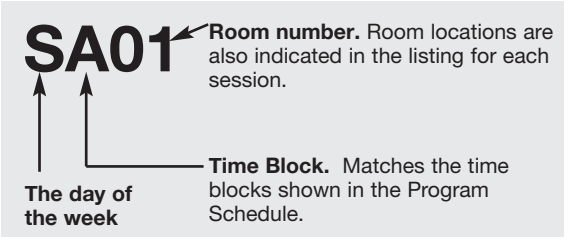
How to Navigate the Technical Sessions

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 (In person only)

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 (In person only)

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 (In person only)

Sunday, 6:00AM - 7:30AM

■ VSA01

Virtual Room 01

Reinforcement Learning with Engineering Applications II

Sponsored: Data Mining

Sponsored Session

Chair: Mohammad Dehghanimohammadabadi, Northeastern University, Snell Engineering Center Boston, MA, United States

Co-Chair: Ashwin Devanga, Northeastern University, Boston, MA, United States

1 - Building Data Mining Test Environments To Compare Performance If 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 In Operations Research – Vehicle Routing Problem

Peng Ren, Northeastern University, Boston, MA, United States, Sahir Belsare, Ashwin Devanga

Usually, industries prefer to use heuristic methods to solve their NP-Hard problems. However, as the problem is scaled up, RL tends to be more efficient than other methods. The project is about the Vehicle Routing Problem and how it can be solved using RL. It will also cover how it competes with meta-heuristic methods.

3 - Reinforcement Learning Applications In Engineering Ising MATLAB

Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, 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.

■ VSA02

Virtual Room 02

Optimization and Surrogate Methods for Black-Box Systems

Sponsored: Data Mining

Sponsored Session

Chair: Hadis Anahideh, University of Illinois at Chicago, Chicago, IL, United States

1 - Smart-Replication For Black-Box Optimization Under Uncertainty

Hadis Anahideh, University of Illinois at Chicago, Chicago, IL, 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.

2 - 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.

3 - 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, 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.

4 - Bayesian Surrogate Constructions for Calibration of Expensive Simulation Model

Moses Chan, Northwestern University, Evanston, IL, United States, Stefan Wild, Matthew Plumlee

We propose a new sequential adaptive method for calibration of an expensive simulation model in the presence of missing data. We study surrogate inferences where simulation data are collected on a regular grid. However, significant fraction of the data can be missing due to cases of model nonconvergence, automated termination, or incomplete evaluation. The missing data pose computational problems for surrogate methods that exploit this data structure. Our method enables surrogate constructions under random missing data with minimal additional cost. The proposed method then facilitates a sequential calibration algorithm with asynchronous simulations coordinated by an active job manager.

5 - Black-box Optimization for Optimizing Expensive Functions With Mixed Inputs

Dzung Phan, IBM Research, Yorktown Heights, NY, United States

We propose a deep neural network-based optimization for minimizing expensive black-box functions with mixed categorical-continuous inputs and linear constraints. We use a ReLU deep neural network to get a surrogate model from the historical data. To overcome the non-smoothness and bad local minimum of the training problem, a smoothed DNN optimized by a second-order optimization method is utilized. A new sample is obtained by solving a linearized version of the DNN surrogate model.

■ VSA03

Virtual Room 03

Improving the Utilization of Renewable Energy Based on Data Analysis and Simulation Technology

Sponsored: Data Mining

Sponsored Session

Chair: Jiang Li, , China, Harbin Institute of Technology, Harbin, China

1 - Managing Cross Building Energy Storage Systems Using Approximate Dynamic Programming

Jiancheng Qin, Harbin Institute of Technology, Harbin, China

We consider a cross-building energy storage system in which the objective function of each step is a piecewise linear function of decision variables and state variables. Thus, the objective function can be modeled as a piecewise linear programming and then transformed into a mix integer linear programming (MILP) problem. However, as a multi-stage stochastic programming problem which we utilize approximate dynamic programming (ADP) to tackle the computational issues, we need to solve the objective function many times. To further decrease computational cost, we propose several approximate algorithms to determine variable segmentation to simplify the problem into a linear programming problem.

2 - Pooling Effect on Renewable Energy with Production and Price Uncertainty

Jin Yang, Harbin Institute of Technology, Harbin, China

Many Renewable electricity plants introduced energy storage system, which brings arbitrage opportunity by managing storage system. We are considering merge the electricity storage systems of some geographically close renewable plant, Then we derived the impact of storage pooling on the benefits of the whole system. Our study theoretically shows that the pooling effect appears when the charge rate and storage energy transfer efficiency meet some condition. And some experiment are designed to verify our theory. We use LP to obtain experiment result of optimal decision under the oracle view and ADP to obtain experiment result under the price uncertainty.

3 - 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.

4 - Optimal Sizing Of Battery Energy Storage Based on Adaptive Design For Controllability

Jiang Li, Harbin Institute of Technology, Harbin, China

The traditional controllability design of complex system usually adopts the research scheme of design before control, a more effective research scheme is to combine system design with system dynamic control, which is the existing research idea of design for controllability. However, considering that there are kinds of system designs, and the real-time dynamic control of the system is faced with the curse of dimensionality, this method still faces difficulties in the practical solution. Based on the existing approximate dynamic programming algorithms, this study focuses on how to improve the accuracy of the solutions of complex system controllability design with limited computation budget by using ranking and selection.

