAND Corporation, Arlington, VA, 22202-5005, United States, Andrea Belz, Fernando Zapatero, Richard Terrile

An important class of R&D investments in public contexts is one in which investments are staggered in multiple stages, with relatively modest early funding for the selected proposals and higher levels subsequently made available for a subset. We present a method based on a real options approach to select a portfolio of proposals in each stage, applied to the NASA's Small Business Innovation Research (SBIR) portfolio. Among the practical implications of our analysis, the model indicates that a strong increase in the funding of the smallest firms has only minimal impact on the overall portfolio value.

■ TE42

CC Room 212B

In Person: Disaster and Disruption Management

Contributed Session

Chair: Jorge Huertas, Georgia Institute of Technology, Atlanta, GA, 30309, United States

1 - Post-Hurricane Damaged Timber Management Problem Using Bilevel Model Formulation
Amin Aghalari, Mississippi State University, Starkville, MS, United States, Mohammad Marufuzzaman, Badr Aladwan, Shaun Tanger, Bruno Silva

This study proposes a bi-level mixed-integer linear programming model to optimize different critical decisions (e.g., purchasing, storage, and transportation decisions) of a post-hurricane damaged timber management problem. Further, this study develops two exact solution methods, namely, the enhanced Benders decomposition and the Benders-based branch-and-cut algorithms to efficiently solve the model in a reasonable timeframe. We use 15 coastal counties in southeast Mississippi to visualize and validate the algorithms' performance.

2 - Optimal Selection of Pre-event Short and Long-term Mitigation Strategies for Flooding Hazards
Himadri Sen Gupta, University of Oklahoma, Norman, OK, United States, Omar Magdy Nofal, Andres David Gonzalez, Charles D. Nicholson, John W. van de Lindt

We propose a mathematical model to study the effects and tradeoffs associated with pre-event short-term and long-term mitigation strategies to minimize the economic loss associated with flooding hazards. We illustrate the capabilities of the model with a case study on Lumberton, NC. Lumberton has been affected by severe flooding events with significant recurring economic loss. The model uses the cost from a portfolio of mitigation strategies, each representative of a different mitigation strategy, and the resulting flood-induced monetary losses corresponding to each strategy. Finally, the optimal flood mitigation plan for buildings is provided based on a mitigation budget constrained.

3 - Use of Ships for Fuel Emergency Distribution on Islands
Vahid Eghbal Akhlaghi, University of Iowa, Iowa City, IA, United States, Ann Melissa Campbell

We present a mixed-integer programming model to examine the strategies for using ships to supplement the fuel supply on islands after a major disaster. The problem is motivated by practices proposed by FEMA after recent hurricanes in the Caribbean. The model presented includes decisions about routing ships to ports and assignment of fuel dispensing sites to ports to minimize the latest time a fuel distribution site receives its required fuel supply. An extension of the model to consider the use of standby ships is introduced. After proving the NP-hardness of the problem, we derive structural properties, lower bounds, and valid inequalities. A case study based on real data for Puerto Rico is presented.

4 - Modeling of Covid-19 Trade Measures on Essential Products: A Multiproduct, Multicountry Spatial Price Equilibrium Framework
Mojtaba Salarpour, University of Massachusetts-Amherst, Amherst, MA, United States, AnnaB. Nagurney, June Dong

We develop a unified variational inequality framework in the context of spatial price network equilibrium problems that handles multiple products with multiple demand and supply markets in multiple countries as well as multiple transportation routes. The model incorporates a plethora of distinct trade measures, which is particularly important in the pandemic, as PPEs and other essential products are in high demand, but short in supply globally. In the model, product flows as well as prices at the supply markets and the demand markets in different countries are variables that allows us to seamlessly introduce various trade measures, including tariffs, quotas, as well as price floors and ceilings.

5 - Multi-objective Community Resilience Optimization with CGE Modeling for Memphis Metropolitan Statistical Area
Rafia Bushra, University of Oklahoma, Norman, OK, United States

Natural hazards have the potential to cause billions of dollars of damage, create major disruptions in key elements of communities worldwide, and drive complex outcomes such as population dislocation, unemployment rates, threats to household income, etc. In this presentation, we consider the Memphis Metropolitan Statistical Area lying within the New Madrid seismic zone. We implement a community resilience multi-objective optimization model that leverages a reversed engineered computable general equilibrium model derived information to capture system-wide impacts to enhance decision-making.

6 - Large-scale Zone-based Evacuation Planning: Generating Convergent and Non-preemptive Evacuation Plans via Column Generation
Jorge A. Huertas, Georgia Institute of Technology, Atlanta, GA, United States, Pascal Van Hentenryck

In zone-based evacuations, the evacuated region is divided into zones, and vehicles follow the single evacuation path assigned to their corresponding zone. Ideally, these evacuation paths converge at intersections to reduce driver hesitation; and non-preemptive schedules ensure that the evacuation of a zone, once it starts, proceeds without interruptions. We present a macroscopic optimization model to produce convergent and non-preemptive evacuation plans. Furthermore, we decompose our model and use a column-generation algorithm to solve it in real large-scale evacuation scenarios. Finally, we use a microscopic traffic simulator to evaluate the quality of the generated plans."

Wednesday, 7:45AM-9:15AM

■ WB08

CC Room 303C

In Person: APS Fairness in Sequential-Decision Making

General Session

Chair: Siddhartha Banerjee, Cornell University, Ithaca, NY, 14853-3801, United States

Co-Chair: Sean Sinclair, Cornell University, Ithaca, NY, 14853, United States

1 - A Markovian Arrival Stream Approach To Stochastic Gene Expression In Cells
Brian Fralix, Clemson University, Clemson, SC, 29642-8005, United States, Mark Holmes, Andreas Lopker

We analyze an abstraction of the stochastic gene expression model studied recently in Fromion et al. (SIAM Journal of Applied Math, 2013) and Robert (Probability Surveys, 2019) using techniques from the theory of point processes, and the theory of matrix-analytic methods. In the model we consider, both the activity of a gene and the creation of mRNA are modeled with an arbitrary Markovian arrival process. This modification is important, as Markovian arrival processes can be used to approximate many types of point processes on the nonnegative real line.

■ WB09

CC Room 303D

In Person: Control of Queueing Systems and Applications

General Session

Chair: Sai Mali Ananthanarayanan, Columbia University, New York, NY, 10027, United States

1 - Dynamic Allocation of Reusable Resources: Logarithmic Regret in Hierarchical Networks

Xinchang Xie, Northwestern University, Kellogg School of Management, Evanston, IL, United States, Itai Gurvich

We study network revenue management problem with reusable resources. The resources are to be sequentially allocated to customers with different arrival rates, rewards, and resource requirements. Each accepted customer occupies the requested resources for a random duration after which the resources become available again. The objective is to maximize the long-run average reward under resource constraints. We adapt a queueing loss network framework to solve such problem. The performance of any online policy is bounded by the solution of a corresponding linear program relaxation. We show that when the network has certain hierarchical structure, a simple threshold policy induced by the LP solution achieves logarithmic regret in proper asymptotic regime. We demonstrate through numerical examples that hierarchical structures play a key role in the performance.

2 - Optimal Ergodic Harvesting under Ambiguity

Chuhao Sun, University of Michigan, Ann Arbor, MI, United States, Asaf Cohen, Alexandru Hening

We consider an ergodic harvesting problem with model ambiguity that arises from biology. To account for the ambiguity, the problem is constructed as a stochastic game with two players: a decision-maker (DM) chooses the best harvesting policy and an adverse player chooses the worst probability measure. The main result is establishing an optimal strategy of the DM and showing that it is a threshold policy. The optimal threshold and payoff are obtained by solving a free-boundary problem based on the HJB equation. As part of the proof, we fix a gap that appeared in the HJB analysis of [Alvarez and Hening, Stochastic Process. Appl., 2019, [5]], a paper analyzed the risk-neutral version of the problem. Finally, we study the dependence of the optimal threshold and payoff on the ambiguity parameter and show that if the ambiguity goes to 0, the problem converges to the risk-neutral problem.

3 - Queuing Safely for Elevator Systems Amidst a Pandemic

Sai Mali Ananthanarayanan, Columbia University, New York, NY, 10027, United States, Charles Branas, Adam Elmachtoub, Clifford Stein, Yeqing Zhou

Elevator capacity in high rise buildings during a contagious pandemic can be reduced by as much as 90% of the normal amount to allow for social distancing. Such a reduction, combined with the commonly used FCFS queuing policy, can cause large queues to build up in lobbies. Using mathematical modeling, epidemiological principles, and simulation, we propose simple interventions requiring no programming of the elevators for safely managing the elevator queues. The key idea is to explicitly or implicitly group passengers going to the same floor into the same elevator as much as possible. Based on simulation and analytical findings, our proposed interventions can significantly reduce queue length and wait time, while also maintaining safety from viral transmission in otherwise crowded elevators, building lobbies, and entrances.

■ WB10

CC Room 304B

In Person: Application of AI on Digital Platforms

General Session

Chair: Ecem Basak, University of Illinois at Chicago, Chicago, IL, 60640, United States

1 - Impact of AI on Consumer Decision-making and Sales Diversity

Yu Kan, University of Washington, Yu Kan, Seattle, WA, 98105, United States, Uttara Ananthakrishnan

In this paper, we aim to address the gap in the literature by addressing the following questions: 1) How does AI-based recommendation systems built on large-scale data with hundreds of features per customer impact consumers' choice, purchase behavior and engagement 2) Can creating taste-based clusters (such as the algorithms deployed by Netflix on their platform) improve customer retention and engagement on the platform? 4) How does advanced machine-learning based personalization impact sales diversity on subscription-based business models? 5) How can advanced, feature-rich recommendation systems match consumers' expectation with the delivered product thereby reducing returns and the associated negative impact on the environment 6) How does feature-rich recommendation systems impact long-chain and social media engagement?

2 - Effectiveness of AI Assistant in Live-streaming: A Randomized Field Experiment

Yumei He, University of Houston, Houston, TX, United States, Lingli Wang, Jiandong Ding, Ni Huang, Yili Kevin Hong, Xunhua Guo, De Liu, Guoqing Chen

Live streaming selling is a transformative ecommerce channel that features real-time interaction. However, streamers' service capacities cannot fulfill viewers' needs for social interaction, resulting in a loss of viewer engagement and financial gains. Accordingly, we examine whether the implementation of an AI assistant that tracks, understands, and responds viewers' requests drives viewers' purchase decision. In collaboration with Taobao.com, we conducted a randomized field experiment on its live streaming platform. In the experiment, a subject was either assigned to the treatment group with an AI assistant in any live streaming or the control group in which the AI assistant was absent. Our research contributes to the literature on the business value of AI applications and live streaming while implicating AI system designs for live streaming platforms.

3 - Pedaling Our Way to Clean Air: An Empirical Investigation of Bike-sharing Platforms and Local Air Quality

Ecem Basak, University of Illinois at Chicago, Chicago, IL, 60640, United States, Ali Tafti, Mary Beth Watson-Manheim

Bike-sharing platforms contribute to better allocation and more efficient utilization of resources. However, bike-sharing platforms are not only associated with reduced traffic congestion and flexible mobility but also offer health benefits such as reduced greenhouse gas emissions and air pollution. Environmental sustainability is important for creating healthy societies and eco-friendly cities. The sustainability of cities and their greening is essential to address environmental and health issues. We implement a difference-in-differences analysis to examine the impact of bike-sharing platform entry on the level of PM2.5 concentrations in U.S. cities. We also explore the heterogeneous impacts of the platforms depending on multiple factors such as bike-friendliness, pedestrian-friendliness, environmental policies, and population.

■ WB11

CC Room 304C

In Person: Airline Operations Recovery

General Session

Chair: Vikrant Vaze, Dartmouth College, Hanover, NH, 03755-3560, United States

Co-Chair: Lu Dai, University of California, Berkeley, CA

1 - The COVID-19 Pandemic and U.S. Aviation: System Adaptation and Performance Impact

Michael O. Ball, University of Maryland-College Park, Silver Spring, MD, 20910, United States, Vivek Ramanathan, Dan Murphy, Mark M. Hansen, Vanessa Li

We investigate the impact of the COVID-19 pandemic on the performance of the U.S. domestic air transportation system. We analyze both the changes in the volume and characteristics of flight operations and also changes in system performance metrics. We also discuss various adjustments made by the FAA both to take advantage of reduced system congestion and also to cope with COVID-19 infections among controllers.

2 - Aiding Airlines in a Pandemic for the Benefit of Whom? An Applied Game-Theoretic Approach

Gianmarco Andreana, Univerità degli Studi di Bergamo, Bergamo, Italy, Nicole Adler

In 2020 the Covid-19 pandemic disrupted aviation industry profitability. Governments and banks stepped in to bailout airlines with substantial financial aid of differing forms. This research models airline competition by developing a single-stage, Nash best-response dynamic game. Given this framework, airlines compete at a strategical level setting airfares and service frequencies across their network. Investigating the European aviation market, characterized by legacy and low-cost carriers, we assess how the form of aid distorts the market equilibrium under different scenarios.

■ WB12

CC Room 304D

In Person: Bilevel Optimization/Bayesian Optimization

General Session

Chair: Raul Astudillo, Cornell University, Ithaca, NY, 14853-3801, United States

1 - Integer Programming Methods for Solving Binary Interdiction Games

Ningji Wei, Heinz College, Carnegie Mellon University, Pittsburgh, PA, 19104, United States, Jose L. Walteros

We study a general class of interdiction problems in which the solution space of both the leader and follower are characterized by two discrete sets: the leader's strategy set and the follower's structure set. The interaction between any strategy-structure pair is assumed to be binary, such that the strategy selected by the leader either interacts or not with the follower's structure and if it does, the structure becomes unavailable. Many interdiction games fall into this type, including shortest paths, minimum spanning trees, minimum dominating sets interdiction, among others. We study a formulation for solving this general problem and analyze the properties of its convex hull. We develop a wide class of inequalities that generalizes several others that have appeared in the literature. We also study their facet-defining conditions and discuss the separation methods.

2 - Interdicting Low-diameter Cohesive Subgroups in Large-scale Social Networks

Niloufar Daemi, Oklahoma State University, Stillwater, OK, United States, Juan Sebastian Borrero, Balabhaskar Balasundaram

An s-club is a subset of vertices in graph G that induces a subgraph of diameter at most s. This concept was introduced in social network analysis to model the cohesive social subgroups as low-diameter clusters in a social network. Several recent articles in the literature address the detection of the largest cardinality s-club in a graph. In this article, we work on the s-club interdiction problem which diminishes the size of the largest s-club in a graph. We propose an interdiction model with an interdiction penalty instead of a hard budget constraint and design a decomposition algorithm to solve the problem. We test the effectiveness of our algorithm on two test-beds of benchmark instances.

3 - Sequential Network Interdiction with Learning under Asymmetric Information and Inexact Evader

Jing Yang, University of Pittsburgh, Pittsburgh, PA, 15232, United States, Oleg A. Prokopyev, Denis R. Saure

We consider a sequential network interdiction setting over a finite horizon, where in each period an interdictor with incomplete knowledge of the arc costs blocks at most k arcs, and an evader with complete knowledge about the costs traverses a path between two fixed nodes in the interdicted network. In each period, the interdictor's objective function depends on a path taken by the evader after interdiction. We assume that in each period the interdictor observes the full path used by the evader. This information feedback is then used by the interdictor to refine his/her interdiction decisions in the subsequent time periods. In this talk, we analyze the implications of relaxing the standard assumption in the related literature that the evader's response must be the shortest path in the interdicted network.

4 - Grey-Box Bayesian Optimization of Nested Functions

Raul Astudillo, Cornell University, Operations Research And Information Engineer, Ithaca, NY, 14853-3801, United States, Peter Frazier

We consider Bayesian optimization of objective functions that are the composition of multiple expensive-to-evaluate functions. While the standard Bayesian optimization approach observes only the objective value, our approach delivers greater sample efficiency by observing information that the standard approach ignores: the output of intermediate functions. Our approach models these functions using independent Gaussian processes and chooses the points to evaluate using as its acquisition function the expected improvement computed with respect to the implied posterior on the objective function. Although this acquisition function cannot be computed in closed form, we maximize it using a sample average approximation approach. Numerical experiments show that our approach substantially outperforms standard Bayesian optimization benchmarks.

■ WB13

CC Room 201A

In Person: Modeling and Optimization for Decision Analytics

General Session

Chair: Yasaman Ghasemi, The University of Texas at Arlington, Arlington, TX, United States

1 - Heatwave Prediction using Classification and Regression Trees

Gazi Md Daud Iqbal, Coppin State University, Baltimore, MD, United States, Jay Michael Rosenberger, Lidan Ha, Sadie Gregory

Global temperature is increasing at an alarming rate, which increases the number of heatwaves. Many people die as a direct or indirect consequence of a heatwave, and elderly people are most affected by a heatwave. Predicting the occurrence of a heatwave can save lives. Because of its geographical location, Bangladesh is one country that is particularly vulnerable to heatwaves. The Bangladesh Meteorological Department collects temperature data at ten weather stations. Data shows that a majority of heatwaves occur in summer months, namely, April, May, and June. In this research, we develop Classification and Regression Tree (CART) models to predict the likelihood of a heatwave in the next 7 days and 28 days using previous two weeks daily temperature.

2 - Modeling Patrol Operations using Agent-Based Simulation

Yasaman Ghasemi, The University of Texas at Arlington, Arlington, TX, United States, Yuan Zhou, Victoria C. Chen, Kent Ryan Kerley

The complex nature of the policing system often makes it very challenging to manage and control. The dynamic and stochastic criminal behavior, compounded with limited policing resources, are rendered current police operations ineffective and inefficient. In this study, a computer simulation-optimization framework is developed to conquer these weaknesses by addressing the dynamically changing complexities and uncertainties in police operations and adaptively optimizing operational performance based on the state of the policing system. A real-world case study will be presented to illustrate how this framework is used in dynamic patrol deployment planning.

■ WB14

CC Room 201B

In Person: The Interplay Between Optimization and Statistics

General Session

Chair: Lijun Ding, Cornell University, Ithaca, NY, 14850-2842, United States

1 - Clustering Gaussian Mixtures with Unknown Covariances

Kaizheng Wang, Columbia University, New York, NY, United States

We investigate the clustering problem with data from a mixture of Gaussians that share a common but unknown covariance matrix. When there are only two equally-sized components, we derive a max-cut integer program for clustering based on maximum likelihood estimation. It is shown to achieve the statistical optimality in terms of the misclassification error. We also develop an efficient algorithm that returns optimal clustering but has worse sample complexity. We provide numerical verifications of the gap together with some theoretical evidence of a possible statistical-computational tradeoff. Finally, we propose and analyze a k-means program on transformed data to handle multiple components with possibly unequal weights. It is an extension of the max-cut program for the two-component case and enjoys similar optimality guarantees.

2 - Importance Sketching for Fast Low-rank Matrix/tensor Learning: Algorithm and High-order Convergence

Anru Zhang, Duke University, Durham, NC, 53562, United States

We consider the matrix/tensor rank constrained least-squares optimization. This problem covers many specific examples arising from applications, including matrix/tensor regression, completion, PCA/SVD, and phase retrieval. We propose a new algorithm RISRO based on a new sketching framework, recursive importance sketching. Several existing algorithms can be reinterpreted under the new sketching framework and RISRO offers clear advantages over them. RISRO is easy to implement and computationally efficient, where the core procedure in each iteration is only solving a dimension reduced least-squares. We establish a local quadratic rate of convergence for RISRO under mild conditions. We also discover a deep connection of RISRO to Riemannian manifold optimization. The effectiveness of RISRO is demonstrated in applications in machine learning and statistics.

■ WB15

CC Room 201C

In Person: Advances in Transportation Management

General Session

Chair: Hamid R. Sayarshad, WPI, Worcester, MA, 01609, United States

1 - Public Transit for Special Events: Analysis, Ridership Prediction, and Train Optimization

Anthony J. Trasatti, ISyE Georgia Tech, Atlanta, GA, United States, Pascal Van Hentenryck

Many special events, including sport games and concerts, often cause surges in demand and congestion for transit systems. This paper proposes a suite of data-driven techniques that exploit entry-exit Automated Fare Collection (AFC) data for evaluating, anticipating, and managing the performance of transit systems during these recurring congestion peaks. Using rail data from the Metropolitan Atlanta Rapid Transit Authority (MARTA), simulations show decreased crowdedness and improved wait times for post-game ridership using proposed predictive analytics to create train schedules.

2 - Designing Intelligent Public Parking Strategies For Autonomous Vehicles' Behaviors

Hamid R. Sayarshad, Worcester Polytechnic Institute, Worcester, MA, United States

With emerging technologies like autonomous vehicles (AVs), travelers do not need to park close to their destination. A bid price for the daytime parking of AVs that considers urban land use is proposed to evaluate parking strategies possibly chosen by AV users. I determine an actual parking demand function by incorporating individual preferences into a p-median problem that controls user-optimality. A novel dynamic optimization formulation is proposed to design the location of parking facilities for AVs, considering AVs' individualized characteristics for parking such as bid price, waiting time for searching parking lots, and travel time from a set of demand nodes to the nearest parking facility.

■ WB16

CC Room 201D

In Person: Probabilistic Modeling in Predictive Analytics

General Session

Chair: Rui Tuo, Texas A & M University, College Station, TX, 77845-7399, United States

1 - Probabilistic Shortest Electric Vehicle Paths: Balancing Efficiency And Reliability

Ridvan Aksu, University of Alabama, Tuscaloosa, AL, United States, Mesut Yavuz

Sustainability efforts and the recent developments in battery technologies are driving the popularity and the market share of Electric Vehicles (EVs) higher than ever. The main obstacles before conquering the market are limited driving autonomy and long charge times. With the state-of-the-art battery technology, we investigated pre-determining a route that minimizes the total waiting and charging costs and employing recourse to update the path in case of severe waiting times. Our analysis includes finding an initial shortest path that allows low expected waiting times and improved worst case times.

2 - Allocating Shelf Space for Fresh Produce under a Probabilistic Waste Bound

Belleh Fontem, Assistant Professor, University of Massachusetts Lowell, Lowell, MA, United States, Cuibing Wu

We examine a supplier duopoly serving a risk-averse retailer who faces compound Poisson demand for (initially) fresh produce that deteriorates exponentially over time. Each supplier sells a unique food item to the retailer, and upon arrival, a customer elects to purchase at most one item. Moreover, a customer's expected demand quantity is proportional to the amount of remaining fresh stock. The retailer's quest is a profit-maximizing allocation of shelf space subject to a probabilistic upper bound on the total space inadvertently wasted on stale inventory. We determine the retailer's optimal allocation, and characterize the Nash equilibria arising from the suppliers' pricing rivalry.

3 - A Sparse Expansion for Deep Tensor Markov Gaussian Processes

Rui Tuo, Texas A & M University, College Station, TX, 77845-7399, United States, Liang Ding, Shahin Shahrampour

Deep Gaussian Processes (DGP) enable a non-parametric approach to quantify the uncertainty of complex deep machine learning models. DGP models can suffer from high computational complexity as they require large-scale operations with kernel matrices for training and inference. In this work, we first introduce a class of Gaussian Processes, called Tensor Markov Gaussian Processes (TMGP). We then develop a deep TMGP (DTMGP) model which is the composition of multiple TMGPs. We formulate our DTMGP based on entropic optimal feature (EOF) expansion. The EOF expansion yields a highly accurate approximation and a sparse representation of DTMGP, based on maximizing the metric entropy among kernel features. Numerical experiments show the computational efficiency of DTMGP compared to other DGPs models.

■ WB17

CC Room 202A

In Person: Renewable and Rmerging Technologies

General Session

Chair: Alexandra M. Newman, Colorado School of Mines, Golden, CO, 80401-1887, United States

1 - Improving Fidelity of Dispatch Decisions for Concentrated Solar Power Plants

Phillip Buelow, Colorado School of Mines, Golden, CO, 80401, United States

Concentrated solar power (CSP) plants paired with thermal energy storage present a promising path towards developing utility-scale renewable energy. To support CSP operator decisions in a real-time setting, a revenue maximizing non-convex mixed-integer, quadradically-constrained program was developed for dispatch scheduling. Amongst commercial CSP plants, the reliability of the steam generator is the most noted issue regarding availability. Thermo-mechanical stress is a main contributor to premature leak-failure within the shell-and-tube heat exchangers (STHX). This work develops a predictive modeling tool that evaluates the thermo-mechanical stress within STHXs for off-design operations. The results from this model inform dispatch decisions such as ramping rates and maintenance forecasting within the optimization model.

2 - Real-time Dispatch Optimization for Concentrating Solar Power with Thermal Energy Storage

John Cox, MS, Colorado School of Mines, Golden, CO, 80401, United States

Concentrating solar power plants with thermal energy storage present a promising path towards utility-scale renewable energy. To support operator decisions in a real-time setting, we develop a revenue-maximizing non-convex mixed-integer, quadradically-constrained program which determines a dispatch schedule with sub-hourly time fidelity and considers temperature-dependent efficiency. We present exact and inexact techniques to improve tractability. Our approach admits solutions within 5\% of optimality, on average, within a five-minute time limit, demonstrating its usability for decision support in a real-time setting.

3 - Using Concentrating Solar Power Plants as Capacity Resources

Ramteen Sioshansi, The Ohio State University, Department Of Integrated Systems Engineering Baker, Columbus, OH, 43210-1273, United States, Kenjiro Yagi, Paul Denholm

In this talk, we explore the use of concentrating solar power plants as capacity resources in electric power systems.

■ WB19

CC Room 203A

In Person: Improving Patient Outcomes/Learning vs Earning Trade-offs in Healthcare

General Session

Chair: Seungyup Lee, Vanderbilt University Medical Center

1 - Service Chains' Operational Strategies: Standardization or Customization?

Lu Kong, University of South Florida, Sarasota, FL, United States, Kejia Hu, Rohit Verma

In this research, we investigate within a customer-recognizable service chain, how standardization and customization across chain-belonging units impact that chain's performance outcomes. We study this question in the nursing home industry. Using rich archival data, we study the Degree of Standardization (DoS) in three operational dimensions: customer mix, service offering, and service delivery, and its impact on three nursing home outcomes: financial outcome, clinical outcome, and resident welfare. We also discuss the implication of our results during a public crisis such as the COVID-19.

2 - Evaluation and Mitigation of Estimation Bias of the Bayesian Beta-bernoulli Two-armed Bandit Problem with Binary Responses
Amin Yarahmadi, Lancaster University, Lancaster, United Kingdom, Peter Jacko

To derive a response-adaptive procedure as an optimal policy to a dynamic optimization problem, we consider the Bayesian Beta-Bernoulli finite-horizon two-armed bandit problem in which binary responses are modelled as Bernoulli random variables and the objective function is defined by maximising the Bayes-expected total number of patient successes in the trial which we call the patient benefit. We first evaluate the per-treatment bias of Maximum Likelihood Estimator (MLE) showing that it is unacceptably high and variable. We propose a new augmented estimator with the aim to mitigate the estimation bias. Using simulations we show that the proposed estimator can be tuned to provide results in which estimation bias and its variability is notably improved. We also investigate several novel modifications of the dynamics of the bandit problem to obtain further improvements.

3 - Adaptive Seamless Dose Finding Clinical Trials
Amin Khademi, Clemson University, Clemson, SC, 29634, United States, Ningyuan Chen

In this work, we study the adaptive design of dose-finding Phase II clinical trials, by simultaneously considering efficacy and toxicity. We formulate this problem as a non-parametric bandit problem and propose two policies. The first one is based on dose escalation principles and the second one is based on bisection search and UCB algorithms. We test the performance of these algorithms along with benchmarks on synthetic and real datasets.

■ WB20

CC Room 203B

In Person: Health Care I

Contributed Session

Chair: Hui Jia, University of Tennessee, Knoxville, TN, 37916, United States

1 - Detection of Blood Clots Within Pulmonary Microcirculation Following E-cigarette Exposure in Mice
Reza Iranzad, University of Arkansas, Fayetteville, AR, United States, Xiao Liu, Margaret Bennewitz, Hunter Snoderly

Edge detection of medical imaging data plays a vital role that helps radiologists, pathologists and improves diagnostic accuracy. In this context, an algorithm is demonstrated through the edge detection of imaging data collected during a medical experiment on mice lungs when exposed to E-cigarette. The edge detection algorithm uses feature engineering coupled with a tree-based ensemble model for medical imaging data. The process helps extract features from raw images and utilizes these features to improve edge detection performance.

2 - The Impact of Economic Insecurity on Covid-19 Mitigation Efforts
Kellas Cameron, Assistant Professor, University of South Florida, Tampa, FL, United States, Deepti Singh

Due to the way that the US federal government delegated the effort to mitigate the impact of the Covid-19 pandemic to state governments, we saw how various prevention methodologies significantly impacted both state infection rates and economic impacts. Different lockdown protocols, social distancing mandates, and mask requirements, implemented over the three waves of the pandemic were posited to have different impacts dependent on state culture, climate, and economic stability. Our work compares three economically similar states Texas, California, and Florida and demonstrates how a state's view of economic insecurity significantly drove infections rates and economic recoveries.

3 - Hospital-physician Integration and Cardiac Surgery Outcomes: A U-shaped Relationship?
Hui Jia, University of Tennessee, Knoxville, Knoxville, TN, United States

We utilize patient-visit level information for Florida patients hospitalized for coronary artery bypass graft (CABG) to test hypotheses that posit a U-shaped association between integration and care outcomes such as patient length of stay (LOS), in-hospital mortality risk, and readmission risk. This study defines the level of integration between a hospital and its cardiovascular surgeons as the fraction of surgeons who operate only at that hospital. Our econometric analysis indicates that patient LOS and mortality risk are minimized at integration tipping points of 51% and 45%, respectively.

4 - Is Supply Chain Diversion Fueling the Opioid Crisis? Evidence From a Quasi-Experiment
Jingwen Yang, PhD Candidate, University of Minnesota-Twin Cities, Minneapolis, MN, United States

This study investigates the impact of supply chain diversion on prescription opioid abuse. It relies on the enactment of the Drug Supply Chain Security Act (DSCSA) as an "anti-diversion" exogenous shock that gives rise to a quasi-experimental design. Exploiting cross-state variations in opioid diversion exposure, the study finds that after the enactment of the DSCSA, states with higher initial prescription opioids seizure rates experience larger decreases in prescription opioid abuse. Such decreases are significant among the female, younger-aged and white populations. The study further explores a potential diversion mechanism and the most targeted prescription opioids.

■ WB22

CC Room 204B

In Person: Empirical and Behavioral Research in Service Operations

General Session

Chair: Hyun Seok (Huck) Lee, Korea University Business School, 97333-3235

1 - The Gatekeeper's Dilemma: When Should I Transfer This Customer?
Maqbool Dada, Johns Hopkins Carey Business School, Baltimore, MD, United States, Evgeny Kagan, Brett Hathaway

In many service encounters front-line workers (often referred to as gatekeepers) have the discretion to attempt to resolve a customer request, or to transfer the customer to an expert service provider. We study the gatekeeper's transfer decision analytically and experimentally. Our experimental results offer mixed support for rational model predictions and advance our understanding of cognitive capabilities and rationality limits on human server behavior in queueing systems.

■ WB23

CC Room 204C

In Person: Analytics in Service Operations

General Session

Chair: Lennart Baardman, University of Michigan, Ann Arbor, MI, 48103, United States

1 - Taylor Approximation of Data-Driven Inventory Policies for Distribution Systems with Feature Information
Kevin Shang, Duke University, Fuqua School of Business, Durham, NC, 27708-9972, United States

This paper studies a pricing problem for a single-server queue where customers arrive according to a Poisson process. For each arriving customer, the service provider announces a price rate and a system wait time, and the customer decides whether to join the queue and the duration of the service time. The objective is to maximize either the long-run average revenue or social welfare. We formulate this problem as a continuous-time control model whose optimality conditions form a set of delay differential equations. We develop an innovative method to obtain the optimal control policy, whose structure reveals new insights. In particular, the provider should compensate the customer by lowering the price when the wait time is sufficiently long. In a numerical study, we find that our revenue-maximizing pricing policy can also improve social welfare over the static pricing policy.

2 - Joint Product Ranking and Inventory Planning on Online Platforms
Zijin Zhang, University of Michigan, Ann Arbor, MI, United States, Hyun-Soo Ahn, Lennart Baardman

In e-commerce, page displays are real estate and how items are shown (e.g., vertical ranking) affects consumer behavior, hence demand. Data shows items placed in top positions substantially receive more clicks or scroll-locks. In this paper, we consider joint inventory planning and product ranking. Specifically, we study analytic models in three separate scenarios: order and rank only once, order and ranking changes over time, and learn to order and rank. We develop an optimal polynomial-time algorithm when order quantities and ranking decisions are made simultaneously. This algorithm and its variant are also proven to be asymptotically optimal when ranking changes over time. Furthermore, we extend it to dynamic settings: real-time optimization and online learning. By analyzing these two extensions, our algorithms remain strong both theoretically and practically.

■ WB24

CC Room 205A

In Person: Technology-driven Emerging Issues in Supply Chains

General Session

Chair: Junghee Lee, University of Notre Dame, New Orleans, LA, 70118-5669, United States

1 - Supplier Development in a Coopetition Setting

Xinxue Qu, University of Notre Dame, Granger, IN, 46530-8209, United States, Hemant K. Bhargava, Daewon Sun

Channel partnership can take many forms, including those where partners also engage in direct competition. Manufacturers and retailers partner to sell goods but retailers can often have their own competing products. Similarly, component specialists partner with producers in offering complete goods to consumers, but component makers sometimes also compete with an end-user product. For instance, Samsung supplies OLED screens that are used in Apple's iPhone X, but Samsung also makes high-end phones that directly compete with Apple's iPhone X. This study aims to analyze the economic tensions and interplay involved in R&D investment in such market settings. The effect of several market variables, including the intensity of competition in the end-user market, firms' market advantage, and the efficiency for product development, is also examined.

2 - Supply Chain Relationship Impacts on Firms' Environmental CSR Practice

Marcus A. Bellamy, Boston University, Rafik B. Hariri Building, Boston, MA, 02215, United States, Elliot Bendoly, Erin McKie

Our study emphasizes how a firm's corporate social responsibility (CSR) efforts are linked to their supply chain entities. Specifically, we examine how changes in Environmental CSR occur across members of their supply chains using supply chain relationship and environmental data over a 10-year period. Based on these findings, we discuss the implications of firms' supply chain engagements and selections.

3 - First or Second Dose first? Two-dose Vaccine Allocation under Finite Capacity

Yun Zhou, McMaster University, Hamilton, ON, L9A 0A3, Canada, Ming Hu

Most Covid-19 vaccines require two doses for a recipient to be considered as fully vaccinated. However, receiving only one dose still provides some protection. We study the allocation of vaccination capacity between 1st and 2nd doses. Building on the SIR model, we formulate an optimal control model and show that the optimal policy makes an all-or-nothing-type allocation at any time instant. We then compare the "first doses first" and "second doses first" policies. We find that even if the 1-dose efficacy is slightly greater than 50% of the 2-dose efficacy, "second doses first" is still better.

■ WB25

CC Room 205B

In Person: Algorithms and Software for Optimization under Uncertainty

General Session

Chair: Weiqi Zhang, Middleton, WI, 53562, United States

1 - ROC++: Robust Optimization in C++

Qing Jin, University of Southern California, Los Angeles, CA, United States, Phebe Vayanos

We propose ROC++, an open source C++ based platform for automatic robust optimization, applicable to a wide array of single- and multi-stage robust problems with both exogenous and endogenous uncertain parameters, that is easy to both use and extend. It also applies to certain classes of stochastic programs involving continuously distributed uncertain parameters and decision-dependent information discovery. We also offers ROPy, a Python interface in the form of a callable library. We showcase the modeling power of ROC++ on several decision-making problems of practical interest. Our platform can help streamline the modeling and solution of stochastic and robust optimization problems for both researchers and practitioners.

2 - Mixed Integer Bilevel Linear Optimization with Bounded Rationality

Yu Xie, Lehigh University, Bethlehem, PA, United States, Ted K. Ralphs

We consider mixed integer linear bilevel optimization problems in which the leader makes an initial decision, and then the follower reacts. Unlike the traditional setting, where decision-makers are assumed to have complete information and act rationally, we consider situations in which the follower may face a difficult optimization in determining their reaction and may therefore not pursue a globally optimal solution to their problem. In such cases, the leader seeks a solution that is robust against a wider range of possible actions by the follower. We discuss modeling and solution procedures for such bounded rationality problems using a branch-and-cut framework.

3 - On the Tightness and Scalability of the Lagrangian Dual Bound for the Alternating Current Optimal Power Flow Problem

Weiqi Zhang, University of Wisconsin-Madison, Madison, WI, United States, Kibaek Kim, Victor Zavala

We study tightness and scalability properties of a Lagrangian dual (LD) bound for the nonconvex alternating current optimal power flow (ACOPF) problem. We show that the LD bound is as tight as that provided by the powerful and popular semidefinite programming relaxation. However, a key advantage of the proposed bound is that it can be computed in a parallel, decentralized manner. Specifically, in the proposed approach we partition the network into a set of subnetworks, we dualize the coupling constraints (giving the LD function), and we maximize the LD function with respect to the dual variables of the coupling constraints (giving the desired LD bound). The dual variables that maximize the LD are obtained by using a bundle method and we provide a proof of convergence for such method.We demonstrate our developments using PGLib test instances.

■ WB27

CC Room 206B

In Person: Optimization in Quantum Computing and Vice Versa I

General Session

Chair: Baoyu Zhou, Lehigh University, Bethlehem, PA, 18015, United States

1 - Automated Design of Magnetic Resonance Pulse Sequences Using Physics-inspired Optimization

Stephen Jordan, Microsoft, Redmond, WA, United States

Quantum annealing is a form of quantum computation that can solve non-convex optimization problems using tunneling effects to escape from local minima. However, in many cases the benefit of such tunneling phenomena can be replicated by Monte Carlo methods on standard classical computers. Here we describe the application of physics-inspired optimization methods to the automated design of pulse sequences for magnetic resonance imaging. This is a non-convex optimization problem with thousands of variables. Our global optimization methods, starting from random initial states, have produced novel pulse sequences which reduce the duration of brain scans by up to 4x relative to state of the art sequences designed by human experts, while also achieving robustness against systematic error due to magnetic field inhomogeneities in the scanner.

2 - Fast Quantum State Tomography via Accelerated Non-convex Programming

J. Lyle Kim, Rice University, Houston, TX, United States

We propose a new quantum state reconstruction method, called Momentum-Inspired Factored Gradient Descent (MiFGD), that combines ideas from compressed sensing, non-convex optimization, and acceleration methods. Despite being a non-convex method, MiFGD converges provably to the true density matrix at a linear rate under common assumptions. With this manuscript, we present the method, prove its convergence property and provide Frobenius norm bound guarantees with respect to the true density matrix. From a practical point of view, we benchmark the algorithm performance with respect to other existing methods, in both synthetic and real experiments performed on an IBM's quantum processing unit. We find that the proposed algorithm performs orders of magnitude faster than state of the art approaches, with the same or better accuracy.

3 - Fast Approximation for Power System State Estimation under Cyber Attacks

Kamal Basulaiman, University of Pittsburgh, Pittsburgh, PA, United States

Power system state estimation (PSSE) is yet a critical problem. With the increasing emergence of renewable energy resources, the power system states are becoming less predictable. Therefore, there is an urgent need for frontier models that can accurately estimates the system states with the associated surges to monitor the electric power system in an economic and secure fashion. This work addresses the PSSE problem when the data is corrupted by cyber attacks. This problem is non-convex and known to be NP-hard in general. We propose a fast approximation via deep learning that is suitable for real-time setting. Experimental results demonstrate the capability of our model compared to the state-of-the-art.

■ WB28

CC Room 207B

In Person: Stochastic Integer Programming and Its Applications

General Session

Chair: Yiling Zhang, University of Minnesota, Minneapolis, MN, 55455-0141, United States

1 - Distributionally Robust Bilevel Programming and Applications of Facility Location

Yiling Zhang, University of Minnesota, Minneapolis, MN, 55455-0141, United States, Chuan He, Akshit Goyal

We study distributionally robust two-stage stochastic bilevel programs (DRBPs) in the context of sequential two-player games under uncertainty, where the leader makes a binary here-and-now decision. After observing the leader's decision and realization of uncertainty, the follower responds with a continuous wait-and-see decision. We show that the DRBP is equivalent to a DR two-stage stochastic integer program with uncertainty in both objective and constraints. Under both moment-based and Wasserstein ambiguity sets, we derive 0-1 semidefinite and copositive programs. Computational study of a facility location problem is conducted to demonstrate the efficiency and effectiveness.

2 - Tight Conic Approximations for Two-Sided Chance-Constrained Optimization

Abolhassan Fathabad, University of Arizona, Tucson, AZ, United States, Jianqiang Cheng, Kai Pan, Boshi Yang

In this talk, we focus on developing tight conic approximations for two-sided chance constrained (TCC) programs with an application to AC optimal power flow problem. We present an efficient second-order cone programming (SOCP) approximation of the TCC programs under Gaussian Mixture (GM) distribution. As compared to the conventional normality assumption for forecast errors, the GM distribution adds an extra level of accuracy representing the uncertainties. Moreover, we show that our SOCP formulation has adjustable rates of accuracy and its optimal value enjoys asymptotic convergence properties. Finally, we demonstrate the effectiveness of our proposed approaches with both real historical data and synthetic data on the IEEE 118-bus system.

■ WB29

CC Room 207C

In Person: Application of Stochastic Programming to COVID-19 Related Problems

General Session

Chair: Lewis Ntaimo, Texas A&M University, College Station, TX, 77843, United States

1 - A Distributionally Robust Optimization Approach for Location and Inventory Prepositioning of Disaster Relief Supplies

Karmel S. Shehadeh, Lehigh University, Bethlehem, PA, 18015-1518, United States, Emily L. Tucker

We study the problem of disaster relief inventory prepositioning under uncertainty of disaster level and location, demand of relief items, usable fraction of prepositioned items post-disaster, procurement quantity, and arc capacity. We propose distributionally robust optimization (DRO) and stochastic programming (SP) approaches, assuming unknown and known uncertainty distributions, respectively. To illustrate potential applications of our approach, we conduct extensive experiments using a hurricane season and an earthquake as case studies. Our results demonstrate the (1) superior operational performance of the DRO decisions compared to SP decisions, (2) trade-off between DRO pessimism and SP optimism, and (3) computational efficiency of our approaches.

2 - Optimal COVID-19 Vaccine Allocation under Uncertain Transmission Characteristics Using Stochastic Programming

Lewis Ntaimo, Texas A&M University, College Station, TX, 77843, United States, Jiangyue Gong, Brittany Segundo, Krishna Reddy Gujjula

We present a chance constrained stochastic programming model to determine optimal COVID-19 vaccination policies for a multi-community population under variability in parameters related to vaccines, age-specific effect of SARS-CoV-2, and social behaviors. The optimal solution provides the minimum number of vaccines to prevent epidemics for a specified reliability level for a given community and the results show that around 80% of the population needs to be vaccinated and vaccines should be targeted towards larger household sizes.

■ WB30

CC Room 207D

In Person: The Internet of Federated Things: An Overview of Federated Learning and a Vision for the Future

Panel Session

Chair: Raed Al Kontar, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - Panelist

Seokhyun Chung, University of Michigan, Ann Arbor, MI, 48109-2117, United States

2 - Panelist

Naichen Shi, University of Michigan, MI, United States

■ WB31

CC Room 208A

In Person: Emerging Topics in Social Media Analytics

General Session

Chair: Tauhid Zaman, Yale University, Boston, MA, 02114, United States

1 - Time-constrained Data Collection for Seeding Time-critical Interventions

M. Amin Rahimian, University of Pittsburgh, Pittsburgh, PA, United States, Sanzeed Anwar, Dean Eckles

Seeding strategies rely on knowledge of social network structure to choose local intervention points that maximally spread information or a desired social behavior. In practice, such structural knowledge of social networks is costly and time-consuming to obtain. In this paper, we provide a framework for performing time-constrained structural queries that inform the design of time-critical seeding interventions (where one cares about not only the eventual extent of the spread, but also the speed at which new adopters join the campaign). Our theoretical results address the following question: how much time and sampling resources the researchers need to spend to acquire enough information for designing seeding interventions with appropriate quality guarantees.

2 - To Pay or Not to Pay: Targeting Referral Rewards in the Presence of Voluntary Word-of-Mouth Diffusion

Shatian Wang, Columbia University, New York, NY, 10027-6715, United States

Marketing campaigns should capitalize on voluntary word-of-mouth (WoM) to avoid paying for diffusion (via referral rewards) that would have otherwise occurred for free. In the presence of voluntary WoM, we study referral rewards targeting and identify conditions where it is optimal to target a strict subset rather than the entire customer population within two settings: 1) a random network model in which the campaign can only access population-level characteristics and 2) explicit network models in which the campaign has full knowledge of individual consumers' social network.

3 - Text Analysis in Social Media Using Transformers

Tauhid Zaman, Yale University, New Haven, CT, United States

In this session we will provide a hands-on course on how to use transformer neural networks to measure the sentiment of social media posts. We will begin with an overview of transformer architectures. Then we will show how to use pre-trained transformers to measure a variety of sentiments on social media posts. These include standard positive and negative sentiment, but also more complex sentiments such as toxicity, joy, and optimism. Finally, we will apply these transformers to real Twitter data to find novel connections between sentiment and engagement on social media. This session will be interactive and attendees will be given access to all Python code used.

■ WB32

CC Room 208B

In Person: New Directions in Pricing and Auction Design

General Session

Chair: Amine Allouah, Columbia University, New York, NY, 10027, United States

1 - Optimal Auction Design with Deferred Inspection and Reward
Azarakhsh Malekian, University of Toronto, Toronto, ON, 02143-2434, United States, Saeed Alaei, Alexandre Belloni, Ali Makhdoumi

Consider a mechanism run by an auctioneer who can use both payment and inspection instruments to incentivize agents. The timeline of the events is as follows. Based on a pre-specified allocation rule and the reported values of agents, the auctioneer allocates the item and secures the reported values as deposits. The auctioneer then inspects the values of agents and, using a pre-specified reward rule, rewards the ones that have reported truthfully. Using techniques from convex analysis and calculus of variation, for any distribution of values, we fully characterize the optimal mechanism for a single agent. Using Border's theorem and duality, we find conditions under which our characterization extends to multiple agents. The optimal allocation function is not a thresholding strategy and instead is an increasing and continuous function of the types.

2 - Persuading Customers to Buy Early: The Value of Personalized Information Provisioning
Ramandeep Randhawa, University of Southern California, Los Angeles, CA, 90089-1035, United States, Kimon Drakopoulos, Shobhit Jain

We study a pricing and information provisioning game between a better informed seller (such as a retailer) and its customers. The seller is (ex-post) better informed about product availability and can choose how to communicate this information to the customers. Using a Bayesian persuasion framework, we find that public information provisioning in which the firm sends the same information to all customers has limited value. However, personalized information provisioning, in which the firm can share different information with different customers, has significant value and has attributes very similar to personalized pricing.

3 - Optimal Pricing with a Single Point
Achraf Bahamou, Columbia University, Columbia, NY, United States, Amine Allouah, Omar Besbes

We study the following fundamental data-driven pricing problem. How can/should a decision-maker price its product based on observations at a single historical price? The decision-maker optimizes over (potentially randomized) pricing policies to maximize the worst-case ratio of the revenue she can garner compared to an oracle with full knowledge of the distribution of values when the latter is only assumed to belong to a broad non-parametric set. In particular, our framework applies to the widely used regular and monotone non-decreasing hazard rate (mhr) classes of distributions. For settings where the seller knows the exact probability of sale associated with one historical price or only a confidence interval for it, we fully characterize optimal performance and near-optimal pricing algorithms that adjust to the information at hand. The framework we develop is general and allows to characterize optimal performance for deterministic or more general randomized mechanisms, and leads to fundamental novel insights on the value of information for pricing. As examples, against mhr distributions, we show that it is possible to guarantee 85% of oracle performance if one knows that half of the customers have bought at the historical price, and if only 1% of the customers bought, it is still possible to guarantee 51% of oracle performance.

■ WB33

CC Room 209A

In Person: Joint Inventory and Pricing Models

General Session

Chair: Emily Barbee, University of Alabama, Tuscaloosa, AL, United States

1 - Implications of Worker Classification in On-Demand Economy
Zhoupeng (Jack) Zhang, Rotman School of Management, University of Toronto, Toronto, ON, M5 S. 3E6, Canada, Ming Hu, Jianfu Wang

Workers in the gig economy have long been treated as independent contractors, which disqualifies them from employee benefits. We evaluate the impacts of California Assembly Bill 5 (AB5), a statute that requires on-demand platforms to reclassify their workers as employees. We model the service process of such a platform as a queueing system with long-term (LT) and ad hoc (AH) workers. We show that AB5 does not always improve LT workers' welfare because, in the free market, the presence of AH workers can incentivize the company to pay a high piece-rate wage. While the company's profit always decreases, transaction volume can either increase or decrease due to AB5, rendering consumer welfare implications ambiguous. We propose a way to refine the current AB5.

2 - Inventory and Pricing Optimization for Resale Firms
Emily C. Barbee, University of Alabama, Tuscaloosa, AL, United States, BurcuB. Keskin

Recent growth in e-commerce and sustainability has fueled demand for resale. Resale firms source used goods from consumers online. Supply is uncertain and item quality varies. We model this unique context as a joint inventory and pricing problem. We investigate responsive and committed pricing under price- and quality-dependent demand.