■ VSA04

Virtual Room 04

Parameter Optimization in Modeling and Complex Systems

Sponsored: Data Mining

Sponsored Session

Chair: Neng Fan, University of Arizona, Tucson, AZ, 85721, United States

Co-Chair: Guangrui Tang, University of Arizona, Tucson, AZ, 85721, United States

1 - Solution Path Algorithm for Doubly Regularized Least Absolute Deviations Regression

Guangrui Tang, University of Arizona, Tucson, AZ, United States, Neng Fan

In this talk, we proposed a doubly regularized least absolute deviation (DRLAD) regression model based on distributionally robust optimization theory. The loss function is the mean absolute loss, which is robust to outliers. The penalty term is elastic net penalty. The elastic net can simultaneously do automatic variable selection and continuous shrinkage. It also removes the limitation on the number of selected variables and encourages grouping effect. A solution path algorithm is proposed to speed up the tuning of two hyperparameters in DRLAD. Numerical experiments are implemented to validate the performance of DRLAD and the computational efficiency of the solution path algorithm.

2 - Machine Learning Hyperparameter Optimization with Single Observation Probabilistic Branch and Bound
Hao Huang, Assistant Professor, Yuan Ze University, Taoyuan, Taiwan, Chih Hsien Cheng

Training certain learning methods have uncertainty due the randomness of the method, where running multiple replications is the common approach to train a set of model with in order to access the expected performance of a set of hyperparameters. This study applies the single observation technique to Probabilistic Branch and Bound (PBnB) in order to propose novel hyperparameter optimization algorithms with improved searching efficiency. The approach only performs one replication for each sampled point, and neighbor sampled points are gathered to approximate the expected performance, where PBnB narrows the search area.

3 - 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.

■ VSA05

Virtual Room 05

Recent Advances in Text Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Ying Wang, Northern Illinois University, Dekalb, IL, United States

1 - Neural Topic Models for Text Classification: A Study on Text Sparsity Issue
Ying Wang, Northern Illinois University, Dekalb, IL, United States, Jaeki Song

In text analysis, sparsity may cause various problems, such as high dimensionality, which leads to less robust results. This study aims to compare the performance of four types of neural topic models (NTM) and classical topic models in analyzing textual information with different levels of sparsity. We found that, in classification tasks, NTM is superior to classical statistical topic models on short texts in terms of accuracy, precision, and F1 scores, but not in terms of recall. This study contributes to topic modeling literature by presenting NTM varieties proposed in recent years and providing guidance on choosing the topic models based on the sparsity of text and the goal of the analysis.

2 - An Empirical Analysis of the Influence of Different Types of Metadata on the Usefulness of Online Reviews for Healthcare Businesses
Jiaxi Luo, Midwestern State University, TX, United States

Online social media platforms such as Yelp.com and RateMDs.com provide patients the opportunity to voice their opinions and concerns on healthcare businesses. Those opinions and feedback empower a healthcare consumer with the knowledge to make informed decisions relating to a medical hospital or a practice. The reviews serve as an easily accessible and reliable source of information about the quality of healthcare provided by hospitals. Despite the growing popularity of healthcare review sites, more research is needed to improve the quality of healthcare reviews from the patient's perspective. In this study, we use online reviews available from Yelp.com for healthcare businesses. We analyze the influence of three types of metadata: review, business, and user. And, we build a predictive model of review usefulness.

3 - Quantifying Risks of Food Insecurity By Analyzing the News
Ananth Balashankar, PhD 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%.

■ VSA06

Virtual Room 06

Data Mining & Machine Learning in Smart Manufacturing

Sponsored: Data Mining

Sponsored Session

Chair: Bo Shen, Virginia Tech, Blacksburg, VA, United States

Co-Chair: Andrew Chung Chee Law, Virginia Tech, Blacksburg, VA, United States

1 - Robust Tensor Regression
Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL, 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 - Modeling The Defect Morphology In Additive Manufacturing Processes Using A Bayesian Knot-free Spline Representation
Bhaskar Botcha, Texas A&M University, Bryan, TX, United States, Ashif S. Iquebal, Satish Bukkapatnam

We present a statistical methodology to represent the morphology of defects on the surface of an AM component and characterize the influence of varying process parameters on defect morphology. We employ a Bayesian knot-free splines with a reversible jump Monte Carlo Markov chain algorithm to obtain a consistent representation of defect morphology. We subsequently characterize the defect morphologies by using a Gaussian process regression. Based on various case studies, we show that Gaussian process regression parameters, viz., length scale and variance effectively capture a wide array of defect morphologies.

3 - 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.

4 - 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.

■ VSA07

Virtual Room 07

Optimization and Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Arthur J. Delarue, Massachusetts Institute of Technology, Cambridge, MA, United States

Co-Chair: Vassilis Digalakis, Massachusetts Institute of Technology, Cambridge, MA, United States

1 - Convex Parameter Recovery For Interacting Marked Processes

Yao Xie, ISyE Georgia Tech, Atlanta, GA, United States, Anatoli Juditsky, Arkadi Nemirovski, Liyan Xie

We introduce a new general approach for multivariate discrete event data with categorical interacting marks, referred to as marked Bernoulli processes, where the probability of an event of a specific category to occur in a location may be influenced by past events at this and other locations. Our model can capture an arbitrary shape of influence from historical events, locations, and events of different categories, and prior knowledge is incorporated by allowing general convex constraints on model parameters. We develop two parameter estimation procedures utilizing the constrained Least Squares (LS) and Maximum Likelihood (ML) estimation, which are solved using variational inequalities with monotone operators. We illustrate the performance of proposed recovery routines on synthetic and a real-world dataset.

2 - Robust and Heterogeneous Odds Ratio

Jean Pauphilet, London Business School, Cambridge, MA, United States

We propose a recursive partitioning procedure to estimate heterogeneous odds ratio, a widely used measure of treatment effect in medicine and social sciences, when the response to treatment is binary. We integrate an adversarial imputation step to allow for robust inference even in presence of partially observed treatment assignments (e.g., discount status for unpurchased items). We validate our methodology on synthetic data and apply it to three case studies from political science, medicine, and revenue management.