■ WB34

CC Room 209B

In Person: Transportation-Freight and Logistics

Contributed Session

Chair: Giulia Burchi, DecisionBrain, Paris, 75010, France

1 - The End of "Set It and Forget It" Pricing? Opportunities For Market-based Freight Contracts
Angela Acocella, Massachusetts Institute of Technology, Cambridge, MA, United States, Chris Caplice, Yossi Sheffi

In the for-hire truckload market, firms experience unexpected costs from contracted transportation service providers due to load rejections. Moreover, the dominant procurement strategy results in long-term fixed-price contracts that become stale as providers' networks change and freight markets fluctuate between over and under supply. We build behavioral models of carriers' load acceptance decisions under two distinct market conditions. We quantify carriers' contract price stickiness as their best-known alternative priced load options become more attractive for different lane, freight, and carrier segments to identify best opportunities for market-based contracts.

2 - A Holistic Approach for Intermodal Facility Location and Freight Distribution under Hurricane Disruptions
Vishal Badyal, Clemson University, Clemson, SC, United States, William G. Ferrell, Nathan Huynh, Bhavya Padmanabhan

We study the intermodal facility location problem under hurricane disruptions. Hurricanes can cause disruption in supply at shippers and throughput capacity at intermodal facilities. Realistic hurricane scenarios are generated using k-means clustering. A level method-based decomposition solution approach is applied. The model is tested and validated by developing a case study for the state of South Carolina. Real-world data sets (FAF4 and HURDAT2) are used. The results show that as direct shipping costs increase, the long-term savings using this model increase non-linearly. The increase in direct shipping cost leads to more intermodal locations selected despite being partially disrupted.

3 - Inbound Logistics Optimization Solution for Toyota
Giulia Burchi, DecisionBrain, Paris, France

In this presentation, DecisionBrain will talk about an inbound logistics optimization solution for Toyota, which resulted in over 10% cost reductions. The project was completed in 8 months, from conception to go-live. This produced a high ROI and a payback time of less than one year. The solution focused on optimizing the Orders Grouping, Trucks Routing: and 3D packing.The solution was built on top of IBM Cplex Optimization Studio and on IBM Decision Optimization Center (DOC), which allowed for a fast and effective implementation, from design to deployment, delivering significant ROI.

■ WB35

CC Room 210A

In Person: Tackling Emerging Logistics Challenges with Large-scale Analytics

General Session

Chair: Alexandria Schmid, MIT, Somerville, MA, 02143, United States

1 - Submodular Dispatching
Ignacio Erazo, ISyE Georgia Tech, Atlanta, GA, United States, Alejandro Toriello

We introduce a submodular dispatching model motivated by applications in e-commerce distribution and scheduling, among others. A server must process a set of jobs to minimize the makespan; jobs have release times and the server is dispatched to process jobs in batches, where the batch dispatching time is non-decreasing and submodular. We prove that the general problem is strongly NP-hard, and characterize "FIFO-optimal" processing time functions for which an efficient dynamic program is optimal. The algorithm produces the optimal batch selection in which jobs are processed in FIFO order, which also serves as a heuristic for the general case, where we show that it has a 1.5 approximation ratio. We also study the lower bound provided by a column generation LP, and verify the efficacy of our heuristic and bound in computational experiments.

2 - Gpu-based Algorithms for Real-time Dial-a-ride Problems

Ramesh Ramasani Pandi, Postdoc, HEC Montreal, Montréal, QC, Canada, Yossiri Adulyasak, Jean-Francois Cordeau, Louis-Martin Rousseau

We study the Real-time Dial-a-ride problems (RT-DARP) and discuss how state-of-the-art GPU technology can be employed to solve RT-DARP. In this problem, the requests arrive dynamically, customers expect quick responses, and vehicles keep moving while computing assignments. Most transportation studies focus on sequential algorithms. We design a GPU-based Adaptive Large Neighborhood Search in a rolling-horizon framework for RT-DARP. The idea is to perform compute-intensive neighborhood explorations in GPU while retaining the control-intensive statements in CPU. We conduct experiments on benchmark instances from the literature and show the effectiveness of GPU on generating high-quality solutions in real-time.

3 - Dynamic Load Dependent Container Pickup and Delivery Problem with Simulation

Siyuan Yao, PhD Student, University of Southern California, Los Angeles, CA, United States, Maged M. Dessouky

A Multicommodity Network Flow problem is defined on a capacitated network with fixed edge costs. However, in a transportation network, edge costs depend on traffic flow in the network. Traditionally, pure mathematical formulations depict cost-flow linear relationships, which may not fit large-scale transportation networks with heterogeneous road and vehicle types. We introduce a Co-simulation-based optimization approach to estimate the network cost and provide routing decisions.

4 - Vehicle Routing Optimization with Relay: An Arc-Based Column Generation Approach

Alexandria Schmid, MIT, Somerville, MA, 02143, United States, Alexandre Jacquillat, Kai Wang

Several logistics providers are leveraging a new relay-based operating model: orders are routed from origin to destination through a series of pit stops and a different driver is assigned to each segment. These operations allow drivers to return home more often and offer opportunity for improved efficiency. At the same time, they raise questions on how to coordinate operations in relay networks. We propose a novel integer programming formulation to optimize the flow of trucks, drivers and orders in a time-space network. To solve it, we propose an original arc-based column generation algorithm, which generates arcs iteratively until convergence to a globally optimal solution. Results show that the algorithm outperforms traditional column generation and direct IP solutions. We conclude with practical insights from a case study on a relay logistics provider in India.

■ WB36

CC Room 210B

In Person: Behavioral Operations

Contributed Session

Chair: Lyudmyla Starostyuk, Metropolitan State University of Denver, Denver, CO, 80209, United States

1 - Performance Impacts of Social and Knowledge Network Alignment in Expertise Search

Aaron Schecter, University of Georgia, Athens, GA, United States, Kaitlin Wowak, Ujjal Kumar Mukherjee

In many organizations, complex problems are solved by effectively identifying individuals with the appropriate expertise and directing problems to them. Members of an organization are linked by two types of networks: Social networks, comprised of behavioral interactions; and knowledge networks, which represent the implicit connections between individuals' expertise. This research examines the role of these two networks on heuristic expertise search, particularly when they converge or diverge. We study the technical service center of a large knowledge-intensive organization and identify both normative behaviors and corresponding performance impacts.

2 - Artificial Intelligence in Customer Service Operations

Aykut Turkoglu, Boston University, Boston, MA, United States, Michelle A. Shell

Companies are deploying artificial intelligence applications into service settings in a variety of ways from automating agent tasks to replacing human servers altogether. Using data from a field study, we provide early evidence that AI-based call monitoring and agent coaching improves both efficiency and customer satisfaction over human supervision alone.

3 - Do Attractive People Make a Better Deal? An Experimental Study

Lyudmyla Starostyuk, PhD, Metropolitan State University of Denver, Denver, CO, United States, Yan Lang, Kay-Yut Chen

The goal of our research is to shed light on the existence of an effect of seeing human faces (i.e., "face effect") on the behavioral economic choices. We conduct a series of controlled experiments with the photographs of human faces shown in the newsvendor setting. The experimental data suggests that the human face plays the role of an environmental moderator which triggers and intensifies the social considerations such as altruism and fairness. Moreover, we find that the facial attractiveness and gender are significant motivators for the behavioral shifts in economic decisions.

4 - The Impact of Cash Transfer Participation on Child Labor in Brazil

Fernanda Araujo Maciel, Assistant Professor, California State University, Sacramento, Sacramento, CA, United States

The objective of this study is to assess the impact of Brazil's Bolsa Familia conditional cash transfer program on child labor. Applying Machine Learning models to improve the estimation of the propensity score method, I analyze the effect of participating in the program on the probability of having worked in the past week and on the number of hours worked among children of 6 to 15 years old. Preliminary results show that child labor increase by 1.8 percentage points among households participating in the Bolsa Familia program. The number of hours allocated for work in this age group is not statistically different between recipients and non-recipients.

■ WB37

CC Room 210C

In Person: Learning and Dynamic Pricing

General Session

Chair: Rene A Caldentey, The University of Chicago, Chicago, IL, 60637-1656, United States

1 - Incentive Design and Pricing under Limited Inventory

Ruiting Zuo, National University of Singapore, Singapore, 138601, Singapore, Jussi Keppo, Tinglong Dai

We consider an airline company that sells tickets for its flight. To boost the demand, the company hires a sales agent who exerts unobservable effort over time in response to a dynamic compensation contract offered by the airline company. The company is concerned not only about utilizing its capacity, but also about loss of goodwill when the realized demand exceeds its capacity. We model the company's dynamic compensation and pricing problem using a continuous-time principal-agent framework. The dynamic strategy depends on the random demand, remaining capacity level, and the time to the departure. Under the estimated model parameters and optimal dynamic pricing, the optimal static compensation scheme provides the airline company with over 99% of the benefits derived from the corresponding optimal dynamic compensation scheme.

2 - Diffusion Approximations for a Class of Sequential Learning Problems

Rene A. Caldentey, The University of Chicago, Booth School Of Business, Chicago, IL, 60637-1656, United States, Victor Araman

We consider a decision maker who must choose an action in order to maximize a reward function that depends also on an unknown parameter. The decision maker can delay taking the action in order to experiment and gather additional information on the unknown parameter. We model the decision maker's problem using a Bayesian sequential experimentation framework and use dynamic programming and diffusion-asymptotic analysis to solve it. For that, we scale our problem in a way that both the average number of experiments that is conducted per unit of time is large and the informativeness of each individual experiment is low. Under such regime, we derive a diffusion approximation for the sequential experimentation problem, which provides a number of important insights about the nature of the problem and its solution."

■ WB40

CC Room 211B

In Person: Managing Uncertainty and Scarcity in Energy Systems: Part II

General Session

Chair: Sebastian Souyris, University of Illinois Urbana-Champaign, Champaign, IL, 61820, United States

1 - Network Effects and Incentives in Solar Panel Diffusion: A Dynamic Discrete Choice Approach

Sebastian Souyris, University of Illinois Urbana-Champaign, Urbana, IL, 61801-4860, United States, Anantaram Balakrishnan, Jason Duan, Varun Rai

As the price of residential photovoltaic (PV) solar panels and government incentives decline intandem, rendering the net cost relatively flat over the years, the annual new solar capacity hasbeen increasing significantly since 1998. In this paper, we study the PV solar panel market inAustin, Texas. We develop a dynamic discrete choice model that explores the neighborhoodnetwork effects and the results of various incentive policies on the diffusion of PV systems. Wefind the network effects are significant, and unobserved household heterogeneity isconsiderable. We use policy simulations to predict the potential impact of various rebateschedules and optimize rebates according to the policymaker objective.

Wednesday, 9:45AM 10:45AM

■ Wednesday Plenary 01

CC Ballroom E /Virtual Theater 1

Plenary: Improving Supply Chain Resilience: Looking Back and Looking Forward

Plenary Session

1 - Plenary: Improving Supply Chain Resilience: Looking Back and Looking Forward

Christopher S. Tang, University of California-Los Angeles, UCLA Anderson School of Management, Operations and, Los Angeles, CA, 90095-1481, United States

Prolonged shortages of PPE, vaccines, and semiconductor chips during the Covid-19 Pandemic exposed the vulnerabilities of global supply chains. In this plenary talk, I share my observations and discuss potential steps that government representatives, industry leaders, and INFORMS members can take to improve supply chain resilience."

Wednesday, 11:00AM-12:20PM

■ WC07

CC Room 303B

In Person: Social Media and Online Platforms

General Session

Chair: Yun Young Hur, Georgia Tech, Atlanta, GA, 30312, United States

1 - Engagement in Interactive Social Media Campaigns: Joint Effects of Social Cause and Monetary Reward

Elizabeth Han, Georgia Institute of Technology, Atlanta, GA, United States, Han Zhang, Samuel Bond

Interactivesocial media campaigns, which ask consumers to create user-generated contentson behalf of a brand, have been a popular social media marketing strategy. Inthis work, we examine how the two common incentives (social cause; monetaryrewards) influence engagement in these campaigns. Based on theself-determination theory, we propose that incorporating social cause ormonetary rewards in a campaign will increase engagement, but adding both willbe counter-productive due to the crowding-out of the conflicting motivations.Results from two laboratory experiments confirm our hypotheses. Our researchprovides insights on engagement in social media campaigns and contentgeneration.

2 - Netflix or AMC: Predicting Release Strategies in the Age of Options

Lavada Blanton, Masters Candidate, Oklahoma State University, Stillwater, OK, United States

Given the pandemic, production companies must decide the risks involved in the traditional movie release vs alternatives (e.g., Netflix). This project analyzed 1,605 movies, released through either the traditional movie theater format or through a streaming service since 2010. To compare distribution type, box office success in streaming movies is predicted based on a theatrical release model. Box office revenue is compared between distribution methods to profile movies based on categories such as genre and release month. Key indicators of box office success are evaluated to find the optimal "Movie Mix" based on release strategy.

3 - The Impact of Physical Attractiveness on Donation and Sharing in Medical Crowdfunding: A Large-scale Randomized Field Experiment

Yun Young Hur, Georgia Tech, Georgia, Atlanta, GA, 30312, United States

This study examines the impact of physical attractiveness on two types of helping behavior: sharing and donation, in the context of medical crowdfunding. We conduct a large-scale randomized field experiment with one of the largest medical crowdfunding platforms in China to discover the beauty penalty for female patients in raising donations and the beauty premium for male patients in sharing medical crowdfunding posts. Neither the penalty for female patients nor the premium for male patients is replicated in the other type of helping behavior. We refer to the impression management theory and explain our findings in relation to people's tendencies to manage impressions in public and show less restricted behaviors in private. Using two moderators, we affirm that impression management is more salient when a larger audience observes the behavior.

■ WC08

CC Room 303C

In Person: Random Graphs and Learning in Applied Probability

General Session

Chair: Jiaming Xu, Duke University, Milano, Italy

1 - Shotgun Assembly of Erd s-Rényi Random Graphs
Julia Gaudio, Northwestern University, Evanston, IL, 02139-4204, United States, Elchanan Mossel

Graph shotgun assembly refers to the problem of reconstructing a graph from a collection of local neighborhoods. We consider shotgun assembly of Erdos-Renyi random graphs G(n, p_n), where p_n = n^{-\alpha} for 0 < \alpha < 1. We consider both reconstruction up to isomorphism as well as exact reconstruction (recovering the vertex labels as well as the structure). We show that given the collection of distance-1 neighborhoods, G is exactly reconstructable for 0 < \alpha < 1/3, but not reconstructable for 1/2 < \alpha < 1. Given the collection of distance-2 neighborhoods, G is exactly reconstructable for 0 < \alpha < 3/5, but not reconstructable for 3/4 < \alpha < 1.

2 - The Planted Matching Problem: Sharp Threshold and Infinite-order Phase Transition
""Ix" "Dana Yang, Duke University, Durham, NC, United States, Jian Ding, Yihong Wu, Jiaming Xu

Motivated by the application of tracking moving particles from snapshots, we study the problem of reconstructing a perfect matching hidden in a randomly weighted Erd s-Rényi bipartite graph with average degree d. The edges are associated with weights independently drawn from distributions P or Q, depending on whether the edge is in the hidden matching.We establish that the information-theoretic threshold for recovering almost all the edges of the hidden matching occurs at √dB(P,Q)=1, where B(P,Q) stands for the Bhattacharyya coefficient. Furthermore, in the special case of complete exponentially weighted graphs, we characterize the optimal reconstruction error near the sharp threshold, confirming the conjectured infinite-order phase transition in [Semerjian et al. 2020].

3 - Detection and Recovery Thresholds for Graph Matching
Sophie H. Yu, Duke University, Durham, NC, United States, Yihong Wu, Jiaming Xu

This talk focuses on detection and recovery problems of matching two Erdos-Renyi random graphs.Specifically, for detection, we aim to decide whether the two observed graphs are independent, or edge-correlated under some latent node correspondence. For recovery, our goal is to recover the latent node correspondence given the two graphs are edge-correlated. In the dense graph regime, we prove that both detection and recovery exhibit an "all-or-nothing" phase transition at a sharp threshold.For sparse graphs, we identify the information-theoretic threshold within some constant factor.

■ WC09

CC Room 303D

In Person: APS session

General Session

Chair: Yuanlu Bai, Columbia University, New York, NY, 10027-7105, United States

Co-Chair: Harsha Honnappa, Purdue University, West Lafayette, IN, 47907-2023, United States

1 - Low-rank Approximation for MDPs via Moment Coupling
Amy B.Z. Zhang, Cornell University, New York, NY, 10044-1500, United States, Itai Gurvich

We propose a method to approximate a Markov Decision Process that is based on state aggregation as the algorithmic infrastructure, and central-limit-theorem-type approximations as the mathematical underpinning for guarantees. The theory is grounded in recent work (Braverman et al, 2020) that relates the solution of the Bellman equation to that of a PDE where the transition matrix is reduced to its local first and second moments. We then construct an approximate "sister" chain whose local transition moments are approximately identical with those of the focal chain, coupling them through the PDE. Embedded into the framework of (soft) aggregation, moment matching motivates a disciplined mechanism to tune the aggregation and disaggregation probabilities, resulting in an efficient addition to the standard aggregation algorithm while providing optimality guarantees.

2 - A Stochastic Control Approach to Quasi-stationary Distributions
Pierre Nyquist, KTH Royal Institute of Technology, KTH Royal Institute of Technology, Department of M, Stockholm, 10044, Sweden, Amarjit Budhiraja, Paul Dupuis, Guo-Jhen Wu

Quasi-stationary distributions (QSDs) are a core concept within applied and computational probability. For example, they are at the heart of the study of population processes, and for systems exhibiting metastability, QSDs determine important quantities such as mean exit times and exit points from metastable states. In this talk, I will introduce a new approach for studying QSDs based on ergodic stochastic control problems, in the setting of diffusions on a bounded domain. I will describe the link between QSDs and such control problems, along with how the associated Hamilton-Jacobi-Bellman equations can be used to characterise important properties of the QSD. Time permitting, I will also mention briefly how this connection can be used to construct efficient numerical schemes, and understand and explain non-uniqueness of QSDs in unbounded domains.

■ WC10

CC Room 304B

In Person: AI in New Business Models

General Session

Chair: Jeffrey Clement, Minneapolis, MN, 55406, United States

1 - The New and the Reliable: Novelty, Credibility, and Helpfulness in Online Reviews
Dicle Yagmur Ozdemir, The University of Texas at Dallas, Dallas, TX, 75080-3021, United States, Harpreet Singh, Sumit Sarkar

Online reviews and ratings are important for online platforms. To better leverage such content, platforms enable users to vote on the helpfulness of reviews. Factors found to impact the helpfulness of a review include, among others, the novelty of the content in the review and the review's credibility characteristics (i.e., source credibility and rating credibility). We investigate the moderating impact of credibility on the effect of review novelty on helpfulness. We find that source credibility and review novelty are substitutes in terms of their contribution to review helpfulness. On the other hand, rating credibility positively moderates the effect of a review's novelty on its helpfulness.

2 - Information Transparency and Market Efficiency in Blockchain-enabled Marketplaces: Role of Traders' Analytical Ability
Hong Zhang, University of Texas at Dallas, Dallas, TX, United States

A unique feature of Blockchain-enabled marketplaces is that detailed account-level transaction data and the entire trading history of products are publicly available. This study examines how transparent information influences market efficiency in Blockchain-enabled marketplaces, and how good people make use of transparent information. We reveal that more information is not necessarily an indicator for higher market efficiency, which may hinge on who the traders are, especially their analytical ability to make use of the transparent information. If traders do not have the ability to utilize information effectively, market inefficiency can persist. Our study reveals that the problem of ability divide instead of digital divide prevails nowadays: digital technology has been available to all, but how to make people use technology effectively is the impending problem.

3 - Disregarding, Modifying, and Adopting: How Medical Experts Incorporate AI Recommendations Into Patient Care Decisions
Jeffrey Clement, University of Minnesota, Minneapolis, MN, United States, Yuqing Ren, Shawn P. Curley

AI Clinical Decision Support Systems (AI CDSS) can generate personalized recommendations to improve patient care, but it is unclear how healthcare professionals incorporate these recommendations into their care decisions. We employ mixed methods with semi-structured interviews and a pair of computer-based experiments with experienced organ transplant clinicians to examine the factors that influence trust of AI CDSS. Our results indicate that the process of incorporating AI recommendations into clinical decisions is not explained by the theories explaining trust in other recommender systems; notably, providing explanations does not seem to increase trust in the recommendations.

■ WC11

CC Room 304C

In Person: Operations Management for Urban Air Mobility

General Session

Chair: Zhangchen Hu, Isenberg School of Management, University of Massachusetts, Isenberg School of Management, Amherst, MA, 1003, United States

1 - UAV Path Planning under Weather Uncertainty and Environmental Impact Considerations

Zhangchen Hu, University of Massachusetts Amherst, Isenberg School of Managemen, Amherst, MA, 1003, United States, Heng Chen, Senay Solak

Unmanned aerial vehicles (UAVs) are expected to be widely used in the near future as an alternative transportation mode to mitigate congestion and pollution in a variety of applications. We design a dynamic and data-driven decision support system for UAV path planning through a stochastic programming based implementation, where both weather uncertainty and environmental impacts are directly considered.

■ WC12

CC Room 304D

In Person: Political Redistricting Part II of II

General Session

Chair: Hamidreza Validi, Rice University, Stillwater, OK, 74078, United States

1 - Partitioning a Graph Into Low-diameter Clusters with Applications to Districting

Hamidreza Validi, Rice University, Houston, TX, 74078, United States, Logan Smith, Austin Buchanan, Illya V. Hicks

In this paper, we study the problem of partitioning the vertices of a graph into s-clubs (s-clustering problem). An s-club is a subset of vertices for which the diameter of its induced subgraph is at most s. We propose new Mixed Integer Programming (MIP) formulations and compare them with the existing ones theoretically and computationally. Also, we develop heuristics and fixing procedures to improve the performance of our MIP formulations. Finally, we employ our s-clustering models to restrict the diameter of political districts for a US districting problem with the objective of minimizing population deviation. We implement our formulations on a large set of instances. For transparency purposes, our code and instances will be available on GitHub.

2 - Fairmandering: A Column Generation Heuristic for Fairness-optimized Political Districting

David B. Shmoys, Cornell University, Ithaca, NY, 14853-3801, United States, Wes Gurnee, Wes Gurnee

The USA winner-take-all congressional district system empowers politicians to engineer electoral outcomes by manipulating district boundaries. Known computational solutions focus on drawing unbiased maps, ignoring political & demographic input, and optimize for compactness. We introduce a scalable 2-stage method to explicitly optimize arbitrary piecewise-linear definitions of fairness, combining a randomized divide-and-conquer column generation heuristic, which produces an exponential number of distinct district plans, and a set partitioning IP. Our decoupled design allows for great flexibility in defining fairness-aligned objective functions. In the largest ever ensemble study of congressional districts, we use our method to understand the range of possible expected outcomes & the implications of this range on potential definitions of fairness.

■ WC13

CC Room 201A

In Person: Reinforcement Learning with Engineering Applications I

General Session

Chair: Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, 02115-5005, United States

Co-Chair: Sahil Belsare, Boston, MA, 02120-2175, United States

1 - The Increased Applicability of Reinforcement Learning in Engineering Applications

Sahil Belsare, Northeastern University, Boston, MA, 02120-2175, United States

In recent years, Reinforcement Learning (RL) has attracted the significant attention of optimization theorists, researchers, and industries because of its noteworthy successes in solving sequential decision-making problems. This is evident by the steady rise in publications displaying the applicability of RL for complex optimization problems in domains like operations research, supply chain, autonomous vehicles/drones, Industry 4.0, finance, health science, and many more. This presentation aims to highlight RL's growing prominence by talking about RL's used cases, scalability, benchmarking, the evolution of Deep RL, and future scope. Along with that, the parallel goal is to encourage researchers to work on the challenges addressed for applying RL in engineering applications.

2 - Integrating Reinforcement Learning with a Discrete Event Simulation Environment for Queueing Networks

Sahil Belsare, Northeastern University, Boston, MA, 02120-2175, United States, Mohammad Dehghanimohammadabadi

In this project, RL is applied to solve a M/M/C queuing system in a simulated environment. To conduct this, SimPy, a discrete event simulation (DES) library in Python, is integrated with RL algorithms. This integration provides a unique platform to link a DES environment with RL techniques and enable a new approach to solve traditional simulation-optimization problems.