3 - 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.

4 - Screening Rules For Sparse Regression

Andres Gomez, University of Southern California, Los Angeles, CA, 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.

5 - Convexifications for Mixed Integer Quadratic Programs

Linchuan Wei, Northwestern University, Evanston, IL, 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).

■ VSA08

Virtual Room 08

The Interplay between Optimization and Statistics III

Sponsored: Data Mining

Sponsored Session

Chair: Lijun Ding, Cornell University, Ithaca, NY, United States

Co: Chair: Yingjie Fei, Cornell University, Ithaca, NY, United States

1 - Phase Synchronization: Spectral Method and SDP Both Work

Yiqiao Zhong, Stanford University, Stanford, CA, United States

Estimation from noisy pairwise measurements is a fundamental statistical and optimization problem. It is useful to understand its fundamental limit, whether there are efficient algorithms under challenging SNR regimes, and how well these algorithms perform statistically. In this talk, I will focus on phase synchronization (estimating angles from their noisy pairwise differences). I will show that two natural algorithms, namely spectral method and SDP relaxation, works well under the near-optimal SNR regime. A technical contribution is the leave-one-out technique for decoupling dependence.

2 - Discovering Discrete Structures in Mixture Models Via SDP Relaxation

Yingjie Fei, Cornell University, Ithaca, NY, 14850, United States

We will introduce the clustering problem under Gaussian mixture models and present an algorithm based on semidefinite programming (SDP). We show that despite being a continuous relaxation, this algorithm achieves a nearly optimal error rate in terms of distance to the discrete target solution, and that the result is enabled by a surprising connection with an oracle integer program. Moreover, our algorithm is robust under the so-called semi-random model, a property that many algorithms lack

3 - Graph Matching Via Regularized Quadratic Relaxations

Jiaming Xu, Duke University, Durham, NC, United States

Given two unlabeled, edge-correlated graphs on the same set of vertices, we study the "graph matching" problem of identifying the unknown mapping from vertices of the first graph to those of the second. This amounts to solving a computationally intractable quadratic assignment problem. We propose a regularized quadratic programming relaxation of the quadratic assignment problem. We show that for a correlated Erdos-Renyi model, this method can return the exact matching with high probability if the two graphs differ by at most a 1/polylog(n) fraction of edges, both for dense graphs and for sparse graphs with at least polylog(n) average degree. Our analysis exploits local laws for the resolvents of sparse Wigner matrices.

■ VSA09

Virtual Room 09

Applied Analytics in Healthcare: Catalyzing Real World Change

Sponsored: Health Applications Society

Sponsored Session

Chair: Taghi Khaniyev, MIT Sloan School of Management, Cambridge, MA, United States

Co-Chair: Christopher Sun, Massachusetts Institute of Technology, Boston, MA, United States

1 - Utilizing Partial Flexibility to Improve Emergency Department Flow: Theory and Implementation

Vahid Sarhangian, University of Toronto, Mie Mechanical And Industrial Eng., Toronto, ON, Canada, Carri Chan, Prem Talwai, Kriti Gogia

Many EDs have multiple areas where patients of different acuity levels receive treatment. In practice, different areas often operate with fixed nurse staffing levels. In instances when there are substantial imbalances in congestion or available staff among different areas, it could be beneficial to deviate from the original assignment and reassign nurses. However, reassignments are typically only possible at the beginning of shifts of 8-12 hours, providing partial flexibility in adjusting staffing levels. We utilize a queueing network model of patient flow in the ED to guide the reassignment decisions at the beginning of the shifts. We implement the new staffing approach at the Weill-Cornell ED and conduct a statistical analysis of the before and after implementation data to empirically measure the benefits of our proposed staffing approach.

2 - American Red Cross Uses Analytics-based Methods to Improve Blood-collection Operations

Turgay Ayer, ISyE Georgia Tech, School of Industrial and Systems Engineering, Gros, Atlanta, GA, United States

We describe a national-level cryoprecipitate (cryo)-collection project at the American Red Cross. Managing collections for cryo units is particularly challenging because producing cryo requires the collected whole blood to be processed within 8 hours after collection. This project focuses on dynamically determining when and from which mobile collection sites the American Red Cross should collect blood for cryo production, such that it meets its collection targets and minimizes its collection costs. To solve this problem, we developed a new collection model, which allows different types of collections at the same collection site. We further developed a decision support tool (DST) to systematize the selection of the collection sites. The implementation of the DST in the Red Cross led to a 20% increase in collections at a lower cost, i.e. a cost saving approach.

3 - A Multi-POMDP Approach for Cancer Screening Optimization With Parameter Ambiguity

Weiyu Li, University of Michigan, Ann Arbor, MI, United States, Brian T. Denton

Active surveillance (AS) is a strategy that involves regular clinical examinations, biomarker tests, and biopsies to monitor patients diagnosed with low-risk prostate cancer. The ideal strategy must strike a balance between the burden of testing and the benefit of early detection of progression to high-risk prostate cancer. We propose a muti-partially observable Markov decision process (MPOMDP) model to find the optimal AS strategy, which improves the traditional POMDP model by accounting for the parameter ambiguity that comes from statistic error. The benefits of the MPOMDP model is then presented.

4 - Online Multi-machine Scheduling for Competing Agents with an Application to Optimal Routing for Bed Cleaning at Wards

Maarten Otten, University of Twente, Enschede, 7522NB, Netherlands, Aleida Braaksma, Richard J. Boucherie

This research focusses on the optimal deployment of employees to different locations where similar jobs, that randomly arrive with associated deadlines, have to be processed. Often, these decisions are not made by an single decision maker but by multiple who, based on partial information, aim to optimize their own operations only. We derive a fast algorithm to approximately solve this problem in real time. We model the interaction of the multiple decision makers with a non-cooperative stochastic game and prove that a Nash-equilibrium always exists. To exemplify the performance of our approach in practice we apply our model to the process of bed cleaning at nursing wards in a Dutch hospital.

5 - 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.

■ VSA10

Virtual Room 10

Data-driven Decisions in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: Vishal Ahuja, Southern Methodist University, Dallas, TX, 75240-3623, United States

1 - Comparison of Medical Coding Before and After Release of ICD-10

Sina Ansari, Driehaus College of Business, DePaul University, Chicago, IL, United States, Laurens G. Debo, Robert Shumsky

On October 1st 2015, CMS and NCHS mandated the use of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). The ICD-10 replaced the ICD-9 with a more comprehensive list of codes and fundamentally changed its structure. We study the impact of re-design of diagnosis codes on the coding behavior of providers.

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 - Rationing Scarce Healthcare Capacity: A Study of the Ventilator Allocation Guidelines During The COVID-19 Pandemic in the United States

Margret V. Bjarnadottir, University of Maryland, College Park, MD, United States, David Anderson, Eren Basar Cil, Tolga Aydinliyim

In the United States, 26 states have specific ventilator allocation guidelines in case of a shortage. We assess the existing procedures and priority rules in place and propose alternative priority schemes. We first build ML models to predict survival probabilities and ventilator length-of-use. Then, we use the resulting estimates and their uncertainties as inputs for a multi-class priority queueing model with abandonments. We find that our proposed priority scheme, achieves an improvement over the other two alternatives; the expected number of survivals increases and death risk while waiting for ventilator use decreases. We also illustrate how priority schemes with sole focus on acute-phase survival odds may be discriminatory with respect to certain demographics, and highlight how the proposed policy allocates scarce healthcare capacity in a more equitable way.

■ VSA11

Virtual Room 11

Public Impact Healthcare Research

Sponsored: Health Applications Society

Sponsored Session

Chair: Soroush Saghafian, Harvard University, Cambridge, MA, 02138-5806, United States

1 - Adaptive Design of Clinical Trials: A Sequential Learning Approach

Zhengli Wang, Stanford Graduate School of Business, Stanford, CA, 94305, United States

We present a Bayesian decision-theoretical framework on adaptive clinical. Our framework builds on the sequential hypothesis testing paradigm where the decision maker can either choose among different experiments, or to terminate the trial. The optimal solution to the problem is derived analytically. We demonstrate that compared to the existing non-adaptive policy, our model achieves a considerable improvement in expected economic benefits.

2 - Preventing Opioid Overdose: From Prediction to Operationalization

Deeksha Sinha, Massachusetts Institute of Technology, Cambridge, MA, 02139-4936, United States, Jonas Oddur Jonasson, Neal Kaw, Nikolaos Trichakis, Anyi Chen, Joseph Conte, Ashley Restaino, Salvatore Volpe

A catalyst for reducing the incidence of opioid-related harm could be the development and operationalization of risk stratification models to identify patients at risk. Predicting the rarest and most severe outcomes, such as fatal overdoses, leads to statistical challenges, stemming from imbalanced datasets. With claims and electronic health records data from Staten Island Performing Provider System, we develop a single model that alleviates the imbalance and therefore achieves high prediction accuracy for a range of adverse opioid-related events, including fatal overdoses. We further explore the capacity requirements of potential interventions based on such models, as well as addressing salient operational trade-offs that arise in implementation, such as interpretability, data delay, and the prediction horizon length.

3 - Who Should See the Patient? On Deviations from Routine Patient-provider Assignments in Hospitals

Soroush Saghafian, Harvard University, Kennedy School of Gov. Cambridge, MA, 02138-5806, United States, Mariam Atkinson

We use evidence on the assignments of generalist and specialists to patients in a children's hospital, and generate insights into whether and when hospital administrators should allow providers to deviate from routine assignments. To perform our analyses, we identify 73 top medical diagnoses and use detailed patient-level electronic medical record (EMR) data of more than 4,700 hospitalizations. In parallel, we conduct a carefully-designed survey of physicians and utilize it to identify the routine provider type that should have been assigned to each patient. Using these two sources of data, we examine the consequence of deviations from routine provider assignments.

■ VSA12

Virtual Room 12

Teaming in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: Cagla Keceli, University of Chicago, Chicago, IL,United States

Co Chair: Daniel Adelman, University of Chicago, Booth School of Business, Chicago, IL, 60637-1610, United States

1 - Optimizing Nurse Assignments to High-performance Surgical Teams

Cagla Keceli, University of Chicago, Booth School of Business, IL, United States, Daniel Adelman

We consider the daily assignment of nurses to operating rooms to maximize team performance in a high-volume academic medical center. Our approach considers not only familiarity between nurses and surgeons, but also nurse experience across surgical specialties. We report on results from a pilot implementing our approach in a real hospital setting.