■ WC14

CC Room 201B

In Person: Energy Systems Integration: Linking Platforms and Stakeholders across Systems, Scales, and Vectors

General Session

Chair: Jacob Garner Monroe, University of Victoria Institute for Integrated Energy Systems, Aberdeen, NC, 28315, United States

1 - Interfacing the CODERS Database with Energy System Models Using the SPINE Platform

Jacob Garner Monroe, North Carolina State University, 36240 U S. Hwy 1 South, Aberdeen, NC, 28315, United States

Governmental and social forces motivated by the onset of climate change have created demand for policy development that addresses decarbonization pathways. Successful decarbonization policy depends on a well built and maintained system of modeling infrastructure to support policy development efforts. Canada's energy system modelling capacity is currently fragmented in the institutional sense and does not have a set of standard tools to assess the operational implications of decarbonization policy. Further, there has been limited effort to apply tools that connect modeling software packages for complex analyses. This research standardizes the input data necessary for energy modeling efforts and develops tools that effectively query and process that data. An open-source platform with an intuitive user interface, the Spine Toolbox, is applied together with the CODERS database to give developers a public instrument to structure, standardize and share energy systems data with work-flow process models. This study develops work-flow process models for both a production cost modeling framework (SILVER) and a generation capacity expansion model (COPPER). The Spine Toolbox weaves CODERS queries into the energy modeling frameworks as input data, then sends the output of those models to a suite of visualization software to illustrate the results. The software tools released here are built in a generic way so that the work-flow process models can be reapplied for other energy system modeling frameworks, thus increasing Canada's modelling capacity. These models will help to bridge the modeller/stakeholder divide by enabling richer engagement sessions during the decarbonization policy development process.

2 - Virtual Microgrids: Implications for Peer-to-Peer Trading of Renewable Energy

Seulchan Lee, PhD student, Texas A&M University, College Station, TX, United States, Alexandar Angelus, Chelliah Sriskandarajah

A blockchain-enabled virtual microgrid has the potential to disrupt the traditional buyer-seller relationships in electricity markets. We examine the impact of virtual microgrids on electricity consumer investment on renewable energy resources: the level of investment, the resulting cost savings from virtual microgrids.

3 - A Simple Panel Data Method under Different Data Generating Processes

Kang-Bok Lee, Auburn University, Auburn, AL, United States, Yeasung Jeong, Joonhwan In, Han Sumin

Using an explanatory variable at time point t1 (first panel data) and at time point t2 (second panel data) with different probability distributions may cause estimation bias that stems from extrapolation, since conventional panel data methods are usually based on the presupposition that the data generating process will not change over time. In this study, we showed that the ordinary least squares method (applied to the first panel data) was not useful for estimating the dependent variables of the second panel data; thus, for simplicity of explanation, we only considered the simple panel data, which contained two time periods. To mitigate this problem, we propose a model that uses the selected informative first panel data in a systematic way by considering the importance of each data at t1 in the estimation of the dependent variable at t2.

■ WC19

CC Room 203A

In Person: Bonder Scholar Session

Award Session

Chair: Arielle Elissa Anderer, The Wharton School, Wynnewood, PA, 19096-2455, United States

1 - Estimating the Value of Incorporating Patient Behavior in Return to Play From Concussion

Gian-Gabriel P. Garcia, Harvard University, Cambridge, MA, 48103, United States

Concussion, the most common type of traumatic brain injury, is a major public health issue. For patients with sports-related concussion, the timing of return-to-play (RTP) is critical; premature RTP can increase likelihood of catastrophic injuries while delayed RTP can decrease benefits of physical activity. RTP decisions are complicated by the potential for strategic symptom-reporting. We formulate this decision problem as a partially observable stochastic game and analyze the equilibrium and doctor's best-response RTP strategy. We then use simulation to quantify the value of incorporating patient behavior by comparing this behavior-aware RTP strategy with practice-based RTP policies.

2 - Improving Diabetes Care with Thermal Imaging and Machine Learning

Jas Wodnicki, University of Wisconsin-Madison, Madison, WI, United States, Thor Larson

Diabetic foot ulcers (DFU) are among the most common and deadly complications of diabetes. Foot ulcers progress rapidly, leading to one million amputations globally which traditional risk assessments fail to prevent. Using thermal imaging, we are quantifying the inflammatory response behind DFU and developing machine learning algorithms for ulceration risk assessment. Our analysis leverages an ensemble of automated image processing methods, with practical use in mind. This technology is tailored to low and middle income countries and the unique cultural and systemic challenges they face.

■ WC20

CC Room 203B

In Person: Health Care II

Contributed Session

Chair: Samaneh Davarzani, Mississippi State University, Starkville, MS, 39759-1110, United States

1 - Generalized Bandits with Learning and Queueing in Split Liver Transplantation

Yanhan Tang, Carnegie Mellon University, Pittsburgh, PA, United States, Alan Scheller-Wolf, Sridhar R. Tayur, Andrew A. Li

We study liver allocation where surgeons with different abilities learn split liver transplantation. We formulate a multi-armed bandit with embedded learning curves to address the trade-off between discovering talents (exploration) and strengthening extant surgeons' skills (exploitation). Our QFL-UCB algorithm, enhanced with queueing dynamics, and fairness, has O(log T) regret. Our algorithms could be applied to help evaluate strategies to increase the use of SLT and other technically difficult procedures that require practice. Methodologically, our proposed MAB model and algorithms are generic and have broad applications.

2 - Cooperative Blood Inventory Ledger (CoBIL): A Decentralized Decision Making Framework for Improving Blood Product Management

Rishabh Bhandawat, University at Buffalo, Buffalo, NY, United States

Existing blood product supply management systems are limited by their segmentation, lack of detailed blood product information, and lack of real-time updating. We propose a novel architecture for blood product information sharing and a pseudo-collaborative decision-making mechanism (CoBIL) to overcome organizational competitive advantage, and to reduce outdates and shortages to benefit donors, patients/hospital, and demand nodes while minimizing operational costs. The work also presents the CoBIL framework along with an inventory routing algorithm to support the adoption of blockchain technology for blood product management.

3 - Acuity-based Nurse Assignment in Cancer Center Infusion Departments

Bryan A. Norman, Professor, Texas Tech University, Lubbock, TX, United States, Maryam Keshtzari

In this study, a mixed-integer mathematical model is proposed to assign nurses to patients based on patient acuity levels to minimize patient wait time and balance the workload across nurses. Moreover, the proposed model considers different levels of flexibility in nurse assignment in order to provide nurse continuity. A heuristic algorithm is developed to investigate the impact of an alternative nurse-patient assignment approach. Numerical examples are presented to compare the performance of the exact and heuristic methods.

4 - A Wearable Gait Recognition System Based on Soft Robotic Sensors Using Deep Learning Methods

Samaneh Davarzani, Mississippi State University, Starkville, MS, 39759-1110, United States, Reuben F. Burch, Brian K. Smith

Gait recognition systems have gained much attention due to the potential applications in healthcare, sports biomechanics, and the workplace. A new solution to gait recognition tasks can be provided by wearable sensors integrated in clothing and textiles and paired with mobile and computer devices. In this study, a sock prototype designed with embedded soft robotic sensors (SRS) is implemented to measure foot-ankle complex kinematic data during treadmill walking. Various deep learning methods have been employed and compared for modeling SRS data against a motion capture system to determine their ability to provide accurate kinematic data from dynamic movements using SRS measurements.

■ WC21

CC Room 204A

In Person: Operations Management

General Session

Chair: Simeng Shao, University of Southern California, Los Angeles, CA, United States

1 - Correlation Neglect in Supply Chains

Anugna Reddy Gondi, Cornell University, Ithaca, NY, United States

We study the effect of correlation in two operations contexts: supply risk and demand uncertainty, and hypothesize that individuals do not adequately account for correlation in such contexts. Through controlled lab experiments, we investigate how human subjects make ordering decisions under non-zero correlation (positive or negative) and zero correlation scenarios. Despite it being optimal to set different orders across these two scenarios, we find that participants set orders that are virtually the same across both settings. We also find that the effect of correlation on order bias is robust to controlling for other known biases.

2 - Disclosure-driven Social Engagement in Supply Chains

Caleb Kwon, Harvard Business School, Cambridge, MA, United States, Jun Li, Andrew Wu

We empirically examine the real effects of corporate social responsibility (CSR) disclosures on actual societal outcomes of disclosing firms and their supply chain connections. To do so, we exploit the passage of the California Transparency in Supply Chains Act (CTSCA) as a regime shift in mandated disclosures and examine the law's impact on an objective measure of CSR impact, which we measure using actual, media-covered incidents in human trafficking, forced labor, child labor, and human rights abuses. Firm-level responses to the CTSCA are measured by scraping the Web for firm disclosures and by analyzing the disclosure's contents using NLP machine learning algorithms. Our principal finding is that CSR activity has significant spillover effects which suggests that supply relations could serve as an important link for the propagation of socially impactful actions.

3 - Multi-Product Dynamic Pricing in High-Dimensions with Heterogeneous Price Sensitivity

Simeng Shao, University of Southern California, Los Angeles, CA, United States

We consider the problem of multi-product dynamic pricing, in a contextual setting, for a seller of differentiated products. In this environment, the customers arrive over time and products are described by high-dimensional feature vectors. Each customer chooses a product according to the Multinomial Logit (MNL) choice model. Our model allows for heterogenous price sensitivities for products. The seller a-priori does not know the parameters of the choice model but can learn them through interactions with the customers. The seller's goal is to design a pricing policy that maximizes her cumulative revenue. We propose a pricing policy, named M3P, that achieves a T-period regret of $O(\log(Td)\ (\sqrt{T}+ d\ \log(T)))$ under heterogenous price sensitivity for products with features of dimension d. We also prove that no policy can achieve worst-case T-regret better than $\Omega(\sqrt{T})$.

■ WC22

CC Room 204B

In Person: Healthcare Policy and Delivery Innovations

General Session

Chair: Shima Nassiri, University of Michigan, Ann Arbor, MI, 48109-1234, United States

1 - Generic Drug Treatment Effectiveness: An Empirical Study
Xinyu Shirley Liang, Doctoral Candidate, Ross School of Business, University of Michigan, Ann Arbor, MI, United States, Jun Li, Ravi Anupindi

Around 90% of drugs consumed in the US are generics, saving billions in prescription costs. However, the cost-saving benefit can only be realized when the drug efficacy is ensured. We examine generic drug's effectiveness by exploiting the market entry of generic Lipitor. We find that generic drugs are associated with higher healthcare service utilization and worse clinical outcomes. We also find heterogeneous effects of generic drugs across patients and manufacturers. Our findings highlight the importance of ensuring generic drugs' quality and accounting for their treatment heterogeneity in prescriptions.

2 - Proximal Policy Optimization for Hospital Inpatient Bed Management
Pengyi Shi, Purdue University, Krannert School of Management, Kra, West Lafayette, IN, 47907, United States, Jim Dai, Mark Gluzman, Jingjing Sun

When waiting time is excessively long before a bed in the primary ward becomes available, patients may be assigned to beds in a non-primary ward, known as off-service placement or overflow. We model this overflow problem as a queueing-network based Markov Decision Process. We leverage the Proximal policy optimization algorithm to tackle the large action space. Specifically, we adopt randomized routing policies and sequentially assigning beds to each waiting patient. Through a novel state aggregation, we further decompose the value function to facilitate the computation. We perform extensive numerical experiments with real hospital data to demonstrate the effectiveness and scalability of our algorithm.

3 - Comprehensive Primary Care Plus: Financial Incentives and Recommendations
Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, 90024-5055, United States, Elodie Adida

The Comprehensive Primary Care Plus (CPC+) is a new payment model used by the Centers for Medicare & Medicaid Services (CMS) to reform the way primary care physicians are paid, to better align incentives, and thus to improve the quality and delivery of care. In this talk, we analyze the impact of the CPC+ payment system on the different stakeholders (physician, patient, and payer), how best to design it, and for what type of patient population it is best suited.

■ WC23

CC Room 204C

In Person: Service Operations and Societal Impact

General Session

Chair: Russell Charles Hannigan, University of Chicago-Booth School of Business, Chicago, IL, 60616-1740, United States

1 - Combatting Gerrymandering with Social Choice: The Design of Multi-member Districts
Nikhil Garg, Cornell Tech, New York, NY, 94025-4714, United States

Every representative democracy must specify a mechanism under which voters choose their representatives. The most common mechanism in the United States — winner-take-all single-member districts — both enables substantial partisan gerrymandering and constrains `fair' redistricting, preventing proportional representation in legislatures. We study the design of multi-member districts (MMDs), in which each district elects multiple representatives, potentially through a non-winner-takes-all voting rule. We carry out large-scale analyses for the U.S. House of Representatives under MMDs with different social choice functions, under algorithmically generated maps optimized for either partisan benefit or proportionality. Doing so requires efficiently incorporating predicted partisan outcomes — under various multi-winner social choice functions — into an algorithm that optimizes over an ensemble of maps. We find that with three-member districts using Single Transferable Vote, fairness-minded independent commissions would be able to achieve proportional outcomes in every state up to rounding, and advantage-seeking partisans would have their power to gerrymander significantly curtailed. Simultaneously, such districts would preserve geographic cohesion, an arguably important aspect of representative democracies. In the process, we open up a rich research agenda at the intersection of social choice and computational redistricting.

2 - Online Policies for Efficient Volunteer Crowdsourcing
Scott Rodilitz, Yale, New Haven, CT, 06511-2572, United States

Nonprofit crowdsourcing platforms encourage volunteers to complete tasks by using nudging mechanisms to notify a subset of volunteers with the hope that at least one of them responds positively. However, since excessive notifications may reduce volunteer engagement, the platform faces a trade-off between notifying more volunteers for the current task and saving them for future ones. Motivated by these applications, we introduce the online volunteer notification problem and develop an online randomized policy that achieves constant-factor guarantees. Further we demonstrate the effectiveness of our policy by testing it on data from a volunteer-based food recovery platform.

3 - Operational Issues in Large Jail and Judiciary Systems
Charlie Hannigan, University of Chicago-Booth School of Business, Chicago, IL, 60616-1740, United States

People are often held in jail excessively long pre-trial. In fact, these pre-trial case lengths are sometimes longer than their eventual sentence. When this happens, the detainees are colloquially called "overstays." In 2016, total excess time for overstays released from the jail we study was over 244 years. Overly long case lengths and overstays arise, in part, due to detainees who intentionally delay their cases. We employ machine learning techniques and structural estimation to identify and understand intentional delaying behavior in the large jail system we study. We also propose policy interventions to reduce excessive case lengths and overstays, some tailored for intentionally delaying detainees and some for non-delaying detainees.

4 - School Choice In Chile
Boris Espstein, Columbia University, New York, NY, United States, Jose Correa, Rafael Epstein, Juan Escobar, Ignacio Rios, Bastian Bahamondes, Carlos Bonet, Natalie Epstein, Nicolas Aramayo, Martin Castillo, Andres Cristi, Felipe Subiabre

Centralized school admission mechanisms are an attractive way of improving social welfare and fairness in large educational systems. In this paper we report the design and implementation of the newly established school choice system in Chile, where over 274,000 students applied to more than 6,400 schools. This is a simultaneous nationwide system that includes all 14 school grade levels, making it one of the largest school choice problems worldwide. One of our primary goals is to favor the assignment of siblings to the same school. By adapting the standard notions of stability, we show that a stable assignment may not exist. Hence, we propose a heuristic approach that elicits preferences and breaks ties between students in the same priority group at the family level. In terms of implementation, we adapt the Deferred Acceptance algorithm as in other systems around the world.

■ WC24

CC Room 205A

In Person: Data-Driven Supply Chain Management

General Session

Chair: Reza Yousefi Maragheh, Walmart Global Tech

1 - Near-optimal Primal-dual Algorithms for Quantity-based Network Revenue Management
Zijie Zhou, PhD student, Massachusetts Institute of Technology (MIT), Cambridge, MA, United States

We study the canonical quantity-based network revenue management problem. The exact solution to the problem by dynamic programming is computationally intractable. Existing works in the literature make use of the solution to the deterministic linear program to design asymptotically optimal algorithms. Those algorithms rely on repeatedly solving DLPs to achieve near-optimal regret bounds. It is, however, time-consuming to repeatedly compute the DLP solutions in real-time.In this paper, we propose innovative algorithms that are easy to implement and do not require solving any DLPs. Our algorithm achieves a regret bound of $O(\log k)$, where k is the system size. To the best of our knowledge, this is the first NRM algorithm that (i) has an $o(\sqrt{k})$ asymptotic regret bound, and (ii) does not require solving any DLPs.

2 - Debiasing In-sample Policy Performance in the Small-data, Large-scale Regime
Michael Huang, University of Southern California, Los Angeles, CA, 90007-2488, United States, Vishal Gupta, Paat Rusmevichientong

Motivated by the poor performance of cross-validation when data are scarce, we propose a novel method called the Variance Gradient Correction to estimate the out-of-sample performance of a policy by debiasing the in-sample performance. Unlike cross-validation, our method does not sacrifice data set for a test set. We prove it is approximately unbiased, and, in many settings, its estimation error tends to zero in probability uniformly over a policy class. Through a empirical study on dispatching EMS services, we show our proposed approach outperforms state-of-the-art approaches in estimating out-of-sample policy performance.

3 - Forecasting Life Cycles Using Bayesian Model Averaging and Exponential Smoothing

Xiaojia Guo, Robert H. Smith School of Business, University of Maryland, International Hall, College Park, MD, WC1N 1AS, United States, Kenneth Lichtendahl, Yael Grushka-Cockayne

We study the problem of forecasting the demand of a product or service that evolves according to a dynamically changing life cycle. These demand forecasts are often made prior to launch, and need to be updated frequently thereafter once realizations are available. We develop a new life cycle model that is based on Bayesian model averaging and exponential smoothing to forecast demand using past similar life cycles. In two empirical studies, we show that the rolling point forecasts and quantile forecasts generated by our new model are more accurate than those generated by the benchmarks. When quantile forecasts are used in a newsvendor setting, our new model also has the potential to provide meaningful economic benefit when compared to various existing models.

4 - Choice Modeling and Assortment Optimization in the Presence of Context Effects

Reza Yousefi Maragheh, University of Illinois at Urbana-Champaign, Urbana, IL, 61801-2925, United States, Xin Chen, James M Davis, Jason Cho, Sushant Kumar

In the presence of context effects, the perceived attractiveness of individual items depends on other items that are offered beside them. In this paper, we introduce a new Utility-Based choice model, the "Contextual MNL" model, that incorporates these effects. We show the high prediction power of the model on a real data set. We also prove the NP-hardness of the assortment optimization problem under this model. Several polynomially solvable special cases of the model are identified that also perform well in our empirical validation for our data set. Also, to derive approximation results, we obtain some conditions for monotonicity and submodularity of the objective of the assortment optimization problem. We also develop fast heuristics for solving the assortment optimization problem which provide near-optimal solutions according to our test results.

■ WC26

CC Room 206A

In Person: Decision Diagram Methods

General Session

Chair: Isaac Rudich, Polytechnique Montréal, Montréal, QC, H3G 1A3, Canada

1 - "ddo" a Fast and Efficient Framework for Solving Combinatorial Optimization Problems with Branch-and-bound MDD

Xavier Gillard, Grad. Student, UC Louvain, Louvain-la-Neuve, Belgium

In this talk I will present you "ddo" a free fast and efficient framework for solving combinatorial optimization problems with branch-and-bound MDDs. To that end, we will start modelling well known problems (Knapsack, Travelling Salesman with Time Window a.k.a TSPTW). Once the basic are in place, we will discuss some performance strategies. In particular, we will see how to easily exploit the available hardware on your platform. We will also see how to boost the performance of the solvers though the introduction of problem specific knowledge in the form of a rough upper bound. Finally, I will present some numerical results comparing the performance of "ddo" and Gurobi on the resolution of MISP (Maximum Independent Set Proble), MCP (Maximum Cut Problem) and MAX2SAT (Maximum 2 Satisfiability). These results show the relevance of using ddo as it may significantly outperform MIP.

2 - DD-based Reformulation for a Class of Combinatorial Bilevel Problems

Leonardo Lozano, University of Cincinnati, Carl H. Lindner Hall 2906 Woodside Ct Ofc 3347, Cincinnati, OH, 45246-2310, United States, David Bergman, Andre Augusto Cire

We study a class of challenging discrete bilevel problems and propose a reformulation based on decision diagrams that results in a single-level mixed integer program (MIP). The decision diagrams are to provide a convex representation of the discrete follower problem which is then appended to the leader problem via KKT conditions. In contrast to previous approaches from the literature that reformulate bilevel problems as nonlinear single-level MIPs and often transform the resulting problem into a linear MIP usually via big-M formulations, our approach exploits the structure given by the decision diagrams to provide a linear reformulation, thus avoiding any linearization or big-M constraints. Computational experiments on a bilevel project selection problem shows that our approach greatly outperform two state-of-the-art bilevel algorithms from the literature.

3 - Improving Decision Diagram Relaxations for Sequencing Problems

Isaac Rudich, Polytechnique Montréal, Montréal, QC, H3G 1A3, Canada

Relaxations of multivalued decision diagrams (MDDs) are effective for improving methods of solving sequencing problems. To strengthen the bounds generated by MDD relaxations, we used multiple metrics to improve merge rules and encoded a restricted MDD into the relaxed MDD. We evaluated our approach by comparing its performance to previous work done by Cire and van Hoeve on variations of the traveling salesman problem (TSP), such as the asymmetric TSP, TSP with time windows, TSP with precedence constraints, and the sequence ordering problem.

■ WC27

CC Room 206B

In Person: Optimization on Manifolds

General Session

Chair: David Gutman, Texas Tech University, Lubbock, TX, 79407, United States

1 - Trade-offs in Nonconvexity and Noise Models in the Global Stability of Stochastic Gradient Descent

Vivak Patel, Assistant Professor, University of Wisconsin-Madison, Madison, WI, United States

Recently, it was demonstrated that stochastic gradient descent (SGD) either diverges or converges to stationary points with probability one for a very broad class of nonconvex stochastic optimization problems. However, this result does not address the question of stability: will SGD diverge to regions where the objective function is diverging? Unfortunately, the answer is not simple. We begin by showing that there is a sufficiently slow growth function on which SGD is unstable. Accoridngly, we will suggest that there is a trade-off between the nonconvexity and the noise models that ensures the stability of SGD. For stochastic objectives that satisfy this trade-off, we will be able to show that SGD is stable using a single analysis. Moreover, we will be able to show that SGD converges (in probability and L1) to regions of the objective function where the gradient is zero.

2 - An Inexact Sequential Quadratic Method for Nonlinear Equality Constrained Stochastic Optimization

Baoyu Zhou, Lehigh University, Bethlehem, PA, 18015, United States, Frank E. Curtis, Daniel Robinson

We propose an inexact sequential quadratic optimization algorithm for minimizing a stochastic objective function subject to deterministic equality constraints. Algorithms that allow inexact subproblem solutions to be used are important in large-scale applications when the matrices used by the subproblem solver are too expensive to form or factorize. The inexact conditions that we propose for characterizing appropriate subproblem solutions address challenges resulting from the stochasticity in the objective function. Convergence results (in expectation) are established for our proposed method (under common assumptions), and numerical experiments demonstrate that our method outperforms exact variants in terms of key efficiency measures.

3 - Coordinate Descent Without Coordinates: Tangent Subspace Descent on Riemannian Manifolds

David Gutman, Texas Tech University, Lubbock, TX, 79407, United States, Nam Ho-Nguyen

We consider an extension of the coordinate descent algorithm to manifold domains, and provide convergence analyses for geodesically convex and non-convex smooth objective functions. Our key insight is to draw an analogy between coordinate blocks in Euclidean space and tangent subspaces of a manifold. Hence, our method is called tangent subspace descent (TSD). The core principle behind ensuring convergence of TSD is the appropriate choice of subspace at each iteration. To this end, we propose two novel conditions: the gap ensuring and C-randomized norm conditions on deterministic and randomized modes of subspace selection respectively. These ensure convergence for smooth functions, and are satisfied in practical contexts. We propose randomized and deterministic subspace selection rules of particular practical interest for the Stiefel manifold.

■ WC28

CC Room 207B

In Person: Learning and Decision-making with Contextual Information

General Session

Chair: Rui Gao, University of Texas at Austin, Austin, TX, 78712-1277, United States

Co-Chair: Luhao Zhang

1 - Contextual Chance-Constrained Programming
Hamed Rahimian, Clemson University, 2145 Tech Dr # C210, Clemson, SC, 60208-0884, United States, Bernardo Kulnig Pagnoncelli

Uncertainty in classical stochastic programming models is often described solely by independent random parameters, ignoring their dependence on multidimensional features. We describe a novel contextual chance-constrained programming formulation that incorporates features, and argue that solutions that do not take them into account may not be implementable. Our formulation cannot be solved exactly in most cases, and we propose a tractable and fully data-driven approximate model that relies on weighted sums of random variables. Borrowing results from quenched large deviation theory we show the exponential convergence of our scheme as the number of data points increases. We illustrate our findings on real and synthetic data.

2 - Residuals-based Distributionally Robust Optimization With Covariate Information
Rohit Kannan, Los Alamos National Laboratory, University of Wisconsin Madison, Los Alamos, NM, United States, Guzin Bayraksan, James Luedtke

We consider data-driven approaches that integrate a machine learning prediction model within distributionally robust optimization (DRO) given limited joint observations of uncertain parameters and covariates. Our framework is flexible in the sense that it can accommodate a variety of learning setups and DRO ambiguity sets. We investigate the asymptotic and finite sample properties of solutions obtained using Wasserstein, sample robust optimization, and phi-divergence-based ambiguity sets within our DRO formulations, and explore cross-validation approaches for sizing these ambiguity sets. Through numerical experiments, we validate our theoretical results, study the effectiveness of our approaches for sizing ambiguity sets, and illustrate the benefits of our DRO formulations in the limited data regime even when the prediction model is misspecified.