2 - Learning from Leaders or Followers in Temporary Teams: The Varying Effects of Partner Exposure by Team Member Role

Hummy Song, University of Pennsylvania, Philadelphia, PA, 19104, United States, Melissa Valentine, Song-Hee Kim

In many workplaces, temporary teams convene to coordinate complex work, despite team members having not worked together before. Most related research has found consistent performance benefits when members of temporary teams work together multiple times (team familiarity). Recent work in this area broke new conceptual ground by instead exploring the learning and performance benefits that team members gain by being exposed to many new partners (partner exposure). In contrast to that new work that examined partner exposure between team members who are peers, in this paper we extend this research by developing and testing theory about the performance effects of partner exposure for team members whose roles are differentiated by authority and skill. We use visit-level data from a hospital ED and leverage the ad hoc assignment of attendings, nurses, and residents to teams and the round-robin assignment of patients to these teams as our identification strategy. We find a negative performance effect of both nurses' and resident trainees' partner exposure to more attendings, and of attendings' and nurses' exposure to more residents. In contrast, both attendings and residents experience a positive impact on performance from working with more nurses. The respective effects of residents working with more attendings and with more nurses is attenuated on patient cases with more structured work flows. Our results suggest that interactions with team members in support roles is an important but often unrecognized part of disciplinary training and team learning.

3 - Family Medicine Provider Care Team Design to Achieve Patient Care Continuity

Yu-Li Huang, Mayo Clinic, Rochester, MN, 55902, United States, Bjorn Berg

Continuity of care is an integral aspect of high-quality patient care in primary care settings. In the Department of Family Medicine at Mayo Clinic, providers have multiple responsibilities such as administration, research, and education in addition to clinical duties and panel management time (PMT). Collectively, these competing time demands limit providers' clinical availability. One way to mitigate the impact on patient access and continuity is to create provider care teams where multiple providers are assigned to a group of patients. This study presents a descriptive characterization of patient continuity based on provider types and their PMT. An optimization model is then used to determine optimal provider mix in a team to balance workload among teams. Results are presented comparing the proposed and current care team structures.

4 - Can Shared Service Delivery Improve Client Engagement? A Study of Shared Medical Appointments

Ryan Buell, Harvard Business School, Boston, MA, 02163, United States, Kamalini Ramdas, Nazli Sonmez

Whether customers are served one-on-one or in batches is a key aspect of the design of any service. Using data from a randomized controlled trial with 1,000 patients at the Aravind Eye Hospital, in India, we examined the impact of a care delivery model called shared medical appointments (SMAs) - in which groups of patients with the same chronic condition meet with a doctor simultaneously, and each receives one-on-one care - on patient engagement. Patients who experienced SMAs exhibited higher engagement levels (engagement, positivity, speech, head wobbling - a South Indian gesture to signal understanding - eye contact and end of appointment happiness), asked more questions, and participated more in conversation relative to those experienced one-on-one appointments. The results of our study shed light on the promise of shared delivery models to improve customer engagement.

■ VSA13

Virtual Room 13

Emergency Medicine Operations?

Sponsored: Health Applications Society

Sponsored Session

Chair: Eric Park, University of Hong Kong, Hong Kong, Hong Kong

1 - The Cost of Task Switching: Evidence from the Emergency Department

Yiwen Jin, UBC, Sauder School of Business, Vancouver, BC, V6T 1V8, Canada

We investigate the impact of task switching on the productivity of ED physicians. Using a comprehensive ED visit dataset and instrumental variable method, we find task switching negatively impacts physician productivity, but little effect on the quality of care. We also explore the mechanisms driving this phenomenon.

2 - Impact of Emergency Department Waiting Time Announcement on Patient Behavior

Eric Park, University of Hong Kong, Hong Kong, Hong Kong

We study how patients incorporate announced waiting time in their decision of choosing which ED to attend. Using a discrete choice model, we structurally estimate the patients' sensitivity to announced ED waiting time and potential travel distance. We also study patient characteristics that differentiate their sensitivity to ED waiting time.

3 - 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.

4 - To Extend or Not to Extend? Dynamic Shift Lengths in Emergency Departments

Negar Ganjouhaghighi, University of Calgary, Calgary, AB, Canada, Marco Bijvank, Alireza Sabouri

Emergency Departments face the challenging task of scheduling physicians to meet uncertain patient demand in the future. To better match physician availability with patient arrivals, we consider the possibility of dynamically extending a shift two hours before it ends. We formulate a Markov Decision Process to find a policy that balances the tradeoff between cost of these extensions and the cost associated with patients' wait times. Our numerical results using real data suggests that our optimal policy outperforms other policies that statically schedule longer shifts.

5 - 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.

■ VSA14

Virtual Room 14

New Topics in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Thunyarat Bam Amornpetchkul, NIDA Business School, Bangkok, 10240, Thailand

1 - 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.

2 - An Optimal Greedy Heuristic with Minimal Learning Regret for the Markov Chain Choice Model

Wentao Lu, HKUST, Hong Kong, Hong Kong, Guillermo Gallego

We study the assortment optimization problem and show that local optima are global optima for all discrete choice models that can be represented by the Markov Chain model. We develop a forward greedy heuristic that finds an optimal assortment for the Markov Chain model and runs in $O(n^2)$ iterations. We also propose a backward greedy heuristic that is optimal for Markov chain model and requires fewer iterations. Numerical results show that our heuristics performs significantly better than the estimate then optimize method and the revenue-ordered assortment heuristic when the ground truth is a latent class multinomial logit choice model. Based on the greedy heuristics, we develop a learning algorithm that enjoys asymptotic optimal regret for the Markov chain choice model and avoids parameter estimations, focusing instead on binary comparisons of revenues.

3 - Competing and Sharing: Optimal Pricing and Capacity Sharing in a Competitive Market

Pavarit Issarathipya, NIDA Business School, Bangkok, 10240, Thailand, Thunyarat Bam Amornpetchkul

This study investigates the possibility for capacity sharing between competing firms to be mutually profitable. We consider a duopoly setting where each firm can optimally choose whether and how much to buy or sell its capacity to produce substitutable products to the other firm at what price. The two firms can also set their retail prices to maximize their profits from selling the products to the same market. Our results show that there exist circumstances where capacity sharing can benefit both competing firms as well as the overall market.

4 - Mystery Discounts: Turning Uncertainty into Profitability

Thunyarat Amornpetchkul, Assistant Professor, NIDA Business School, Bangkok, 10240, Thailand

"Mystery discount," under which multiple discount levels are distributed among customers based on chance, is gaining popularity in retail due to its potential to effectively attract customers' interests while leveraging cognitive customer response to boost retailers' profits. When offering a mystery discount, the retailer can design the scheme to reveal the discount level to the customers either prior to making their purchase decisions or at the point of purchase. The retailer can also choose how much information about the distribution of the discount levels to disclose to the customers. This paper analytically investigates how mystery discounts influence consumer purchase behavior and retailers' profitability. A survey data set is analyzed to further support the findings.

■ VSA15

Virtual Room 15

Consumer Privacy in Operations Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ruslan Momot, Kellogg School of Management, Northwestern University, Ann Arbor, MI, 48105, United States

1 - Consumer Privacy and Retail Platform Operations

Xiaoyu Wang, Washington University in St. Louis, St. Louis, MO, 63144, United States, Fasheng Xu, Fuqiang Zhang

The exploitation of the individual-level data allows online retail platforms to provide better services to consumers, but at the risk of causing unintended privacy issues. In this paper, we aim to understand the implications of newly adopted data privacy policies such as the GDPR. Our analysis yields three main sets of insights. First, the GDPR indeed helps to decrease the collection/usage of consumer data. However, it can hurt the consumer surplus under some conditions. Second, the GDPR policy might even lead to an all-lose situation (platform, supplier, and consumers). Third, we show that under the centralized system (resp., agency selling model), the GDPR policy always enhances social welfare.

2 - 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.

3 - Privacy-Preserving Personalized Revenue Management

Murray Lei, Queen's University, Kingston, ON, K7L 3N6, Canada, Sentao Miao, Ruslan Momot

We examine how data-driven personalized decisions can be made while preserving consumer privacy. Our setting is one in which the firm chooses a personalized price based on each new customer's vector of individual features; the true set of individual demand-generating parameters is unknown to the firm and so must be estimated from historical data. We extend this classical framework of personalized pricing by requiring also that the firm's pricing policy preserve consumer privacy, or (formally) that it be differentially private. Our analysis suggests that with a sufficient amount of historical data in hand, firms can achieve privacy at a cost of the same order as the "classical" loss in revenue due to estimation error. We also extend our analysis to the setting of personalized assortment optimization.

4 - Product Personalization and Privacy Commitment Trap

Marat Salikhov, Yale School of Management, New Haven, CT, 06511-8978, United States, Ruslan Momot

Companies collect personal data about their customers in order to customize their offerings, but that might come at odds with the customers' privacy concerns. Since it might be difficult for a company to signal its commitment to privacy to customers, companies might provide inefficiently low or high levels of privacy. We formalize these intuitions in a stylized model and explore potential ways to correct these inefficiencies.

■ VSA16

Virtual Room 16

Coupling Techniques for Online Decision-Making

Sponsored: Revenue Management and Pricing

Sponsored 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 Ω(√ ;) 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.

■ VSA17

Virtual Room 17

Economics of Blockchains

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Garud N. Iyengar, Columbia University, New York, NY, 10027, United States

1 - The Adoption of Blockchain-based Decentralized Exchanges

Agostino Capponi, Columbia University, New York, NY, 10027, United States, Ruzihe Jia

We study the market microstructure of Automated Market Maker (AMM), the most prominent type of blockchain-based decentralized crypto exchange. We show that, even without information asymmetries, the order execution mechanism of the blockchain-based exchange yields a token value loss for liquidity providers if exchange rates are volatile. AMMs are more likely to be adopted for pairs of coins which are stable or of high personal use for investors. Liquidity providers may not deposit their tokens if the exchange rate volatility is high, leading to a liquidity freeze. The adoption of AMMs leads to a surge of transaction fees on the underlying blockchain if token exchange rates fluctuate wildly. We empirically support our model implications using transaction-level data of AMMs associated with the most actively traded pairs in Uniswap and Sushiswap.

2 - Product Market Competition with Crypto Tokens and Smart Contracts

Evgeny Lyandres, Tel Aviv University, Israel

This paper models benefits of pricing a firm's output in units of crypto token and of using smart contracts under duopolistic product market competition with switching costs. Pricing output in tokens leads to the firm's de-facto second-mover advantage in equilibrium, raising its expected profit. In addition, by using a conditional smart contract, the firm can set a capacity constraint, further raising equilibrium output prices and its profit. By focusing on "utility" tokens used at the product market competition stage, the paper highlights additional benefits of crypto tokens that extend beyond advantages of issuing "security" tokens at the financing stage.

3 - Economic Implications of Scaling Blockchains: Why the Consensus Protocol Matters

Fahad Saleh, Wake Forest University, Winston-Salem, NC, 77479-3826, United States, Kose John, Thomas Rivera

We contrast the economic implications of scaling blockchains under two consensus protocols: Proof-of-Work (PoW) and Proof-of-Stake (PoS). Agents can store wealth through the blockchain's cryptocurrency but may face a costly delay when liquidating due to the blockchain's finite transaction rate. Agents may expedite processing by paying fees to miners. We show how improved scaling alleviates congestion, leading to a decrease in equilibrium fees. Under PoW, this leads validators to spend less on computational power. This reduced computational power then lowers the cost of a successful attack and therefore PoW security. Scaling has the opposite effect for PoS as alleviating congestion increases the demand and thus market value of the cryptocurrency. This increases the cost of acquiring enough cryptocurrency necessary for a successful attack under PoS.