3 - Optimal Policies for Robust Big Data Newsvendor
Luhao Zhang

We consider a robust big newsvendor problem that seeks an optimal end-to-end policy, under the Wasserstein robust framework that hedges against data uncertainty on demand and covariates.We develop an equivalent linear programming reformulation, by proving the optimality of a novel Shapley policy.This provides the first policy optimization framework that produces a robust optimal policy without restricting the policy class while still maintaining tractability. Numerical experiments on real and synthetic datasets demonstrate the competitive performance of our proposed policy.

■ WC29

CC Room 207C

In Person: Recent Advances in Reinforcement Learning

General Session

Chair: Parshan Pakiman, University of Illinois-Chicago, Chicago, IL, 60605, United States

1 - Biodiversity Preservation via Adjustable Robust Optimization
Yingxiao Ye, University of Southern California, Los Angeles, CA, United States, Christopher Doehring, Angelos Georghiou, Hugh Robinson, Phebe Vayanos

To protect biodiversity against human impact, existing methods purchase lands to maximize the value of the protected area with the given budget. However, budget is usually received progressively over time, and also, the existing models cannot capture the uncertainty in development. We propose a multistage, robust optimization problem with a data-driven uncertainty set to minimize the biodiversity loss due to human impact. We prove that the problem can be reformulated into a robust problem with exogenous objective uncertainty. The numerical results based on real data show that the proposed method outperforms the MARXAN, a conservation planning software, in 90% cases.

2 - Self-guided Approximate Linear Programs
Parshan Pakiman, Information and Decision Sciences, University of Illinois at Chicago, Chicago, IL, 60605, United States, Selvaprabu Nadarajah, Negar Soheili, Qihang Lin

Solving real-world Markov decision processes using reinforcement learning (RL) methods requires selecting approximation architectures (i.e., basis functions) and tuning parameters, limiting their deployment in practice. We develop an RL framework that solves a convergent sequence of approximate linear programs (ALPs), largely side-steps basis function selection by sampling random basis functions. It also self-tunes state-relevance weights, which are parameters that determine the approximation quality across states. Our methodology facilitates implementation, has strong theoretical guarantees, and outperforms existing control policies on two business applications.

■ WC30

CC Room 207D

In Person: Statistical Methods for Quality and Engineering

General Session

Chair: Rui Tuo, Texas A & M University, College Station, TX, 77845-7399, United States

1 - High-dimensional Change-point Detection using Generalized Homogeneity Metrics
Xianyang Zhang, Texas A&M University, College Station, TX, United States

This work focuses on detecting abrupt distributional changes in high-dimensional data generating distribution. We develop a nonparametric methodology to detect an unknown number of change-points in an independent sequence of high-dimensional observations and to test for the significance of the estimated change-point locations. Our approach essentially rests upon nonparametric tests for the homogeneity of two high-dimensional distributions. We construct a single change-point location estimator via defining a cumulative sum process in an embedded Hilbert space. Subsequently, we combine our statistics with the idea of wild binary segmentation to recursively estimate and test for multiple change-point locations. The method is further extended to incorporate external graph information.

2 - Optimal Maintenance Planning and Budget Prioritization of the Deteriorating Co-located Road and Water Systems with Interdependencies
Hung Quoc Nguyen, University of South Florida, Tampa, FL, United States, Noha Abdel-Mottaleb, Shihab Uddin, Qiong Zhang, Qing Lu, He Zhang, Mingyang Li

For co-located interdependent systems, such as transportation & water systems (TS & WS), proactive and joint maintenance is one of the promising solutions to reduce costs and improve overall serviceability. Many of existing maintenance works for interdependent systems often focus on short-term reactive maintenance instead of long-term proactive maintenance planning. We propose a model-based analytics framework for long-term maintenance planning and budget prioritization of TS and WS with a high level of co-location by accounting for their interdependencies and varied spatial heterogeneity. A case study on a sub-region in the City of Tampa is provided to show the benefits of the proposed work.

■ WC31

CC Room 208A

In Person: Revenue Management with Customer Choice

General Session

Chair: Mika Sumida, Cornell Tech, Cornell Tech, New York, NY, 10128-5805, United States

1 - Price Discrimination with Fairness Constraints
Adam Elmachtoub, Columbia University, 560 Riverside Dr Apt 15a, New York, NY, 10027-3241, United States, Maxime Cohen, Xiao Lei

Price discrimination allows sellers to increase their profits, but it also raises several concerns in terms of fairness which has received extensive attention from media, industry, and regulatory agencies. In this paper, we consider the problem of setting prices for different groups under fairness constraints. We first propose four definitions: fairness in price, demand, consumer surplus, and no-purchase valuation. We analyze the pricing strategy of a profit-maximizing seller and the impact of imposing fairness on the seller's profit, consumer surplus, and social welfare.

2 - Fair Dynamic Rationing
Vahideh Manshadi, Yale University, Quincy, MA, 02169-4688, United States

Our paper studies a fundamental sequential resource allocation problem in which we aim to equitably and efficiently ration a divisible good to a sequence of agents with stochastic correlated demands. Focusing on the objective of maximizing the minimum fill rate, we show that an adaptive policy which is both simple and transparent simultaneously achieves the best possible ex-ante and ex-post guarantees. Our work is motivated by rationing social goods in situations where demands (needs) realize sequentially and are possibly correlated, such as a pandemic or a hurricane impacting multiple localities.

3 - Revenue Management for Boutique Hotels: Resources with Unit Capacities and Itineraries over Intervals of Resources
Mika Sumida, University of Southern California, Los Angeles, CA, 10128-5805, United States, Paat Rusmevichientong, Huseyin Topaloglu, Yicheng Bai

We consider the revenue management problem for a boutique hotel offering unique rooms. Customers arriving into the system make booking requests for different intervals of stay. The goal is to find a policy that determines an assortment of rooms to offer to each customer to maximize the total expected revenue. Because each room is unique and customers book intervals of days, the problem has two special features. First, each resource has a unit capacity. Second, the resources can be ordered such that each itinerary consumes an interval of resources. We develop two policies and give performance guarantees for both policies. We also develop an approach for computing an upper bound on the optimal total expected revenue. We give computational experiments on both a real-world boutique hotel dataset and synthetic datasets.

■ WC32

CC Room 208B

In Person: Pricing Innovations

General Session

Chair: Aydin Alptekinoglu, Pennsylvania State University, University Park, PA, 16802-3603, United States

Co-Chair: A. Serdar Simsek, University of Texas-Dallas, Richardson, TX, 75080-3021, United States

1 - Pricing With Samples
Amine Allouah, Facebook, Menlo Park, CA, 10027, United States, Achraf Bahamou, Omar Besbes

we study a fundamental data-driven pricing problem in low information environments: how should a decision-maker (optimally) price based on a finite and limited number of samples from the distribution of values of customers. The decision-maker's objective is to select a general pricing policy with maximum competitive ratio when the value distribution is only known to belong to some general non-parametric class. We study achievable performance for two central classes: regular and monotone hazard rate (mhr) distributions. At a higher level, this work also provides insights on the value of samples for pricing purposes. For example, against mhr distributions, a single sample guarantees 64% of the performance an oracle with knowledge of the distribution would achieve, two samples suffice to ensure 71%, and ten samples guarantee 80% of such performance.

2 - The Winner's Curse in Dynamic Forecasting of Auction Data: Empirical Evidence from Ebay
A. Serdar Simsek, The University of Texas at Dallas, Naveen Jindal School Of Man., Richardson, TX, 75080-3021, United States, Ernan Haruvy, Meisam Hejazi Nia, Özalp Özer

Dynamic auctions typically have a stage of high exploratory activity, followed by an inactivity period, and then a final stage of last-minute bids with sharp jumps. In addition, when bidder valuations are correlated, bidders decrease their bids to account for winner's curse. We develop a methodology to predict final stage bids in an auction and quantify the impact of winner's curse. Our approach improves the forecast of a sample of eBay auctions' final stage bids by 13.6%, on average, compared to a commonly used benchmark. We find that bidders in common value auctions decrease their bids by 29% due to the winner's curse adjustment. Auction platform managers can use our methodology and results to support their choice of auction-specific minimum bid increments. Platforms can also decide how to allocate their resources to mitigate the adverse effects of winner's curse adjustment.

■ WC34

CC Room 209B

In Person: Transportation-Operations II

Contributed Session

Chair: Jose H. Ablanedo-Rosas, University of Texas at El Paso, El Paso, TX, 79912, United States

1 - Transit Network Design with Passenger Assignment Constraints
Pramesh Kumar, University of Minnesota-Civil Egineering, Minneapolis, MN, United States, Alireza Khani

The research proposes a bi-level optimization model for designing an efficient transit network. It considers both passengers' and operator's perspectives when deciding where to locate transit routes and determining their optimal frequency. It captures user behavior through the optimal strategy transit assignment model at the lower level. The overall model is a mixed-integer non-linear program that is solved using Benders decomposition.

2 - Designing a MATSim Environment for a One-way Car Sharing System as a Transport Mode
Selin Ataç, EPFL, Lausanne, Switzerland, Nikola Obrenovi, Michel Bierlaire

Car sharing (CS) services have become popular due to their financial and environmental benefits. The CS operators have offered flexibility by allowing one-way trips which resulted in vehicle imbalance in the service area. They have then introduced rebalancing operations to reduce the imbalance thus, to increase the level of service. Since it is exhausting to collect the data to develop a demand model, this work makes use of the agent-based simulation MATSim in a one-way CS system. The results are used to explain the relation between the city structure, demand structure and the different rebalancing strategies.

3 - Quantifying Shareability Potential in a Transportation Network: Introducing the Maximum Network Flow Overlap Problem
Navjyoth Sarma, University of California-Irvine, Irvine, CA, United States, Michael Hyland

The structure of transport networks and spatial distribution of demand vary across and within cities, affecting the viability of shared mobility modes ranging from fixed-route transit to on-demand ride-pooling. To inform the viability of shared mobility modes, this study proposes a modeling framework to quantify shareability potential within a city. The study introduces the 'flow overlap' metric to measure the number of trips sharing a path between an O-D pair. This concept is used to formulate the Maximum Network Flow Overlap Problem to assign person flows to paths that maximize shareability. The model output provides unique insights to support design of multi-modal shared mobility systems.

4 - Traffic Equilibrium with Shared Mobility Services in a Coupled Morning-evening Commute Framework
Wei Gu, University of Southern California, Los Angeles, CA, United States, Maged Dessouky, Jong-Shi Pang, Michael Zhang

In this study, we develop a general equilibrium model to capture the complex interactions between solo-driving, rideshare and e-hailing that allows travelers to switch between different transportation modes in a coupled morning-evening commute. The model is formulated as a mixed complementarity problem. Then the existence of an equilibrium solution and the properties of the solution are investigated, and we provide conditions on the model parameters under which the equilibrium will be unique. The proposed model is validated with the renowned Sioux-Falls network.

5 - Operational Efficiency of Major Cargo Seaports in Some Developing Regions: Results from a Bootstrap DEA
Jose H. Ablanedo-Rosas, University of Texas at El Paso, El Paso, TX, United States

This study estimated the operational efficiency of 40 seaports located in five different developing regions. The study considered panel data from 2013 to 2018. The results showed that most of the ports were not operating at their optimal scale and reported an increasing and decreasing trend in their bias-corrected CRS and VRS efficiency scores respectively. One major finding is that most of the ports have experienced an increase in their operations without attaining the corresponding increase in their technical capabilities. The overall and regional top port performers were identified for benchmarking purposes.

■ WC35

CC Room 210A

In Person: Optimizing Ride-Sourcing Vehicle Routing, Tolling and Information Provision

General Session

Chair: Kenan Zhang, Northwestern University, Evanston, IL, 60208-0001, United States

1 - A Co-optimization Approach for Compensating Toll Facility Concessionaires for Reduced Tolls during Roadway Maintenance
Sohrab Mamdoohi, George Mason University, 10570 Main St Apt 413, Fairfax, VA, 22030-7108, United States, Elise Miller-Hooks, Jonathan Gifford

Execution of improvement activities, such as maintenance and repair, along roadways reduces roadway capacity and, thus, increases traffic congestion. This study investigates the potential to reduce such resulting congestion through an option to reimburse a toll facility concessionaire for decreasing or suspending tolls during improvement activity execution. The problem of determining optimal toll prices, concessionaire remuneration and improvement action schedules is formulated through concepts of bilevel mixed integer programming and equilibrium modeling.

2 - A Game Theorectic Approach for Ride-hail Vehicle Routing
Kenan Zhang, Northwestern University, Evanston, IL, 60208-0001, United States, Nie Yu

This study proposes a game-theoretic approach to modeling the routing behaviors of drivers in a spatiotemporal ride-hail market. Driven by profit, idle drivers move across local markets for passenger search and their search strategies are modeled as Markov decision process (MDP). Since the probability of meeting a passenger in a local market is determined by the number of idle drivers, each driver has to optimize his own search strategy given others' strategies. The collective vehicle routing behaviors lead to an MDP congestion game. We characterize the congestion game for two common ride-hail modes, namely, street-hail and e-hail, and develop a solution algorithm to solve the equilibrium.

■ WC37

CC Room 210C

In Person: Advances in Analytics for Military and Security Applications I

General Session

Chair: Trevor Bihl, Air Force Research Laboratory, Wheelersburg, OH, 45694, United States

1 - Equitable Assignment of U.S. Marine Corps Reserve Recruiting
Gary Lazzaro, Permanent Military Professor, United States Naval Academy, Annapolis, MD, United States

We focuses on the assignment of new reservist Marines to jobs at Reserve Centers by Marine Corps Recruiting Command (MCRC). Recruiting Substations acquire new reservists to be stationed at Reserve Centers to fill specific job openings. Manual assignment of jobs to Recruiting Substations takes MCRC weeks to complete. We create a novel application of the classic assignment problem with additional constraints for maximum travel distance and recruiter workload to automate the process. Our model displays the 6,011 job openings for FY2021, their assigned Recruiting Substation, and the distance between the Recruiting Substation and Reserve Center in miles.

2 - Meta-heuristic Optimization Methods for Quaternion-valued Neural Networks
Jeremiah Bill, Air Force Institute of Technology

Real-valued neural networks have demonstrated promising, and often striking, results across a broad range of domains. This has driven a surge of applications utilizing high-dimensional datasets. While many techniques exist to alleviate issues of high dimensionality, they all induce a cost in terms of network size or computational runtime. This work examines the use of quaternions in neural networks. The constructed networks demonstrate the ability of quaternions to encode high-dimensional data in an efficient manner while reducing the number of total trainable network parameters compared to their real-valued equivalents. Finally, this work introduces a novel training algorithm using a meta-heuristic approach that bypasses the need for a quaternion chain rule and analytic quaternion loss or activation functions.

3 - Artificial Intelligence and Autonomy
Trevor Bihl, Air Force Research Laboratory, Wheelersburg, OH, United States

Autonomous systems are in development with promises to revolutionize everything from cars to commerce to government. To be autonomous, systems must sense and extract meaning from their surroundings, and take actions to achieve their goals. This involves a considerable amount of intelligence and the fields of autonomy and artificial intelligence (AI) are necessarily heavily intertwined. This talk will present a discussion of what is autonomy, what is AI, how they are related, and what the future holds.

Wednesday, 1:30PM 2:30PM

■ Wednesday Keynote 01

CC Ballroom A /Virtual Theater 1

Keynote: Boundary-Expanding OR/OM Research

Keynote Session

1 - Boundary-Expanding OR/OM Research
Rachel Q. Zhang, The Hong Kong University of Science & Technology, Dept of IEEM, Clear Water Bay, Kowloon, Hong Kong

OR and OM have brought about significant improvements to operations in diverse domains, including military, manufacturing and service, and the knowledge economy. Every technological advance in the modern world has been met with the pursuit of new models by the OR/OM community, often providing fundamental understanding of and significant improvements to its deployment. In this talk, the speaker will share her experience in pursuing research in the boundaries of operations and finance, wireless communications and blockchains, including the inspirations, execution, challenges and lessons learned. Pursuing such projects is not without risk, but is an effective way for a researcher to reinvent him/herself and have a fulfilling career.

■ Wednesday Keynote 02

CC Ballroom B /Virtual Theater 2

Edelman Reprise: UN World Food Programme

Keynote Session"

1 - The world's leading humanitarian organization, and 2020 Nobel Peace Prize Laureate, is saving and changing lives by delivering food assistance in emergencies and working with communities to improve nutrition and build resilience. In 2020, WFP assisted nearly 100 million people across 88 countries. Analytics has underpinned WFP's management of its vast and complex humanitarian operations, helping it reach more people, respond faster in emergencies, and realize significant savings that are used to improve lives and empower communities.

■ Wednesday Keynote 03

CC Ballroom C /Virtual Theater 3

Keynote: Operational Data Driven Interventions to Decrease Adverse Events Associated with Opioid Overdose

Keynote Session

1 - Operational Data Driven Interventions to Decrease Adverse Events Associated with Opioid Overdose
Mahesh Nagarajan, University of British Columbia, Sauder School Of Bus. 2053 Main Mall, Vancouver, BC, V6T 1Z2, Canada

In this talk, we present a systematic data driven approach to decrease adverse events associated with overdose episodes. We take a three-fold approach. First, we examine pathways that result in opioid use and devise protocols to decrease the number of new users. Second, we predict adverse occurrence of adverse episodes among current users and adopt timely interventions that will decrease the likelihood and severity of an event. Third, we focus on the care pathways for existing users and use simple operational techniques to increase the system's capacity as well as improve outcomes.

■ Wednesday Keynote 04

CC Ballroom D /Virtual Theater 4

Keynote: Algorithms and Social Service Provisions

Keynote Session

1 - Algorithms and Social Service Provisions

Rediet Abebe, University of California-Berkeley, Berkeley, CA, 14853, United States

Bio: Rediet Abebe is an Assistant Professor of Computer Science at the University of California, Berkeley and a Junior Fellow at the Harvard Society of Fellows. Abebe holds a Ph.D. in computer science from Cornell University and graduate degrees in mathematics from Harvard University and the University of Cambridge. Her research is broadly in algorithms and artificial intelligence, with a focus on equity and distributive justice concerns. As part of this research agenda, Abebe co-founded and co-organizes the MD4SG initiative and is serving as a Program Co-Chair for the inaugural ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization (EAAMO '21). Her dissertation received the 2020 ACM SIGKDD Dissertation Award and an honorable mention for the ACM SIGEcom Dissertation Award for offering the foundations of this emerging research area. Abebe's work has informed policy and practice at the National Institute of Health (NIH), the Ethiopian Ministry of Education, and the United Nations Food Systems Summit. Abebe also co-founded Black in AI, a non-profit organization tackling equity issues in AI. Her work is influenced by her upbringing in her hometown of Addis Ababa, Ethiopia.

Wednesday, 2:45-4:15pm

■ WD06

CC Room 303A

In Person: Analytics for Migration and Resettlement

General Session

Chair: Buket Cilali, The University of Oklahoma, Norman, OK, 73069-5703, United States

1 - Refugee Resettlement with a Time-evolving Minimum Cost Problem Approach

Deniz Emre, University of Oklahoma, Norman, OK, United States, Buket Cilali, Kash Barker, Andres David Gonzalez

The literature in refugee relocation focuses generally on short-term planning, but such problems are continuous and require long-term planning. Inspired by the long-term nature of the problem, we consider temporal networks, a special case of multi-layered networks in which time is incorporated with layers. With this snapshot representation of time for the resettlement problem such that each layer is a static representation of the network at a different point in time, we create a network of temporal layers. Our aim is to solve a minimum cost flow problem from the first to final layers while synchronously solving a resettlement facility location problem in each layer and managing the temporal opening or expansion of resettlement locations.

2 - Multi-stage Stochastic Programming for Long-term Refugee Resettlement Planning

Buket Cilali, University of Oklahoma, Norman, OK, 73069-5703, United States, Kash Barker, Andres David Gonzalez

Most studies in refugee resettlement assume that capacity/demand within a fixed time interval is given. However, refugee resettlement is not a one-time event. On the contrary, it is an ongoing and long-term process with dynamic parameters. To deal with the current conflict-based resettlement problem, as well as future climate-driven variants of the long-term displacement problem, we take a stochastic approach and adapt the supply change management framework. To this end, we address issues related to the nature of resettlement (e.g., cost of opening new locations to service, penalties/incentives for unmet demand, dynamic capacity/demand management, socio-cultural impact of the resettlement process).

■ WD07

CC Room 303B

In Person: Probabilistic Forecasting/Operations of Knowledge-Intensive Services

General Session

Chair: Pavel Atanasov

1 - The Efficacy-revenue Trade Off In Pharma R&D and its Incentive Implications

Stylianos Kavadias, Margaret Thatcher Professor of Innovation & Growth, University of Cambridge, Cambridge, United Kingdom, Jeremy Hutchison-Krupat, Konstantinos Stouras

There exists a fundamental tension that underlies the R&D process for pharmaceutical drugs between achieving a sufficient efficacy level to advance a drug further and rapid development to ensure maximum opportunity to exploit the drug patent times. We explore differences in how this trade-off manifests itself amongst different stakeholders in the development process and how senior management can best adapt their incentives.

2 - Human Forest vs. Random Forest in Time-sensitive Covid-19 Clinical Trial Prediction

Pavel Atanasov, Pytho LLC, Brooklyn, NY, United States, Regina Joseph, Felipe A. Feijoo, Max Marshall, Sauleh Ahmad Siddiqui

What methods generate the most accurate forecasts about clinical trial phase success? We describe the first multi-method clinical trial forecasting tournament, comparing machine learning models and crowdsourcing methods that estimate the time-dependent probability of phase transition for COVID-19 vaccines and treatments. The crowdsourcing approach uses the Human Forest process and software, which enables forecasters to define custom reference classes, query a historical database and review resulting base rates. The base rates, and forecaster-adjusted probabilistic estimates, are aggregated. Accuracy was compared against a random survival forest machine model, across 28 questions. Results show that Human Forest significantly outperformed the RSF model, registering 32%-48% better Brier scores. Human Forest's advantage was due to better calibration.

■ WD09

CC Room 303D

In Person: Optimistic/Robust Sequential Decision-Making

General Session

Chair: Rui Gao, University of Texas at Austin, Austin, TX, 78712-1277, United States

1 - Data-driven Optimistic Optimization and Contextual Decision-making

Junyu Cao, The University of Texas at Austin, Austin, TX, 94706-1991, United States, Rui Gao

We study sequential decision making under uncertainty with contextual information, in which the decision-maker jointly learns a predictive model and optimizes a downstream decision task based on the relevant context. Inspired from the optimistic counterpart of data-driven robust optimization, we propose a novel framework that designs principled upper-confidence-bound algorithms with efficient implementation and strong performance guarantees.

2 - An Efficient UCB Algorithm for Contextual-bandit-based Learning with Continuous Actions

Zhi Wang, University of Texas at Austin, Austin, TX, United States, Rui Gao

In online learning and decision-making with contextual information, upper-confidence-bound (UCB) algorithms are a celebrated class of algorithms. Choosing an action with the highest upper confidence bound of the reward, each iteration of the algorithm involves a joint optimization over the action set and the parameter confidence set. When the action set is in continuum, this subproblem is computationally intractable, thus prevents the design of efficient UCB algorithms. In this paper, we propose an efficient UCB algorithm based on the first-order approximation of the optimal reward function. To the best of our knowledge, this is the first efficient UCB algorithm that achieves nearly optimal regret for a variety of problems, including linear bandits, generalized linear bandits, multi-product dynamic pricing, and parametric contextual bandits.

■ WD10

CC Room 304B

In Person: Auction Markets

General Session

Chair: Martin Bichler, Technical University of Munich, Garching B. München, 85748, Germany

1 - Revenue Maximization for Consumer Software: Subscription or Perpetual License?

Ludwig Dierks, University of Zurich, Binzmühlestrasse 14, Zurich, CH-8050, Switzerland, Sven Seuken

We study the revenue maximization problem of a publisher selling consumer software. We assume that the publisher sells either traditional perpetual licenses, subscription licenses, or both. For our analysis, we employ a game-theoretic model, which enables us to derive the users' equilibrium strategies and the publisher's optimal pricing strategy. Via extensive numerical evaluations, we then demonstrate the sizable impact different pricing strategies have on the publisher's revenue, and we provide comparative statics for the most important settings parameters. Although in practice, many publishers still only sell perpetual licenses, we find that offering a subscription license in addition to a perpetual license typically (but not always) leads to significantly higher revenue than only selling either type of license on its own.