4 - From Hotelling to Nakamoto: The Economics of Bitcoin Mining

Steven Kou, Boston University, Questrom School Of Bus., Boston, MA, 02215-1704, United States, Min Dai, Wei Jiang, Cong Qin

We propose a unified dynamic framework to study the economics of the supply side of bitcoin mining, such as endogenous transaction fees, the miners' liquidation policies, and endogenous inventory holdings, in the face of declining system block rewards and stochastic demand. The model yields two economic insights: First, high jump risk and transaction fees income can be major forces driving miners to significantly reduce their inventory even when bitcoin prices are relatively low. Second, the model explains the observed co-movements of average transaction fees, average block sizes, and Bitcoin prices.

5 - Tradeoffs in Permissioned vs Permissionless Blockchains: Trust and Performance

Hanna Halaburda, NYU Stern, New York, NY, United States

It is generally agreed that permissioned blockchains can improve on operational cost and performance of permissionless blockchains, but it is assumed that this improvement comes at the cost of transaction security. We develop a model of transaction safety in permissioned and permissionless blockchains to study this tradeoff and find that in several settings there may be no tradeoff at all. With a minimal level of trust, well-designed permissioned blockchains can offer both higher operational efficiency and higher transaction security. This minimal trust is also inherent in most business relationships, making permissioned blockchains well suited for enterprise applications of the technology.

■ VSA18

Virtual Room 18

Emerging Topics in Information Systems

Sponsored: Information Systems

Sponsored Session

Chair: Sameer Mehta, The University of Illinois at Urbana-Champaign, Urbana, IL, 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, Uninversity of Texas-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 - Dark Side of Gamification in Financial Trading: Moral Disengagement, Unethical Decision Making, and the

'Robinhood Dilemma'
Nicholas Brown, Virginia Tech, Blacksburg, VA, United States

The popularity of gamified investing apps presents an interesting opportunity to explore the unintended consequences of gamification in financial trading, a context filled with asymmetric payoff structures that incentivize risk-taking and moral hazards. Surprisingly, empirical studies on spillover effects of companies' use of gamification elements on users' ethical decision making are sparse. We thus use the moral disengagement theory to investigate possible underlying relationships between rhetorical gamification and decision making. We present an experimental design that uses (non)gamified trading interfaces to influence users' decisions during a financial stock picking task.

3 - 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.

■ VSA19

Virtual Room 19

Large-Scale Analysis of Stochastic Systems

Sponsored: Applied Probability Society

Sponsored 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 - Epidemic Models with Memory, Varying Infectivity and Immunity/susceptibility in Large Populations
Guodong Pang, Penn State University, University Park, PA, 16802-6817, United States, Etienne Pardoux, Raphael Forien, Arsene Brice Zotsa–Ngoufack

In this talk we will discuss several epidemic models recently developed to account for general infectious durations, varying infectivity and immunity/susceptibility, extending the standard SIR, SEIR, SIS, SIRS and SEIRS models. Each individual in the population is attached with a random function that represents the infectivity force. It is also extended to include a random function that represents the immunity/susceptibility attached to each individual. The exposed and infectious periods are generated by these random functions. We analyze the population dynamics of the exposed, infectious and recovered individuals, and the total infectivity and susceptibility processes by establishing the FLLNs and FCLTs in large populations. The limits are deterministic and stochastic Volterra integral equations. We also discuss the new PDEs models arising from the FLLNs.

3 - 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.

4 - Low-complexity Switch Scheduling Algorithms for Large-scale Switches
Prakirt R. Jhunjhunwala, Georgia Institute of Technology, Atlanta, GA, United States

Motivated by applications in data center networks, we study the problem of scheduling in input queued switches. It was recently shown that the well-known MaxWeight algorithm achieves optimal scaling of mean queue lengths in steady-state in the heavy-traffic regime. However, because of the high time complexity, MaxWeight is not used in practice for large-scale switches. We study several low complexity algorithms (including a new algorithm named Random d-Flip) and show that their heavy-traffic performance is identical to that of MaxWeight. We also discuss the performance of these algorithms in the large-scale heavy-traffic regime when the size of the switch increases simultaneously with the load.

5 - Long Time Limits and Concentration Bounds for Graphon Mean Field Systems
Ruoyu Wu, Iowa State University, Ames, IA, 50011, United States, Erhan Bayraktar, Suman Chakraborty

We consider heterogeneously interacting diffusive particle systems and their large population limit. The interaction is of mean field type with random weights characterized by an underlying graphon. The limit is given by a graphon particle system consisting of independent but heterogeneous nonlinear diffusions whose probability distributions are fully coupled. Under suitable convexity/dissipativity assumptions, we show the exponential ergodicity for both systems, establish a uniform-in-time law of large numbers for the empirical measure of particle states, and introduce the uniform-in-time Euler approximation. The precise rate of convergence of the Euler approximation is provided. We also provide uniform-in-time exponential concentration bounds for the rate of the LLN convergence under additional integrability conditions.

■ VSA21

Virtual Room 21

APS Special Session on 'High-dimensional Statistics, Algorithms, and Algorithmic Intractability'

Sponsored: Applied Probability Society

Sponsored Session

Chair: Siva Theja Maguluri, ISyE Georgia Tech, Atlanta, GA, 30339, United States

1 - High-dimensional Statistics, Algorithms, and Algorithmic Intractability
David Gamarnik, Massachusetts Institute of Technology, Sloan School of Man, Cambridge, MA, 02142-1508, United States

Conducting statistical inference often amounts to solving optimization problems involving many dimensions. While many such optimization problems admit scalable computational procedures, other problems resisted multi-year efforts. Examples include sparse high dimensional linear regression, sparse principal component analysis, stochastic block model and many others. Despite the fact that these problems exhibit an apparent algorithmic hardness, no universally accepted formal theory of such hardness is available.