2 - Core-Stability in Assignment Markets with Financially Constrained Buyers

Martin Bichler, Technical University of Munich, Boltzmannstr. 3, Garching, 85748, Germany

We consider auctions of indivisible items to unit-demand bidders with budgets. Without financial constraints and pure quasilinear bidders, this assignment model allows for a simple ascending auction format that maximizes welfare and is incentive-compatible and core-stable. Introducing budget constraints, the ascending auction requires strong additional conditions on the unit-demand preferences to maintain its properties. We show that without these conditions, there does not exist an incentive-compatible and core-stable mechanism. Even if bidders reveal their valuations and budgets truthfully, the allocation and pricing problem becomes an NP-hard optimization problem. The analysis complements complexity results for more complex valuations and raises doubts on the efficiency of simple auction designs in the presence of financially constrained buyers.

■ WD11

CC Room 304C

In Person: Airline Operations Management

General Session

Chair: Burak Cankaya, Embry Riddle Aeronautical University, Lake Mary, FL, 32746, United States

1 - Sortation Network in Cargo Airlines

Chieh-hsien Tiao, Amazon, Dallas, TX, 75235, United States

Cargo airlines differ from passenger airlines in many aspects, among them, how packages connect through the transportation network is most significant. Sortation provides a guidance to the connecting process. However, sorting for destinations too far out creates too many small "channels" that waste resources; while sorting for destinations too close by provides chance to consolidate but each sorting slow down the entire transportation process. We present a solution to select sortation strategies so maximal number of packages can flow through the network while maintain satisfiable performance.

2 - Enhancing Day-ahead Airline Planning with Data-driven Flight Delay Predictions

Sebastian Birolini, University of Bergamo, Dalmine (BG), 24044, Italy, Alexandre Jacquillat, Stephanie Franklin, Gabrielle Rappaport

Flight delays are the major drivers of disruptions and unexpected costs in airline operations. It is therefore of paramount importance to get visibility into flights' delays as early as possible and as accurately as possible, in order to minimize their overall impact. In this paper, we collaborate with Vueling Airlines to build predictive models of flight delays and enhance day-ahead planning decisions accordingly. We first assemble a large-scale database of flight-level observations, using airline-specific features, system-wide features, and environmental features. Using a quantile regression model, we estimate minimum turnaround times for each pair of flights and reconstruct each flight's primary (as opposed to propagated) delay. We then develop machine learning models to predict primary delays. Our best model, based on extreme gradient boosting, achieves a mean absolute error of 7-8 minutes—a significant improvement as compared to baseline models using simpler machine learning methods or simpler sets of predictors. Finally, we embed our data-driven delay predictions into a tail assignment model to support day-ahead planning. Out-of-sample results demonstrate that leveraging the proposed predictive model can reduce overall delay costs by 3-5%. Ultimately, this paper shows the potential of combining advanced predictive and prescriptive analytics methods to enhance airline planning and operations decisions.

3 - Airline Network Planning: Mixed-integer Non-convex Optimization with Demand-supply Interactions

Mattia Cattaneo, University of Bergamo, Salmine, Italy, Alexandre Jacquillat, Sebastian Birolini, António Pais Antunes

Airlines routinely use analytics tools to support flight scheduling, fleet assignment, revenue management, crew scheduling, and many other operational decisions. However, decision support systems are less prevalent to support strategic planning. This paper fills that gap with an original mixed-integer non-convex optimization model, named Airline Network Planning with Supply and Demandinteractions (ANPSD). The ANPSD optimizes network planning (including route selection, flight frequencies and fleet composition), while capturing interdependencies between airline supply and passenger demand. We first estimate a demand model as a function of flight frequencies and network configuration, using a two-stage least-squares procedure fitted to historical data, and then formalize the ANPSD by integrating the empirical demand function into an optimization model. The model is formulated as a non-convex mixed-integer program. To solve it, we develop an exact cutting plane algorithm, named 2 ECP, which iteratively generates hyperplanes to develop an outer approximation of the non-linear demand functions. Computational results show that the 2 ECPalgorithm outperforms state-of-the-art benchmarks and generates tight solution quality guarantees. A case study based on the network of a major European carrier shows that the ANPSD provides much stronger solutions than baselines that ignore—fully or partially—demand-supply interactions.

4 - Long-term Crew Planning For Airlines

Burak Cankaya, Assistant Professor, Embry Riddle Aeronautical University, Daytona Beach, FL, United States

Pilots and aircrafts are the most valuable assets of an airline company. Union rules, pilot shortage/surplus, cost of employing an excessive number of pilots are existing constraints for airline operator companies almost all around the world. Under these harsh circumstances, many companies cannot plan the allocating of pilotsto aircraft strategically to meet near-future goals and mid/long future company objectives. In this study, we are optimizing the required crew to fleet allocation over the years with a dynamicapproach that the company both protects the most senior pilots and minimizes the pilot costs with a hybrid MIP and Heuristic apprach.

■ WD14

CC Room 201B

In Person: Statistical Learning and Decision Making

General Session

Chair: Yunzong Xu, Massachusetts Institute of Technology, Cambridge, MA, 02139-4204, United States

Co-Chair: Yunbei Xu, Columbia Business School, Columbia Business School, New York, NY, 10027-6945, United States

1 - Towards Optimal Problem Dependent Generalization Error Bounds in Statistical Learning Theory

Yunbei Xu, Columbia Business School, New York, NY, 10027-6945, United States, Assaf Zeevi

We study problem-dependent rates, i.e., generalization errors that scale near-optimally with the variance, the effective loss, or the gradient norms evaluated at the "best hypothesis." We introduce a principled framework dubbed "uniform localized convergence," and characterize sharp problem-dependent rates for central statistical learning problems. From a methodological viewpoint, our framework resolves several fundamental limitations of existing uniform convergence and localization analysis approaches. It also provides improvements and some level of unification in the study of localized complexities, one-sided uniform inequalities, and sample-based iterative algorithms.

2 - Estimating Mixture Models in Consumer Segmentation

Yiqun Hu, Massachusetts Institute of Technology, Cambridge, MA, United States, Zhenzhen Yan, David Simchi-Levi

Mixture models are used in various fields to capture different sources of uncertainties. In the setting of revenue management, market demand is an aggregate of each individual's choice probabilities. Consumers with different preferences will be driven by different choice models. To predict market demand accurately, the key is to accurately estimate the underlying mixture choice models, which remains an open research question. We propose a non-parametric estimation method based on the Frank-Wolfe algorithm to segment consumers and further apply the calibrated consumer segmentation to price optimization problem an important application in revenue management. Convergence result and sample complexity is provided for the proposed estimation method and numeric tests are conducted to demonstrate the efficiency of the proposed algorithms.

■ WD16

CC Room 201D

In Person: Interpretable Machine Learning

General Session

Chair: Cynthia Rudin, Duke University, Durham, NC, 27708, United States

1 - Multi-label Classification for Aviation Accident Reports
Xinyu Zhao, Arizona State University, Tempe, AZ, 85281, United States, Hao Yan

The NTSB aviation accident database recorded information about civil aviation accidents since 1982. The data are organized in a relational database where several tables jointly describe a specific accident. Finally, we end up with 61671 accidents in 62570 aircraft. Each accident is represented with a sequence of failure events which is very useful information for risk analysis. However, there exists inconsistency within the definition of the event among the dataset which prevents researchers from making full use of the dataset. In this project, we convert the problem into a multi-label classification problem which enables us to extract the consistent events automatically. Furthermore, the developed algorithms are able to identify the important sentences through the attention mechanism.

2 - PaCMAP: A New Algorithm for Dimension Reduction
Cynthia Rudin, Duke University, Durham, NC, 27708, United States

Dimension reduction (DR) techniques such as t-SNE, UMAP, and TriMap have demonstrated impressive visualization performance on many real world datasets. One tension that has always faced these methods is the trade-off between preservation of global structure and preservation of local structure: these methods can either handle one or the other, but not both. In this work, our main goal is to understand what aspects of DR methods are important for preserving both local and global structure: it is difficult to design a better method without a true understanding of the choices we make in our algorithms and their empirical impact on the lower-dimensional embeddings they produce.

3 - Identifying Influential Factors on Recipients' Quality of Life After Lung Transplantation using Predictive Analytics and Explainable AI
Mostafa Amini, Oklahoma State University, Stillwater, OK, 74075, United States, Ali Bagheri, Dursun Delen

Algorithmic modeling's prediction power is crucial in healthcare systems where the patients' lives are at stake. We employ predictive analytics and Explainable Artificial Intelligence (XAI) techniques to address the end-stage lung failure which leaves the patients with no option other than a transplantation. We rely on the UNOS (united network for organ sharing) data with a massive number of features associated with the donors, patients, and conditions in which the transplant is performed. We investigate the most influential factors on the prediction of the quality of life of the lung recipients which in turn participate in the utility function corresponding to the assignment of organ-patient.

■ WD19

CC Room 203A

In Person: Modern Approaches to Pricing

General Session

Chair: Michael L Hamilton, University of Pittsburgh, Morristown, NJ, 07960-5148, United States

1 - Loss Functions for Data-driven Personalized Pricing
Max Biggs, Assistant Professor, University of Virginia, Charlottesville, VA, 02139-1784, United States, Ruijiang Gao, Wei Sun

We study a pricing setting where each customer is offered a personalized price based on customer and/or product features that are predictive of the customer's valuation for that product. Often only historical sales records are available, where we only observe whether each customer purchased a product at the price prescribed rather than the customer's true valuation. As such, the data is influenced by the historical sales policy which introduces difficulties in estimating revenue from pricing policies. We approach this problem using ideas from causal inference and machine learning. In particular, we study how to formulate loss functions which directly optimize revenue, rather than going through an intermediate demand estimation stage. These loss functions have certain asymmetries which aren't present in typical classification loss functions.

2 - Revenue Management with Product Retirement and Customer Selection
Harsh Tarak Sheth, Columbia University, New York, NY, 10027-4052, United States, Adam Elmachtoub, Vineet Goyal

We consider a multi-product revenue management problem where a seller has a fixed inventory of each product to sell to a set of customers. The seller sequentially offers the set of available products to the customers and can also choose to retire products at any point. Once a product is retired, it is no longer offered to any subsequent customers. When customers follow a common MNL choice model, we provide an asymptotically optimal policy for product retirement. When there are multiple customer types, we provide a policy for jointly selecting customers and retiring products that guarantees one fourth of the optimal policy. With multiple customer types and two products, we provide an asymptotically optimal policy.

3 - Feature-based Market Segmentation and Pricing
Michael L. Hamilton, University of Pittsburgh, Pittsburgh, PA, 07960-5148, United States

With the rapid development of data-driven analytics, many firms have begun experimenting with personalized pricing strategies, i.e. strategies that predict a customer's valuation then offer them a individualized price. Ideally, a firm would perfectly predict each customer's valuation and price their goods accordingly. Unfortunately, in practice these valuations are often predicted by the firm using noisy regression models, and the number of prices the firm can offer are constrained by operational considerations. In this work, we propose and analyze a general framework for semi-personalized pricing strategies where the seller uses features about their customers to segment their market, and where customers are offered segment level prices.

■ WD20

CC Room 203B

In Person: Health Care, Modeling and Optimization I

Contributed Session

Chair: Alireza Farnoush, Auburn University, Auburn, AL, 36830-3141, United States

1 - Analysis of Covid-19 Spread in the Metropolitan Areas Within U.S via Integrating Multi-source Data
Bilal Majeed, University of Houston, Houston, TX, United States, Jiming Peng, Ying Lin, Li Ang

The COVID-19 has wreaked havoc upon the world with over 162 million confirmed cases and a death toll of over 3.36 million. It is alarming that the United States contributes to about a quarter of these confirmed cases and deaths. In this talk, we analyze major metropolitan areas (MSAs) in the U.S. and compare MSAs with similar demographic characteristics, to explore the association between some COVID-19 related measurements and the demographic characteristics in MSAs. Particularly, we explore possible reasons for the MSAs with high mortality rate (MR) and fatality rate (FR).

2 - Exploring a Multi-tiered Priced Pediatric Vaccine Gavi Market via OR
Ruben Proano, Associate Professor, Rochester Institute of Technology, Rochester, NY, United States, Galo Mosquera

Through a hypothetically coordinated vaccine market framework, we explore how to enhance affordability in pediatric vaccine purchases in the Gavi market via challenging its single-price policy. First, we develop an innovative approach to estimate the unknown vaccine reservation prices at each of the Gavi market countries from their known single-tier market prices. Then, we use these estimates to determine the reservation prices for new market configurations in multi-tiered priced Gavi markets. Via an optimization-based process, we maximize the affordability of the different configurations.

3 - Optimal Deferral Strategies for Elective Surgeries with Application to Non-infected US Population.
Kristian Singh, Benefits Science Technology, Needham, MA, United States, Omid Nohadani

The time span between diagnosis and the actual surgery is often driven by non-medical reasons, as magnified by capacity constraints caused by COVID-19 pandemic. Determining this wait time is a decision in which physicians, patients, employers, and insurers all participate. Using claims data from a large portion of the US population who received a hernia surgery, we developed a framework consisting of a machine learning method to assess individual impact of delays and an optimization model to inform deferral strategies for surgeries. This framework, delivered through a web-based application, provides decision tools for tradeoffs of the consequences when deferring any given individual.

4 - Analyzing the Language Used in Fake News Related to Covid-19
Alireza Farnoush, Auburn University, Auburn, AL, United States, Ashish Gupta, Gregory Purdy

The flood of fake news in a situation of a pandemic such as COVID-19 which affected many people can result in serious effects on societies. In this study, we aim to analyze the language used in fake associated with COVID-19. We provided the theoretical foundation needed to develop a better understanding of the science of fake news. We also raised different hypotheses and test them by applying the text analytics method and component-based SEM. Our finding indicates that fake news in COVID-19 has more uncertainty, less complexity, more negative affect, less specificity, less information quantity, less diversity, more expressivity words, and more cognitive process.

■ WD21

CC Room 204A

In Person: Sustainability and Emerging Technologies

General Session

Chair: Saed Alizamir, Yale University, New Haven, CT, 6520, United States

Chair: Michael Blair, New Haven, CT, 06510-1008, United States

1 - Two-sided Benefits of Price Transparency in Informal Supply Chains
Yuan Shi, Massachusetts Institute of Technology, Cambridge, MA, United States, Joann de Zegher, Irene Yuan Lo

This paper develops a new Hotelling model of price search for the welfare impact of price transparency in informal supply chains. The model incorporates the price-setters' operations under downstream contractual obligations and informal business relationships. We show that under demand asymmetry and costly supply uncertainty, a moderate increase in price transparency leads to a strong Pareto improvement in a competitive duopoly market. This effect persists under price collusion. Our findings contrast with the typical assumption that increased price transparency leads to one-sided benefits at the cost of the other side and inform the design of information platforms in informal supply chains.

2 - When the Wind of Change Blows, Build Batteries? Optimum Renewable Generation and Energy Storage Investments.
Christian Kaps, PA, United States, Simone Marinesi, Serguie Netessine

Renewables have become the cheapest energy source in most of the world, but their generation remains variable and difficult to predict. Recent technological advances have rendered large-scale electricity storage economically viable, thus mitigating the renewable intermittency issue. However, it is not yet well-understood how to jointly determine optimal capacity for their generation and storage. Our work aims to shed light on this question by developing a two-product newsvendor model of a utility's strategic capacity investment in renewable generation and storage to match demand with supply, while using fossil-fuel backup, if needed.

3 - Leveraging Smart Thermostat Data to understand the Impact of Climate Change on Residential Energy Consumption
Michael Blair, Yale University, New Haven, CT, 06510-1008, United States, Saed Alizamir, Shouqiang Wang

In this work, we empirically analyze a rich micro-level thermostat data set provided by a large smart thermostat manufacturer. Our analysis reveals that households differ significantly in how they utilize their thermostats. This is partially driven by heterogeneity in daily occupancy schedules, but more importantly, many households do not utilize the essential features of their thermostat. This suboptimal behavior leads to increases in consumption that are magnified on extremely hot or cold days. We also see that even small changes to our climate will have a profound impact on consumption, and this impact is correlated with how a household uses their thermostat. This highlights the potential value of smart technologies, but also the importance of using these products properly.

■ WD22

CC Room 204B

In Person: Health Care, Modeling and Optimization I

Contributed Session

Chair: Pritom Kumar Mondal, Texas Tech University, Lubbock, TX, 79407-2622, United States

1 - The Provider Network Selection Problem in Healthcare Markets
Amin Hosseininasab, Warrington College of Business, University of Florida, Gainesville, FL, United States, Willem-Jan van Hoeve, Sridhar R. Tayur

Provider network selection is a central problem faced by the healthcare insurance industry. A provider network consists of healthcare providers that are contracted by an insurer in order to provide healthcare services at discounted prices to insured patients. The problem involves insurance plan and network design to target patients under competition. We develop a novel methodology for optimal provider network selection, and show that our approach improves over methods used in the literature and a real-world insurer on test instances. We then use our methodology to analyze a number of insurance policies and mandates in terms of their effects on social welfare, equity, profits, and expenditures.

2 - A Continuous Scoring Model for Fair Liver Transplant Allocation
Subramanian Raghavan, University of Maryland-College Park, College Park, MD, United States, Shubham Akshat

The United States (U.S.) Department of Health and Human Services is interested in increasing geographical equity in access to liver transplant. We develop a novel analytical method to design heterogeneous scoring functions for continuous scoring policy in the deceased donor liver transplantation that equalizes supply to demand ratios across the transplant centers. The framework is general enough to be applied to other organs as well.

3 - Multi-Hospital Surgical Block Scheduling
Candace Arai Yano, University of California-Berkeley, Berkeley, CA, United States, Alexandra M. Newman, Vishrut Rana

Mergers and organic growth of healthcare systems have led to systems with multiple hospitals in the same general vicinity. These healthcare systems are considering whether to consolidate certain surgical procedures in a limited number of locations, thereby better justifying the purchase of advanced surgical equipment such as robots via higher utilization of this equipment. We address a multi-hospital surgical block scheduling problem that allows for such consolidation while accounting for nursing costs, capacity in downstream hospital wards and numerous other realistic factors while also limiting the assignment of surgical patients to distant hospitals for simpler surgical procedures.

4 - Optimizing Equitable Access to Emergency Care in San Francisco
Robert Newton, PhD Student, Pennsylvania State University, University Park, PA, United States

San Francisco's "Blueprint" plans to re-open post-pandemic include a metric of healthcare equity but look solely at number of insured adults. Previous work suggested inequity in the distribution the city's emergency rooms, leaving lower income areas underserviced. We consider two models to optimize ER locations—Set Covering (SCP) and Maximal Coverage (MCLP). The SCP suggests seven ERs can service the city with four new locations not controlling for capacity. The MCLP better accounts for existing ERs and proposes a new ER in ZIP code 94112 to maximize coverage of underserviced areas—tripling the probability 911 calls from low-income ZIP codes are within the threshold distance to an emergency room.

5 - Capacity Planning in a Psychiatric Hospital Using Mixed Integer Linear Programming
Pritom Kumar Mondal, PhD Student, Texas Tech University, Lubbock, TX, United States, Bryan A. Norman

Severely ill psychiatric patients from outpatient mental health settings are referred to a psychiatric hospital to potentially receive treatment. However, due to not having sufficient mental health therapists, patients do not always receive therapy treatments in a timely manner, which hinders their quality of care and health status. A mixed integer linear program has been developed to determine the number of mental health therapists required to ensure patients get all necessary therapies at the appropriate time.

■ WD24

CC Room 205A

In Person: Supply Chain Data Analytics Applications

General Session

Chair: Ahmet Colak, Clemson University, Pendleton, SC, 29670, United States

1 - Capacity Planning and Online Order Fulfillment with Integrated Logistics

Pin-Yi Chen, Massachusetts Institute of Technology, Cambridge, MA, 02141-1904, United States, Tolga Cezik, Daniel Chongli Chen, Tamar Cohen-Hillel, Stephen C. Graves

The order fulfillment decision for an online retailer includes determining the fulfillment center from which to source an order as well as the transportation route for shipping the order to the customer. Increasingly, online retailers are relying on their own integrated logistics operations for their shipping, in addition to third-party shipping. For this case we propose a framework for capacity planning of the integrated logistics operations in conjunction with dynamic order fulfillment decisions. A realistic capacity plan of a large-scale network is realized with our framework.

2 - An Empirical Analysis of Feature-based Pricing in the Automobile Industry

Choi Hojun, Northwestern University, Evanston, IL, United States, Achal Bassamboo, Ahmet Colak, Sina Golara

Auto consumers pay close attention to a car's pricing, functionality, and attributes, and dealerships consider this aspect of consumer behavior when determining their prices and which features to emphasize. We explore whether listing similar features improves dealerships' performance based on 10,000 auto dealerships from a national sample. Our cars.com dataset of 2 million cars is obtained daily from August until December 2020. W e estimate the main effects by regressing price and listing duration on the car, brand, dealership, location, and feature characteristics. Our findings can provide more concrete insights into customers' behaviors regarding redundant information of an item.

■ WD27

CC Room 206B

In Person: Faster Conditional Gradient Methods

General Session

Chair: Alejandro Carderera, United States

1 - Universal Conditional Gradient Sliding for Convex Optimization

Trevor Squires, Clemson, Clemson, SC, 29678-1719, United States, Yuyuan Ouyang

We present a first-order projection-free method, namely, the universal conditional gradient sliding (UCGS) method, for solving -approximate solutions to convex differentiable optimization problems. For objective functions with Hölder continuous gradients, we show that UCGS is able to terminate with -solutions with at most O((1/)2/(1+3v)) gradient evaluations and O((1/)4/(1+3v)) linear objective optimizations, where v is the exponent and of the Hölder condition. In the weakly smooth case when v is in (0,1), both complexity results improve the current state-of-the-art O((1/)1/v) result achieved by the conditional gradient method. In the smooth case when =1, UCGS matches the state-of-the-art complexity result and adds more features allowing for practical implementation. Furthermore, UCGS runs without explicit knowledge of the smoothness information.

2 - The Primal-Dual Davis-Yin Algorithm(s)

Adil Salim, King Abdullah University of Science and Technology (KAUST), King Abdullah University of Science and Technology, Thuwal, Saudi Arabia

We introduce new primal-dual algorithms to minimize the sum of three convex functions, each having its own oracle. Namely, the first one is differentiable, smooth and possibly stochastic, the second is proximable, and the last one is a composition of a proximable function with a linear map. By leveraging variance reduction, we prove convergence to an exact solution with sublinear or linear rates, depending on strong convexity properties. The proposed theory is simple and unified by the umbrella of stochastic Davis-Yin splitting, which we first design in this work. Our theory covers several settings that are not tackled by any existing algorithm.Joint work with Laurent Condat, Konstantin Mishchenko and Peter Richtárik.

■ WD30

CC Room 207D

In Person: Recent Developments on Modeling Financial Systemic Risk

General Session

Chair: Nils Detering,

1 - Credit Freezes, Equilibrium Multiplicity and Optimal Bailouts in Financial Networks

Agathe Pernoud, Stanford University, Stanford, CA, United States

We analyze how interdependencies between organizations in financial networks can lead to multiple possible equilibrium outcomes. A multiplicity arises if and only if there exists a certain type of dependency cycle in the network that allows for self-fulfilling chains of defaults. We provide necessary and sufficient conditions for banks' solvency in any equilibrium. Building on these conditions, we characterize the minimum bailout payments needed to ensure systemic solvency, as well as how solvency can be ensured by guaranteeing a specific set of debt payments. We show that the minimum bailout problem is computationally hard, but provide an upper bound on optimal payments and show that the problem has intuitive solutions in specific network structures such as those with disjoint cycles or a core-periphery structure.

2 - Zooming in Distress Anomaly: Bankruptcy vs. Other Failures

Xiaorui Zhu, University of Cincinnati, Cincinnati, OH, United States, Yuhang Xing, Yan Yu

This paper reinvestigates the distress risk anomaly that financially distressed firms deliver abnormally low returns. We distinguish between bankruptcy and other-failure events and then utilizing the state-of-the-art adaptive Lasso variable selection method to identify predictors for these two types of risk. We obtain strikingly different predictors of bankruptcy and other-failure risk. In addition, both selected models gain better out-of-sample prediction performances than that of classical models in the literature. With the new risk measures, we find that the other-failure risk anomaly disappears while the anomalous return is persistently associated with the bankruptcy risk.

3 - When Do You Stop Supporting Your Bankrupt Subsidiary?

Nils Detering, Santa Barbara, CA, 93106, United States

Most global banks consist of dozens if not hundreds of subsidiaries. For corporations becoming a holding with subsidiaries has several advantages: It allows them to limit the spillover risk if one business line is in trouble or to defer taxable business income. For example a bank holding may naturally divide into subsidiaries based on location (i.e. Europe, US) and/or business lines (i.e. equity trading, fixed income trading). We consider a network of holding banks. We show that comprising a firms business activity in a holding can have both, positive or negative effects on systemic stability. We analyse to what extent voluntary support benefits society and/or the holding itself. We observe that an increased commitment of the holding to its subsidiaries can have both, positive and negative effects on systemic risk depending on the type of the holding.

■ WD31

CC Room 208A

In Person: Operations of Matching Markets

General Session

Chair: Vahideh Manshadi, Yale University, Quincy, MA, 02169-4688, United States

1 - Online Ranking Policies for Maximizing Engagement on Nonprofit Matching Platforms

Akshaya Suresh, Yale University, New Haven, CT, United States, Vahideh Manshadi, Daniela Saban, Scott Rodilitz

Nonprofit platforms that facilitate connections between volunteers and opportunities rely on their on-platform ranking engines as well as off-platform targeted promotion of opportunities to engage volunteers. In collaboration with VolunteerMatch, the largest of such platforms, we show that off-platform traffic constitutes a large portion of engagement but that opportunities enjoy disparate levels of such traffic. We develop ranking policies that effectively utilize off-platform traffic to maximize overall engagement and demonstrate their effectiveness by testing them on VolunteerMatch's data.

2 - Two-Sided Assortment Optimization

Ignacio Rios, Assistant Professor, The University of Texas at Dallas, Richardson, TX, United States

We consider a two-sided market mediated by platform, where agents on each side of the market see a subset of profiles in each period. Matches are generated if two users mutually like each other, possibly on different periods. The goal of the platform is to maximize the expected number of matches generated. We model this problem as a dynamic program, we analyze its properties, and we provide performance guarantees for some particular cases of special interest.

3 - Optimizing for Strategy Diversity in the Design of Video Games

Will Ma, Columbia University, New York, NY, United States, Oussama Hanguir, Christopher Ryan

A situation common to video games is that a player, with limited resources, must choose a "loadout" of weapons to spend the resources on to maximize firepower. As the video game designer, is it possible to create weapons so that different players, at different stages of the game and possessing different resources, end up wielding different weapons in their loadout, as opposed to some weapons having so much firepower or being so cost-efficient that they are ubiquitous? In this work we show that there is a mathematical limit to the diversity in loadout strategies, and introduce an optimized weapon design which approaches this limit.

■ WD32

CC Room 208B

In Person: Statistical Learning and Optimization in Revenue Management/Platform Strategies

General Session

Chair: Hao Ding, Emory University, Emory University, Atlanta, GA, United States

1 - A New Approach for Vehicle Routing with Stochastic Demand: Combining Route Assignment with Process Flexibility

Hanzhang Qin, Massachusetts Institute of Technology, Cambridge, MA, 02142-1365, United States, Kirby Ledvina, David Simchi-Levi, Yehua Wei

We propose a new approach for the vehicle routing problem with stochastic demands for the case in which customer demands are revealed before vehicles are dispatched. Our approach combines ideas from vehicle routing and manufacturing process flexibility to propose overlapped routing strategies with customer sharing. We characterize the asymptotic performance of the overlapped routing strategies under probabilistic analysis. Using the characterization, we demonstrate that our overlapped routing strategies perform close to the theoretical lower-bound derived from the reoptimization strategy, and significantly outperforms the routing strategy without overlapped routes. The effectiveness of the proposed overlapped routing strategies in non-asymptotic regimes is further verified through numerical analysis.

2 - Learning to Use Auxiliary Observations in Adaptive Sequential Experiments

Yonatan Gur, Stanford University, Stanford, CA, 94305-7216, United States

In many practical settings, including assortment selection, pricing, and healthcare, Performance of sequential experiments can be improved in the presence of auxiliary observations that can be mapped to information on mean rewards. When these mappings are a priori unknown, we characterize necessary and sufficient conditions under which auxiliary information allows performance improvement. We devise a policy based on two different upper confidence bounds and establish its near-optimality.

3 - Are Buyers Strategic in Their Reviews in the B2B Market

Hao Ding, Emory University

In the digital age, buyer-generated-reviews drive purchasing decisions for buyers and success for both sellers and platforms. Buyers contribute in reviews to reward good sellers and help other buyers make informed purchasing decisions. Are buyers always altruistic in leaving reviews? In this paper, we study whether buyers in the B2B market leverage reviews strategically to maintain their bargaining power and preserve capacity allocation. Our unique dataset contains 240,288 reviews and 1,261,278 transactions of 6,682 suppliers on the largest B2B trading platform in the world. Using a difference-in-difference design with an exogenous shock, we causally test whether buyers change their review behaviors based on sellers' recent transaction level. We find that buyers are 8% to 16% less likely to leave a review for each additional transactions that sellers had.

■ WD33

CC Room 209A

In Person: New Directions in Revenue Optimization

General Session

Chair: Georgia Perakis, Massachusetts Institute of Technology, Cambridge, MA, United States

1 - Addressing High Dimensional Prediction Challenges in RM Applications

Ioannis Spantidakis, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Tamar Cohen-Hillel, Georgia Perakis, Leann Thayaparan

High dimensional data is a blessing and a curse, often necessary for the most interesting machine learning problems but bringing with it feature-correlation, noise, and long runtimes. This is especially true in retail, where a large amount of information is needed to make optimal decisions. In this research, we develop a new dimensionality reduction algorithm called Supervised Approach for Feature Engineering (SAFE), which is an alternative to Principal Component Analysis (PCA). SAFE finds uncorrelated, lower dimensional features that best explain differences in the dependent variable (e.g., sales) facilitating the prediction task.

2 - XSTrees: Extended Sampled Tree Ensembles for Classification And Regression

Omar Skali Lami, MIT, Ashdown 4091B, Cambridge, MA, 2139, United States, Georgia Perakis, Divya Singhvi

Extended Sampled Trees (XSTrees), is a novel tree ensemble method for classification and regression. Instead of learning a single decision tree like CART, or an independent collection of trees like Random Forests, XSTrees learns the entire probability distribution over the tree space. This approach results in good theoretical guarantees and a significant edge over other methods in terms of performance. Analytically, we prove that XSTrees converge to the true underlying tree model with rate O(log(n)/n), where n is the number of observations. Experimentally, we show on publicly available datasets, synthetic data and two real-world case studies that XSTrees are very competitive with the state-of-the-art predictive models, with an average accuracy between 2.5% and 50% higher than competitors for classification, and an average R2 between 2% and 85% higher for regression.

■ WD34

CC Room 209B

In Person: Transportation-Operations I

Contributed Session

Chair: Bekircan Kirkici, Auburn University, Auburn, AL, 36830, United States

1 - Modeling System-wide Energy in Urban Rail Transit Systems for Sustainable Strategy Discovery and Decision-making

Zhuo Han, University of Massachusetts Amherst, Amherst, MA, United States, Sean Donaghy, Eleni Christofa, Eric Gonzales, Jimi Oke

Rail transit is critical to mobility in dense urban areas. In 2019, the light and heavy rail systems of the Boston area served 151M rides and consumed 414 GWh of energy. We estimate an interpretable machine learning model to predict energy usage, based on train trajectories, ridership and weather. We then develop a framework for discovering strategies to reduce energy (and consequently, costs and emissions) under a variety of scenarios. Further, we analyze the impacts of COVID-19 on the system in 2020 (ridership fell to 52M with 385 GWh energy consumed). We expect our framework will serve as a viable decision tool for sustainable and resilient urban rail systems.

2 - Modeling a Mixed-fleet Of Electric and Diesel Buses Operational Characteristics and Charging Infrastructure Planning in a Public Transit Network

Amirali Soltanpour, Doctoral Researcher, Michigan State University, East Lansing, MI, United States, Mehrnaz Ghamami

Electric buses (EB) reduce fuel consumption and emission production, while have limited range and are costly. This study finds the optimal bus types for each route and locates charging infrastructure within a transit network. Due to the computational complexity of the optimization model, a metaheuristic algorithm is developed to find the minimum investment and operation cost of transit systems. This study shows that smaller EBs can be more cost-effective than diesel buses. Electricity rate and availability of distributed energy resources affects the optimum location of charging infrastructure.

3 - Performance Evaluation and Pooling Efficiency for On-demand Public Transportation: A Case Study

Bekircan Kirkici, Auburn University, Auburn, AL, United States, Daniel F. Silva, Alexander Vinel

Demand responsive transportation system experiments have been recently implemented in several localities, which has renewed academic interest in the topic. We investigate a real-world system which aimed to create inexpensive means of transportation for those with limited access to mass transit. Hence, the focus is not profit maximization but equity and efficiency. First, we analyze the existing system's performance. We then focus on pooling efficiency and investigate different related metrics and pooling criteria. Naturally, there exists a trade-off between waiting times and pooling, which we quantify based on the real data for the system in question.

4 - Performance Factors Influencing the Service Reliability and Service Interruption in Train Operations under PTC
Yalda Khashe, University of Southern California, Los Angeles, CA, United State

Railroads operate in high-risk and rapidly changing environments while avoiding catastrophic events. Positive Train Control (PTC) is a range of fully integrated technologies that overlay existing safety systems to prevent train-to-train collision and improve worker safety. This research identifies factors that affect the reliability and serviceability of train operations under PTC. The results show that although technical factors affected the PTC operation, issues that arise from inadequate interaction of the subsystems or lack of alignment between organizational and human factors, and the technical system have a significantly higher contribution to PTC failures and major delays.

■ WD35

CC Room 210A

In Person: Transportation-Freight II

Contributed Session

Chair: Camill Harter, Erasmus University-Rotterdam, Rotterdam, 3062PA, Netherlands

1 - Determinants of Air Cargo Pricing
Arim Park, North Carolina A& T. State University, Greensboro, NC, United States, Min Kyung Lee, Ji-Hung (Ryan) Choi, Ju Myung Song

This paper is to examine critical factors that influence air cargo pricing. We estimated fixed effect regressions and explored the surcharge cases with analytical modeling approaches using a major company's operational level dataset that provides an air cargo service in South Korea between 2008 and 2013.

2 - Evaluation and Comparison of Three Alternative Collaboration and Profit Sharing Methods for Less Than Truckload Carriers
Bhavya Padmanabhan, University of South Carolina, Columbia, SC, United States, Nathan Huynh, William G. Ferrell, Vishal Badyal

This study addresses three methods for less than truckload carrier collaboration under centralized planning, but the carriers are allowed to retain some of their jobs and share the rest. Method 1 and Method 3 are two step approaches and Method 2 is a one step approach. Two step refers finding the job allocation first and then sharing the profit whereas one step refers finding both simultaneously. Mathematical models for job allocation and profit sharing are proposed for all the three methods. The experiment results indicate that the total profit from Method 1 is 5.29% higher than that of Method 2 and 11.25% higher than that of Method 3. The total profit from Method 2 is 6.60% higher than that of Method 3.

3 - Selection of Auto-carrier Loading Policy in Automobile Distribution
Yanshuo Sun, FAMU-FSU College of Engineering, Tallahassee, FL, United States, Sajeeb Kirtonia

When finished vehicles are shipped from automobile manufacturers to dealerships, auto-carriers are employed, which are specially designed to allow the compact storage of multiple automobiles. This special design means automobiles can only be loaded and unloaded through a single exit of an auto-carrier, which complicates the automobile loading and unloading operations. As there is no consensus in the auto-carrier routing literature regarding whether to enforce a Last In First Out (LIFO) policy or allow reloading en-route, this study explores how to optimize the selection of loading policy based on a trade-off between solution complexity and quality.

4 - An Efficiency-vulnerability Trade-off for Information Layer Integration in Multimodal Transport Networks
Camill Harter, Erasmus University Rotterdam, Rotterdam, Netherlands, Otto Koppius, Rob A. Zuidwijk

Synchromodality tackles inefficiency in hinterland transport through a dynamic system allowing for flexible routes and use of transport modes. This requires extensive integration of digital infrastructure, resulting in an interdependent complex system with digital and physical layer. Such systems have shown high vulnerability to cascadic failure. Applying a multi-layer network approach to a network of all intermodal services in Europe, we analyze a trade-off between efficiency and vulnerability that comes with synchromodality. We show that the system benefits from synchromodal transport under light attack, but it collapses quickly under heavy and targeted attack to the information layer.

Wednesday, 4:30PM-6:00PM

■ WE06

CC Room 303A

In Person: Agriculture Applications

Contributed Session

Chair: Erick Jones, II, University of Texas at Arlington, Arlington, TX, United States

1 - Water Quality Impacts of Optimal Crop Insurance Policy Selection
Gorkem Emirhuseyinoglu, Iowa State University, Ames, IA, United States, Sarah M. Ryan

Crop yield and prices are the major uncertainties affecting farm revenue. Farm yield is a function of nitrogen (N) and random weather elements. However, farmland runoff of N negatively impacts biodiversity via water quality. Insurance programs target yield and/or price uncertainty to mitigate farming risks. From a farmer's viewpoint, we generate weather scenarios and build stochastic programs for insurance and N application decisions to maximize risk-adjusted farm profits. We investigate how insurance programs affect N fertilizer application and the consequent surface water quality impacts.

2 - Food Flows Between US Counties Through Time
Deniz Berfin Karakoc, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Junren Wang, Megan Konar

Food supply chains are essential for distributing goods from production to consumption points. Recent research has developed novel methods to estimate food flows with high spatial resolution. Yet, we do not currently understand how fine-grained food supply chains vary in time. In this study, we develop a time-series analysis of food flows between the counties in the United States. We use the Food Flow Model to estimate food flows across all food commodity groups (approximately 70 million links) for the years 2007, 2012, and 2017. We then determine the core nodes and links in the US food supply chain, which may prove useful for future research, policy, and decision-making.

3 - Stochastic Optimization Modeling of an Agriculture, Water and Energy System under Future Water Uncertainty
Erick Jones, University of Texas at Arlington, Arlington, TX, United States

Climate change has caused prolonged droughts which strains water resource availability. However, there are unconventional sources of water that could become profitable for agricultural uses when water or crop prices increase. Therefore, we develop a stochastic multi-systems optimization scheme based on decomposition that takes creates a distribution for likely water and energy resource futures and optimize all the systems under uncertainty simultaneously so that the farm can make the best decisions today.

■ WE07

CC Room 303B

In Person: Lavanya's Session

General Session

Chair: Lavanya Marla, U of Illinois at Urbana-Champaign, Urbana, IL, 61801-2925, United States

1 - An Optimization Model for Vaccine Distribution via UAVS or Drone
Abhijeet Kumar, University of North Texas, Denton, TX, United States, M. A. Shariful Amin, Rishabh Rana, Victor Prybutok

The pandemic that began in December 2019 in China is now taking a toll on developing countries like India. Due to a lack of proper outreach of vaccines, India is suffering from low coverage rates. India needs to vaccinate its people quickly otherwise the virus would continue to mutate and spread not only locally but also globally. The use of unmanned aerial vehicles (UAVs) can help in outreach and help in the last-mile distribution of the vaccine. The objective of this research is to formulate an optimization model for the delivery of vaccine packages via UAVs to a remote location.

■ WE08

CC Room 303C

In Person: Parallel Server Systems

General Session

Chair: Gal Mendelson, Stanford Graduate School of Business, Adi, 1794000, Israel

1 - Heavy-traffic Universality of Redundancy Systems with Data Locality Constraints

Ellen Cardinaels, Eindhoven University of Technology, Eindhoven, Netherlands, Sem Borst, Johan S. van Leeuwaarden

Heterogeneity and compatibility relations between jobs and servers are becoming ubiquitous in cloud computing platforms due to data locality and network topology constraints. These features strongly diverge from the inherent symmetry of the supermarket model as the baseline scenario for performance benchmarking in parallel-server systems. In this talk we will specifically focus on redundancy scheduling systems with compatibility constraints to gain insight from product-form distributions via a heavy-traffic limit. The asymptotics reveal a striking universality property, in the sense that the system achieves complete resource pooling and exhibits the same behavior across a broad range of scenarios. In particular, the performance of a fully flexible system can asymptotically be matched even with quite stringent compatibility constraints.

2 - Stability Properties of Parallel Server Systems under State Dependent Policies

Gorkem Unlu, Booth School of Business, The University of Chicago, Chicago, IL, 60615, United States, Yuan Zhong

We consider the X-Model parallel server system and examine its stability properties under state dependent policies. State dependent policies are attractive because they require only the queue size information. However, they can lead to instability for relatively low system loads. For the X-Model system, we show that switching curve policies, where each server makes the service decision according to a non-decreasing function of queue sizes, can lead to instability. We conjecture that there does not exist a state dependent policy that stabilizes all underloaded parallel server systems.

3 - Asymptotic Optimality of Approximation Based Load Balancing

Gal Mendelson, Stanford Graduate School of Business, Palo Alto, CA, 1794000, United States

Recent work has shown that using queue length approximations to inform load balancing decisions in systems with multiple dispatchers and parallel servers can lead to excellent performance with a small amount of communication. We consider a general time varying model of such systems and provide a sufficient condition on the approximations under which the queue lengths equalize in the diffusion scale limit. This, in turn, implies that the workload in the system is minimized yielding asymptotic optimality. We analyze several low communication approximation schemes and prove that the resulting approximations satisfy the sufficient condition.

■ WE09

CC Room 303D

In Person: Local Algorithms for Dynamic Optimization in Networks

Joint Session

Chair: Yash Kanoria, Columbia University, Cambridge, United States

Co-Chair: Judy Gan, Columbia University, New York, NY, 10027-6945, United States

1 - PTAS for the Optimal Policy in Online Stochastic Combinatorial Optimization

Yilun Chen, Cornell, Ithaca, NY, 14850-1854, United States

Recently, Chen and Goldberg devised the first polynomial time approximation scheme (PTAS) for high-dimensional optimal stopping, and left open whether the approach could be applied to other high-dimensional stochastic control problems. We present an interesting extension to a natural online high-dimensional combinatorial optimization problem, developing a PTAS (polynomial in the time horizon for any fixed error tolerance and degree) for online stochastic max weight independent set in bounded-degree bipartite graphs. Our approach allows for generally correlated weights, exhibits an interesting correlation decay property, and suggests that the framework may be more broadly applicable.

2 - Know Thy Neighbor: Local Algorithms for Network MDPs

Yuanling Gan, Columbia University, New York, NY, United States, Yash Kanoria, Xuan Zhang

Motivated by large-scale online marketplaces and other applications, we introduce a benchmark model for dynamic decision-making in networks with future uncertainty. The controller makes a decision at each node in a network at each time. Nodes and edges have associated random reward functions at each time and stochastic (with known distribution) future reward functions. A decision algorithm is "local" if the decision at each node is based on information only about a constant radius neighborhood of the node. We construct a local algorithm for this dynamic decision problem and show that our algorithm is near-optimal when edge rewards are small with respect to the randomness in node rewards and the graph degree.

■ WE12

CC Room 304D

In Person: Political Redistricting Part I of II

General Session

Chair: Hamidreza Validi, Rice University, Stillwater, OK, 74078, United States

1 - An Analysis of Multilevel Algorithms for Compact Districting

Rahul Swamy, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, Douglas M. King, Sheldon H Jacobson

The Compact Districting Problem (CDP) divides a region into districts (subregions) such that each district is compact, balanced in population, and contiguous. This is a fundamental problem that arises in many applications ranging from political redistricting to service territory design. A multilevel algorithm is a popular algorithm in graph partitioning that has been adapted to solve CDPs in recent work. This talk provides an analysis of the performance of the multilevel algorithm for CDPs. The goal is to compare its performance for various parameter settings to benefit a decision-maker that seeks to find scalable solutions to a CDP.

2 - Compactness in Redistricting; Red Flag or Red Herring?

Laurel Travis, Virginia Tech, Blacksburg, VA, 24060-8700, United States, Jamie Fravel, Nicholas Goedert, Robert Hildebrand, Renan Lopes, Matthew Pierson

We examine the impact of various objective functions on redistricting results, especially compactness. Tradeoffs between compactness and racial equity are examined visually. The ability of partisan gerrymanders to pass visual and analytical compactness tests is explored for Southern states. Methodology includes hill climbing with network techniques used to achieve and maintain feasibility. Cluster analysis is used to compare results of multiple hill-climbing replications. Hill-climbing results are compared to bounds from a stylized non-spatial Karush-Kuhn-Tucker analytical model.

■ WE17

CC Room 202A

In Person: Distributed energy generation

General Session

Chair: Alexandra M Newman, Colorado School of Mines, Colorado School of Mines, Golden, CO, 80401-1887, United States

1 - Balancing Cost and Resilience: Distributed Energy System Design And Dispatch

Jamie Grymes, MS, Colorado School of Mines, Golden, CO, 80401, United States

As the frequency and duration of grid outages increase, backup power systems are becoming more important for ensuring critical infrastructure can continue to provide essential services. Distributed energy resources such as solar, storage, and combined heat and power are increasingly common sources of onsite power generation. However, a system sized to maximize economic savings may be insufficient to sustain the critical load for an extended outage. In this work, we solve a multi-objective mixed integer linear program to explore the tradeoffs between cost and resilience.

2 - Optimizing Design and Dispatch of a Renewable Energy System with Combined Heat and Power: A Case Study of South Africa

Jusse Hirwa, MS, Colorado School of Mines, Golden, CO, 80401, United States, Alexander Zolan, Tulay Flamand, William Becker

Lack of access to reliable energy is a major concern for countries in sub-Saharan Africa. Users therefore turn to distributed generation in the form of back-up generators to remain operational in the event of an outage. However, the design of such systems is usually based on rules of thumb. Our optimization model incorporates means of energy supply, in addition to existing on-site technologies, such as renewable energy, combined heat and power, and storage technologies. We examine a hospital in South Africa with requirements of highly reliable electrical and thermal energy supply.

3 - Optimizing Vehicle Fleet and Assignment for Concentrating Solar Power Plant Mirror Washing

Alexander Zolan, National Renewable Energy Laboratory, Austin, TX, 78757-2608, United States, Jesse Wales, Alexandra M. Newman, Michael J. Wagner

Concentrating solar power central-receiver plants use thousands of sun-tracking mirrors, i.e., heliostats, to redirect sunlight to a central receiver, which collects and uses the heat to generate electricity. Over time, soiling reduces the reflectivity of the heliostats and, therefore, the efficiency of the system. We present a mixed-integer nonlinear program that determines wash vehicle fleet size, mix, and assignment of wash crews to heliostats to minimize the sum of (i) the revenues lost due to soiling, (ii) the costs of hiring crews and operating vehicles, and (iii) the costs of purchasing vehicles. We propose a decomposition method that enables near-optimal solutions to the wash vehicle sizing and assignment problem on the order of a couple of minutes. These solutions yield hundreds of thousands of dollars in savings per year over current industry practices.

■ WE19

CC Room 203A

In Person: Studies of the Pharmaceutical Supply Chain

General Session

Chair: Emily L Tucker, Clemson University, Clemson, SC, 29634, United States

1 - The Interactions of Crowding, Patient Severity, and Queue Rank at a Hospital Emergency Department

Lu Wang, Ball State University, Muncie, IN, United States, Mazhar Arikan, Suman Mallik

Utilizing the patient data from the ED of a large urban teaching hospital, we characterize the impacts of the change in patient queue rank on patient LOS. We study how arrivals of higher/lower severity patients influence patient LOS, and how changes in queue rank, severity, and crowding simultaneously affect LOS.

2 - International Drug Shortages: Associations Between Shortages Across Continents

Emily L. Tucker, Assistant Professor, Clemson, SC, 29634, United States, Emilia Vann Yaroson, Shravan Anil Shinde, Martha L. Sabogal De La Pava

Drug shortages regularly occur around the globe. Beyond the immediate concerns of COVID-19 supply and demand pressures, supply chain issues have caused shortages for decades. Much of the research about drug shortages in the US has abstracted away the global context of these international supply chains. European researchers have begun to consider the effects of shortages across intra-continental borders, and in this work, we evaluate the associations between shortages in the US and other countries around the world. We consider whether particular causes increase the likelihood of occurrence in other countries and discuss potential ramifications for policy.

■ WE20

CC Room 203B

In Person: Health Care, Modeling and Optimization II

Contributed Session

Chair: Fernando A C C Fontes, Universidade do Porto, Porto, 4200-465, Portugal

1 - Temporal Network Architectures of Neurocognitive and Psychological Symptoms in Collegiate Athletes with Sport-related Concussion

Caroline G. Turner, United States Naval Academy, Annapolis, MD, United States, Anna Svirsko, Gian-Gabriel P. Garcia, Spencer Liebel

Concussions are a common brain injury, affecting millions of Americans each year but, the relationship between concussion symptoms during the healing process is not well understood. In order to further understand the concussion recovery process, we develop a weighted temporal network to analyze how concussion symptoms are interrelated, mutually reinforcing, and amplifying. In analyzing this network, we look to identify each symptom's evolution through the healing process and how symptoms influence each other over to allow for a better understanding of the concussion recovery process.

2 - Appointment Scheduling with Multiple Servers and Optional Batch Arrivals

Robert H. Lee, University of Amsterdam, Amsterdam, Netherlands, Alex Kuiper

In healthcare appointment scheduling one often seeks to minimize a weighted sum of patient waiting time and physician idle time. It is common to suppose that patients arrive singly and that the schedule is served by a single physician. However, these assumptions are frequently relaxed. By formulating an appointment schedule as a queue where patients arrive in batches of size at least one, and where there are one or more servers, a Db/M/c queue, one can analytically investigate the effect on optimal appointment schedules of varying the batch size and the number of servers independently of one another.

3 - VRP with Release Dates and Deadlines: A Blood Sample Collection Application

Fernando A.C. Fontes, Universidade do Porto, Faculdade de Engenharia, Universidade do Porto, NI, Porto, 4200-465 PORTO, Portugal, Dalila B. M. M. Fontes, Helena V. Ferreira

Blood sample collection is critical due to the blood short lifespan. Once extracted, the blood samples are stored until collected, transported, and delivered to the lab. Biological degradation imposes a limit on the time between extraction and delivery. If this limit is not respected, the blood must be disposed of and a new extraction arrange for, which in addition to the extraction, collection, and delivery costs, also implies environmental costs associated with the disposal of biological residues. This problem can be cast as a VRP with release dates (the extraction timing) and deadlines (the lifespan). We propose a MILP model to solve this problem.

■ WE21

CC Room 204A

In Person: Marketplace Design and Operations

General Session

Chair: Park Sinchaisri, The Wharton School, University of Pennsylvania, Philadelphis, PA, United States

1 - Crowdsourcing Market Information From Competitors

Irene Y Lo, Stanford University, Stanford, CA, 94305-4121, United States, Joann de Zegher

Market price information is often not widely available in the developing world, and information sharing agreements among competing firms can create significant benefits. However, such agreements may be difficult to implement, as a firm might fear that sharing information will benefit competitors. We show that an appropriately designed information-sharing platform can disclose partial information that will benefit all firms. By eliminating business stealing concerns, our information disclosure policy creates a Pareto improvement and is implementable if the information shared by the platform is sufficiently valuable. The model requires minimal assumptions and can account for general market dynamics. The interpretability of our results allows us to propose a heuristic for use in practice by an Indonesia-based information-sharing platform we collaborate with.

2 - Intertemporal Pricing with Resellers: An Empirical Study of Product Drops

Dayton T. Steele, University of North Carolina Chapel Hill, Ashbrook Apts 601 Jones Ferry Rd Apt B7, Carrboro, NC, 27510-2159, United States, Seyedmorteza Emadi, Saravanan Kesavan

Product drops occur when a firm releases a limited-edition product line on a specific date for a short period of time. The product drop generates hype from customers that results in large sales, and a resale market may emerge where products resell at higher prices once the firm stocks out. A firm may ask: "Am I leaving money on the table?" To answer this, we obtain a unique data set from a retailer of baby clothing with weekly product drops. We estimate a structural model that incorporates the strategic behavior of customers reselling as well as firm pricing decisions based on limited inventory. We find that ignoring the resale market in pricing reduces firm profit by 7.0% on average.

3 - The Structural Behavioral Model of Gig Economy Workers

Park Sinchaisri, Assistant Professor, Haas School of Business, UC Berkeley, Berkeley, CA, 19104, United States, Gad Allon, Maxime Cohen, Kenneth Moon

With the flexibility in the choice of service, gig workers often exhibit a "multihoming" behavior. An increase in the number of options available to gig workers has resulted in increased competition among platforms to win over a limited mutual pool of workers. How workers respond to platform competition is therefore an important topic to study, but studying multihoming behavior empirically is challenging due to the unobservability of work options. We combine proprietary data from a ride-hailing platform and public trip records to estimate a structural model of workers' labor decisions when facing multiple work opportunities, using a machine learning-based adversarial estimation approach. Our counterfactual analyses demonstrate the effectiveness of different policies and offer insights that can help the firm manage its workers during different demand scenarios.

■ WE22

CC Room 204B

In Person: Optimal Large-scale Policies in Emerging Healthcare Problems

General Session

Chair: Sohom Chatterjee, Texas A&M University, College Station, TX, 77840, United States

1 - The Impact of Early Large-scale Screening on the Evolution of Pandemics

Marwan Safwan Shams Eddin, George Mason University, Manassas, VA, 20110, United States, Hadi El-Amine, Hrayer Aprahamian

We study the problem of large-scale screening in the early stages of a pandemic. In this setting, resources such as testing kits, budget, and hospital beds are scarce, and early-stage testing has the potential to alter the dynamics of disease spread. Thus, devising optimal screening strategies that operate within these constraints is crucial to saving lives and reducing healthcare costs. To address the issue of limited testing capacity, we study two models that focus on either individual or group (pooled) testing, and we determine conditions under which each scheme is superior. We calibrate our models using data on the ongoing COVID pandemic and demonstrate the benefits of our proposed methods.

2 - Presenter

Seth D. Brown, Rice University, Houston, TX, 77098, United States

We present a general framework for allocating scarce resources to disparate groups fairly and efficiently. We focus on the example of liver transplant allocation among multiple patient groups. In particular, we show how the parameters of a given patient population can be used to determine a score exception approach which lies on the efficient frontier with respect to each patient's well-being while taking individual patient agency into account. We provide a two-stage stochastic model whose parametrized recourse function takes the form of a binary linear program which can be solved as an LP.

3 - Capturing the Dilution Effect of Risk-based Group Testing with Application to COVID-19 Screening

Sohom Chatterjee, Texas A&M University, College Station, TX, United States, Hrayer Aprahamian

In this paper, we construct optimal group testing schemes for heterogeneous populations considering imperfect tests and the dilution effect of grouping. We first conduct an analysis under a general sensitivity dilution function and, since closed-form expressions are not possible, identify a closed-form upper bound which is treated as a proxy objective function and optimized. We then consider a special sensitivity function that is realistic, calibratable, and possesses favorable properties that enable us to reach the global optimum in polynomial time. We illustrate the benefits of this framework using a case-study on recently published dilution data for the COVID-19 PCR test. Our results highlight the importance of incorporating important test and population-level risk characteristics into the modeling framework, as failing to do so can lead to poor outcomes.

■ WE23

CC Room 204C

In Person: Learning and Economic Optimization in Stochastic Systems

General Session

Chair: Jeunghyun Kim, Korea, Republic of

1 - Dynamic Dispatch and Pricing in Ride-Hailing Systems

Amir Anastasios Alwan, University of Chicago Booth School of Business, Chicago, IL, 60616-1740, United States, Baris Ata

Motivated by ride-hailing systems, we consider a dynamic control problem of a multi-class closed queueing network with infinite-server nodes. Crucially, our model incorporates the travel times between different nodes in the network. The platform seeks to maximize long-run average expected profit by making dynamic dispatch and pricing control decisions. Under heavy-traffic conditions, we approximate the original control problem by a Brownian control problem that leads to an effective policy for the ride-hailing system.

2 - Dynamic Car Dispatching and Pricing: Revenue and Fairness for Ridesharing Platforms

Zishuo Zhao, PhD Student, University of Illinois at Urbana-Champaign, Urbana, IL, United States

It is essential for ridesharing platforms to balance supply and demand with dynamic prices, but a major challenge is to guarantee profit and fairness simultaneously in the presence of misaligned incentives of drivers and riders. We focus on the problem to maximize the drivers' revenue while keeping both drivers and riders satisfied via a two-phase mechanism. In Phase 1, we develop a max-weight flow model that theoretically yields maximum revenue for deterministic future orders under a regularity assumption, and prove its NP-hardness the general case; in Phase 2, we reallocate revenue via potential-based optimization to guarantee subgame-perfect equilibrium and envy-freeness for drivers. We additionally reduce the stochastic model to the deterministic model to justify its credibility in real-world applications, and show its performance with simulation results.

3 - The Effectiveness of Single Price Change in Learning and Earning via Sequential Estimation

Jeunghyun Kim, Korea University, Seoul, 02841, Korea, Republic of, Dongyuan Zhan, Chihoon Lee

We study a revenue maximization problem in a congestible system with unknown demand parameters. We show that a single price change during the learning phase is sufficient to obtain a revenue regret that is on the same scale with the optimal regret achievable when demand parameters are known up front. The sufficiency of single price change in learning is due to the implementation of sequential maximum likelihood estimation (SMLE). Without knowledge of demand parameters, an initial price is randomly chosen. With a typical MLE under which a sample size for learning is pre-fixed, the quality of estimation with the randomly chosen price is not controllable, making the choice of the second price as equally uninformative as for the first price. On the other hand, SMLE makes learning with the first price informative as it can control the estimation quality.

■ WE25

CC Room 205B

In Person: Combinatorial Optimization

Contributed Session

Chair: Ian Griffith Ludden, University of Illinois at Urbana-Champaign, Urbana, IL, 61801-6628, United States

1 - Comparison of Local Search Algorithms for Solving Car Sequencing Problem

Ibrahim Ozan Yilmazlar, PhD Student, Clemson University, Clemson, SC, United States, Mary Beth Kurz

Sequencing varying models in a mixed-model assembly line has the objective of preventing line stoppage resulting from work overload. Consecutive models that require a high amount of work at a station results in an inevitable work overload. The car sequencing problem (CSP) minimizes the work overload by applying capacity rules, resulting in the goal of finding the sequence with the minimum number of capacity rule violations. In this study, a mathematical formulation of the CSP is presented. Additionally, fast and effective Adaptive Local Search (ALS) and Variable Neighborhood Search (VNS) algorithms are proposed to solve respectively larger instances and compared over benchmark instances.

2 - On Small-Depth Tree Augmentations

Michael Zlatin, Carnegie Mellon University, Pittsburgh, PA, United States, R. Ravi, Ojas Parekh

The Tree Augmentation Problem is a fundamental and intensely studied problem in the area of survivable network design. We show that the integrality gap of the ODD-LP relaxation for the (weighted) Tree Augmentation Problem for a k-level tree instance is at most 2 (1/2)^(k-1). For 2- and 3-level trees, these ratios are 3/2 and 7/4 respectively. Our proofs are constructive and yield polynomial-time approximation algorithms with matching guarantees.

3 - Application of Flexible Flow Shop Scheduling with Sequence Dependent Setup Times in Labeling Industry

Sam Heshmati, Lecturer, University of Kentucky, Lexington, KY, United States, Charles R. Sox

The flexible flow shop (FFS) is a common manufacturing layout which has applications in many industries. This study considers the FFS with sequence dependent setup times in labeling industry. The case considered by the authors exhibits some of the complexity of the real-life industry. In addition to a mathematical formulation, a fast metaheuristic based on late acceptance hill climbing algorithm is presented. The quality of the proposed approach is compared against the state-of-the-art approaches.The results indicate the significant improvements over current practice in the case study industry. The proposed approach has a general setup which enables the usage of model within other industries.

4 - Combinatorial Optimization Problems in Ising Form: Issues in Using Single-Spin-Flip Local Search Heuristics

Ignacio Rozada, 1QBit, Vancouver, BC, Canada, Brad Woods

Specialized hardware for solving Ising problems using local search heuristics is being increasingly developed, as many combinatorial optimization problems can easily be reduced to Ising form. However, the usual approach of performing single-flip updates can have serious drawbacks. The Ising form of some problems, like the quadratic assignment and travelling salesman problems, where penalty methods encode constraints, is akin to minimizing an optimization problem with O(n!) local optima separated by high penalty barriers. Consequently, the performance achievable using a single-flip Ising solver is equivalent to randomly drawing feasible configurations in the original solution space.

5 - 3-D Geo-graphs: Efficient Contiguity Verification for 3-D Graph Partitioning

Ian G. Ludden, PhD Student, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Douglas M. King, Sheldon H. Jacobson

The constrained contiguous graph partitioning problem (CCGP) requires partitioning the vertices of a node-weighted graph into connected parts with balanced weights to minimize a cost function. CCGP is often solved by local search metaheuristics with a flip operation, which transfers a vertex between parts if the transfer preserves contiguity. For planar graphs, previous work proposes the geo-graph data structure for efficiently verifying contiguity after flips. This work extends the geo-graph to three-dimensional graphs such as 3-D Voronoi diagrams and tetrahedral/hexahedral meshes.

■ WE26

CC Room 206A

In Person: Bridging Discrete and Continuous Optimization

General Session

Chair: Hassan Mortagy, Georgia Institute of Technology, Atlanta, GA, 30308-1007, United States

1 - Revisiting Priority K-center: Fairness and Outliers

Maryam Negahbani, Dartmouth College, Hanover, NH, United States, Tanvi Bajpai, Deeparnab Chakrabarty, Chandra Chekuri

Clustering is a well-studied unsupervised learning and facility location problem. In this talk we focus on the k-center objective: Given a set of points in the metric space and a parameter k, cover the points using k balls with minimum radius. We discuss two definitions of fair k-center, individual fairness (introduced by Jung et al. FORC '20) and the lottery model (introduced by Harris et. al. NeurIPS '18) and show how they are connected to a previously studied problem called the priority k-center problem (Plesnik '87). Our main contribution is approximating priority k-center with outliers and providing a framework for approximation the problem with general constraints on the set of solution centers.

2 - Electrical Flows Over Spanning Trees

""Ix" "Hassan Mortagy, Georgia Institute of Technology, Atlanta, GA, 30308-1007, United States, Swati Gupta, Ali Khodabakhsh, Evdokia Velinova Nikolova

The network reconfiguration problem seeks to find a rooted tree T such that the energy of the (unique) feasible electrical flow over T is minimized. The tree requirement on the support of the flow is motivated by operational constraints in electricity distribution networks. We give the first provable approximation guarantees for this problem. We provide novel lower bounds and corresponding approximation factors for various settings ranging from min{O(m − n), O(n)} to O(1) for grids with uniform edge resistances and demands. To obtain the result for general graphs, we propose a new spectral graph sparsification approach, which may be of independent interest. Using insights from our theoretical results, we propose a general heuristic that is orders of magnitude faster than existing methods in the literature, while obtaining comparable performance.

■ WE27

CC Room 206B

In Person: Stochastic Optimization in Machine Learning

General Session

Chair: Zhe Zhang, Georgia Tech, Georgia Tech, Atlanta, GA, 30318, United States

1 - Higher-order Optimistic Methods for Saddle Point Problems

Aryan Mokhtari, University of Texas at Austin, Austin, TX, 78750-3312, United States

In this talk, we consider solving saddle point problems, and, in particular, we discuss the concept of "optimism" or "negative momentum" a technique which is observed to have superior empirical performance in training GANs. The goal of this talk is to provide a theoretical understanding on why optimism helps, in particular why the Optimistic Gradient Descent Ascent (OGDA) algorithm performs well in practice. To do so, we first consider the classical Proximal Point algorithm which is an implicit algorithm to solve this problem. We then show that OGDA inherently tries to approximate the proximal point method, and this is the rationale behind the "negative momentum" term in the update of OGDA. We also extend our theoretical results to the case of higher-order methods. In particular, we present higher-order optimistic methods that exploit higher-order information of the function to find a saddle point faster than first-order methods.

2 - A Progressive Barrier for Constrained Derivative-Free Multiobjective Optimization

Ludovic Salomon, Polytechnique Montreal, Montréal, QC, Canada, Sebastien Le Digabel, Jean Bigeon

The last decade has seen the development of new efficient convergent-based derivative-free and blackbox optimization algorithms for multiobjective optimization, most of them extensions of reliable single-objective methods. However, very few have been designed to take into account inequality blackbox constraints. This work presents an extension of the single-objective blackbox Mesh Adaptive Direct Search (MADS) algorithm with the progressive barrier to multiobjective blackbox optimization. It integrates the knowledge of inequality constraints. Numerical experiments on synthetic benchmarks and engineering applications show that this new method is competitive according to other state-of-the-art algorithms.

3 - Optimal Distributed Algorithms for Risk Neutral and Robust Optimization

Zhe Zhang, ISyE, Gatech, Atlanta, GA, 30332, United States, Guanghui Lan

We study the distributed optimization of risk averse functions of the form $\max_{p \in \mathcal{P}}\sum_{i=1}^{m} p_i f_i(x)$ over a network, where $\mathcal{P}$ denotes the probability ambiguity set and convex cost functions f_i are local to their respect agents in the network. The problem generalizes the well-studied finite-sum distributed optimization problem and poses new challenges due to the varying p in $\mathcal{P}.$ Its importance stems from the need to avoid risk or to handle unknown underlying probability distribution over agents. In this paper, we consider both centralized and decentralized settings with either smooth or nonsmooth f_is. We develop minimax models to illustrate theoretically possible lower communication complexity bounds and propose primal algorithms to achieve almost tight communication complexities.

■ WE28 - Cancelled

CC Room 207B

In Person: Recent Developments on Statistical Process Control

General Session

Chair: Kai Yang, University of Florida, Gainesville, FL, 32610-3010, United States

1 - Water Resource Surveillance for the Salton Sea in California by Adaptive Sequential Monitoring of its Landsat Images

Fan Yi, University of Florida, Gainesville, FL, United States

Gradual loss of water resource in the Salton Sea has got much attention from researchers recently for its damage to the local environment and ecosystems. To monitor the water resource of the lake, researchers usually obtain certain water resource indices manually from databases such as the satellite images of the region. We develop a new method to monitor the area of the Salton Sea automatically. By this method, the lake is first segmented properly from each satellite image by an image segmentation procedure, and then its area is computed by a numerical algorithm. The sequence of lake areas computed from satellite images taken at different time points is then monitored by a new adaptive CUSUM chart. Numerical studies show that the proposed method works well for the water resource surveillance application.

2 - Transparent Sequential Learning for Statistical Process Control

Xiulin Xie, University of Florida, Gainesville, FL, United States, Peihua Qiu

Machine learning methods have been widely used in different applications, including SPC. For handling SPC problems, conventional machine learning methods would have some difficulties. In this project, we extend the self-starting process monitoring idea that has been employed widely in modern SPC research to a general learning framework for process control and monitoring. Under the new framework, process characteristics to learn are well specified in advance, and process learning is sequential in the sense that the learned process characteristics keep being updated during process monitoring. The learned process characteristics are then incorporated into a control chart for detecting process distributional shift based on all available data by the current observation time. Numerical studies show that the new learning framework is reliable and effective

3 - Design Variable-Sampling Control Charts using Covariate Information

Kai Yang, University of Florida, Gainesville, FL, 32610-3010, United States

Statistical process control charts are widely used in the manufacturing industry for monitoring quality variables. In practice, the quality variables are often affected by certain covariates, and it should improve the performance of a control chart if the covariate information can be used properly. However, because of the complex relationship between the quality variables and the covariates, it is quite challenging to properly use covariate information in process monitoring. To address this problem, we propose a general framework to design a variable-sampling control chart by using covariate information. Our proposed chart is self-starting and can well accommodate stationary short-range serial data correlation. It should be the first variable-sampling control chart in the literature that the sampling intervals are determined by the covariate information.

■ WE30

CC Room 207D

In Person: Big Data Analytics in System Monitoring and Anomaly Detection

General Session

Chair: Yuanxiang Wang, University of Southern California, Los Angeles, CA, 90007, United States

1 - Penalized Linked Component Analysis for Spatial-Temporal Burst Detection in Water Distribution Systems

Shenghao Xia, University of Arizona, Tucson, AZ, United States, Jian Liu, Kevin Lansey

Detecting bursts from spatial-temporal (ST) hydraulic data is critical for water distribution system management. Traditional anomaly detection methods based on basis expansion are inefficient and inaccurate in detecting and localizing bursts from data continuously collected from multiple potential locations. This research proposes a new method based on Penalized Linked Component Analysis, which extracts ST anomaly features by differentiating the commonly shared normal features and individual anomaly features. Penalization is adapted in the algorithm to increase the sensitivity of location detection and reduce the rate of false alarm. The effectiveness of the proposed method is demonstrated with a simulated case study.

2 - Wavelet Gaussian Process for Monitoring Image Profiles

Runsang Liu, Pennsylvania State University, State College, PA, 16803, United States, Hui Yang, Bryan D. Vogt

Advanced sensing is increasingly invested in the manufacturing industry to cope with the complexity of new additive manufacturing (AM) technologies. However, imaging data from manufacturing processes have complex correlations and often contain hidden information that cannot be revealed on a single scale, which jeopardizes the effectiveness of image-based process monitoring. In this paper, we investigate the wavelet Gaussian Process monitoring of layerwise image data from multiscale spatial-frequency perspectives. The proposed methodology is evaluated and validated using both simulated data and real-world layerwise imaging data from an additive manufacturing process.

3 - Learning and Predicting Shape Deformation Through an Extended Convolution Learning Framework for Additive Manufacturing

Yuanxiang Wang, University of Southern California, Los Angeles, CA, 90007-3952, United States, Cesar Alexander Ruiz, Qiang Huang

Geometric accuracy control is critical for precision additive manufacturing (AM). To learn and predict the shape deformation of 3D printed products from a limited number of training samples, we extend the previously developed fabrication-aware convolution learning framework to a broader class of geometries by constructively incorporating spherical and polyhedral shapes into a unified model. The modeling approach generalizes the 2D cookie-cutter functions to 3D shapes and considers the spatial correlation among neighboring regions and across different shapes through a novel distance metric. The framework approximates 3D freeform shapes by using spherical and polyhedral patches. Case studies show the promise of the framework for shape accuracy control of complex geometries.

■ WE32

CC Room 208B

In Person: Topics in RM

General Session

Chair: John G. Turner, University of California Irvine, University of California Irvine, Irvine, CA, 92697, United States

1 - Managing Retail Inventory and Pricing in the Presence of Stochastic Purchase Returns

Alys Liang, Michigan Ross, Ann Arbor, MI, 48104, United States

In US alone, returns cost retailers a total of hundreds of billions of dollars annually in the last few years. It is generally accepted in the industry that returns are inevitable and often considered as the necessary cost of doing business. In this paper, we consider a single warehouse/store joint inventory and pricing problem in the presence of stochastic purchase returns. A purchase returned could be re-stocked for resale after inspection. A key feature of our model is that we allow a general class of return time distributions. This problem is very challenging to solve optimally since we need to keep track the return status of all purchases made in the past. We propose an easy-to-implement joint inventory and pricing policy and show that it is near optimal in the setting with a large annual market size, which is a practically relevant setting for many product categories.

2 - Assortment Optimization with Multi-item Basket Purchase under The Multivariate MNL Model

Chengyi Lyu, University of Colorado Boulder, Boulder, CO, United States, Stefanus Jasin, Sajjad Najafi, Huanan Zhang

We incorporate customers' multi-item purchase behavior into the assortment optimization problem which we consider under the Multivariate MNL (MVMNL) model. Under MVMNL, products are clustered into different groups, and a customer can simultaneously purchase from as many groups as possible, where at most one product gets selected from each group. We first show that the revenue-ordered assortment may not be optimal. Nonetheless, we show that under some mild conditions, a certain variant of this property holds (in the uncapacitated assortment problem) under the MVMNL model—the optimal assortment consists of revenue-ordered local assortments in each group. We develop FPTAS for capacitated and uncapacitated assortment problems. Our analysis reveals that disregarding multi-item purchase behavior can have a significant negative impact on a retailer's profitability.

■ WE36

CC Room 210B

In Person: Sustainability/Big Data

Contributed Session

Chair: Guanzhou Wei, Fayetteville, AR, 72701, United States

1 - Fine-Grained Spatio-temporal Pollution Forecasting and Hotspot Identification Using Low-cost Sensors in Delhi: A Three-Year Study

Shiva R. Iyer, PhD Student, New York University, New York, NY, United States

The city of Delhi has 32 air quality monitors over an area of about 900 sq km, but we do not have information on fine-grained variations in air quality in the city in order to reason about citizen exposure and identify hotspots. We have installed 28 low-cost sensors, many of them concentrated in the south Delhi region. We have developed a generic definition of "hotspots" in terms of spatio-temporal variations, using which we validate some known hotspots and discover new ones. We have also designed a novel model combining geostatistics and deep learning that is able to make spatio-temporal pollution predictions by the hour with an MAPE of about 10% across all locations.

2 - The Economic and Environmental Impact of Sharing Economy Business Model

Fahimeh Rahmanniya, PhD Candidate, University of Tennessee, Knoxville, Knoxville, TN, United States, Paolo Letizia, Paolo Roma

Sharing economy models involve owners renting out their poorly utilized assets to renters, generally through an online platform. In this research, we analytically study the impact of sharing economy business models on the firms' profits and the environment. The analysis shows that sharing economy can be a win-win from these two perspectives, and it can also outperform other consumption models such as pure sales and servicizing.

3 - Examining the Sustainability Frontier: Sustainability Performance Versus Efficiency

Meltem Denizel, Associate Professor, Iowa State University, Ames, IA, United States, Yiming Zhuang, Frank Montabon

Sustainability undertakings require efficient use of resources to achieve the desired performance. This leads to the question of how efficient companies are in their sustainability practices. Relying on data from CSRHub, we employ DEA to evaluate the sustainability efficiency of 1141 large U.S. manufacturing companies from 2009 to 2018.

4 - Physics-Informed Spatio-Temporal Modeling for Multi-Source Environmental Data

Guanzhou Wei, University of Arkansas, Fayetteville, AR, United States, Xiao Liu, Venkat Krishnan, Manajit Sengupta, Yu Xie, Haitao Liao

Natural and environmental processes are governed by physics laws, and are often monitored by data from multiple sources, such as remote sensing, field measurements, and so on. This research proposes a general framework for physics-informed spatio-temporal models for environmental processes where observations are available from multiple sources. The proposed modeling approach is illustrated through two environmental processes, including wildfire smoke propagation and sea surface temperature.