In this tutorial we will discuss several approaches for building such a theory, primarily focusing on the the approach based on the complex solution space geometry of these problems and the associated phase transition properties. We will demonstrate how the presence of such a complex geometry can be used to formally rule out broad classes of algorithms.

■ VSA22

Virtual Room 22

QSR Best Student Paper Award Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Bianca Maria Colosimo, Politecnico di Milano, Milan, I-20156, Italy

1 - QSR Best Student paper
Bianca Maria Colosimo, Politecnico di Milano, Milan, I-20156, Italy

Four finalists for the Best Student Paper Award will be selected to make presentations at the 2021 INFORMS Annual Meeting. The winner will be announced at the QSR business meeting later at the conference. All finalists will receive an award certificate. The winner will also receive a plaque of recognition. The broad criteria for selecting the recipient of the QSR Best Student Paper Award are: (a) Academic significance(originality, depth, and completeness of the work and its potential impact on future research); (b) Engineering or business relevance (importance of the problem and its impact on engineering or business practice). Specifically, papers will be assessed in six aspects: originality of ideas, depth of study, thoroughness of literature review, importance of problem, expected impact on future research, and potential impact on engineering or

business practice

2 - Data-Level Transfer Learning for Degradation Modeling and Prognosis
Amirhossein Fallahdizcheh, University of Iowa, Iowa City, IA, 52246, United States, Chao Wang

3 - NP-ODE: Neural Process Aided Ordinary Differential Equations for Uncertainty Quantification of Finite Element Analysis
Yinan Wang, Virginia Tech, Blacksburg, VA, 24060, United States, Kaiwen Wang, Wenjun Cai, Xiaowei Yue

4 - Adaptive Graph-Based Support Vector Data Description for Weakly-Supervised Anomaly Detection
Hui Wu, Tsinghua University, Beijing, 100084, China, Yan Fu Li

5 - A Registration-free Approach for Statistical Process Control of 3D Scanned Objects via FEM
Xueqi Zhao, Penn State University, State College, PA, 16801-4554, United States, Enrique Del Castillo

■ VSA23

Virtual Room 23

Spatial & Temporal Analytics and Applications I

Sponsored: Quality, Statistics and Reliability

Sponsored 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, University of Illinois, Champaign, IL, 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.

■ VSA24

Virtual Room 24

Advanced Machine Learning Techniques in Manufacturing Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hao Yan, Arizona State University, Tempe, AZ, 85281-3673, United States

Co-Chair: Imtiaz Ahmed, Texas A. & M University, College Station, TX, 77840-6717, United States

1 - Multi-task Gaussian Process Upper Confidence Bound for Hyperparameter Tuning
Zhenyu James Kong, Virginia Tech, Dept Of Industrial And Systems Engineering, Blacksburg, VA, 24061-2000, United States, Bo Shen, Raghav Gnanasambandam

Additive manufacturing (AM) is rapidly expanding beyond prototyping into production. To optimize AM processes in the pursuit of greater repeatability and reliability, lots of software has been developed to simulate AM processes. However, there are still some material property parameters need to be determined so that the simulated process is very close to the actual one. We often encounter the following problem: one set of material property parameters works well for one printing setting while it exhibits poor performance in another printing setting. To solve this problem, a Multi-Task Bayesian Optimization method is developed by actively querying one set of material property parameters, which leverages the performance of different printing settings. Furthermore, an upper confidence bound type of algorithm is developed with a sub-linear convergence rate.

2 - Creating Compensation Plans for Additively Manufactured Products Via Bayesian Extreme Learning Machines
Wenbin Zhu, Purdue University, West Lafayette, IN, United States, Arman Sabbaghi

Shape deviation control of additively manufactured products is essential for the potential of additive manufacturing systems to be realized. One effective strategy for reducing shape deviations in additive manufacturing systems is to add compensation plans to the nominal CAD models for shapes to be printed. However, the comprehensive development of compensation plans is made difficult by the wide variety of geometries and materials that are of interest to manufacture in additive manufacturing systems. We propose a new method to develop compensation plans based on Bayesian extreme learning machine (BELM) models for shape deviations of test shapes. We demonstrate the power and broad scope of our methods on 3D objects manufactured using MetalX additive manufacturing machines.

3 - 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.

4 - Surprise Driven Autonomous Experimentation Platform
Imtiaz Ahmed, Texas A. & M, College Station, TX, 77840-6717, 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.

5 - A Hierarchical RNN-based Framework for Machine Health Monitoring and Prognostics in Manufacturing Systems
Mengfei Chen, Rutgers, The State University of New Jersey, Piscataway, NJ, United States, Weihong "Grace" Guo

In-time and precise monitoring and prognostics in manufacturing are essential to facilitate downtime prevention, optimal repair decisions, and improved operations. Today's advanced manufacturing systems are equipped with smart sensors that record instantaneous events across plant floor machines. We propose a hierarchical RNN-based framework for machine health monitoring and prognostics given such instantaneous events data. The proposed method effectively addresses the inter-relationship among plant floor machines, the time-dependency in machine status, and the complexity of sensing data. The effectiveness of the method is demonstrated in a case study from automotive manufacturing.

6 - An Industry Taxonomy Enabled Approach for Automatic Clustering of Maintenance Records
Abhijeet Sandeep Bhardwaj, University of Wisconsin Madison, Madison, WI, United States

Maintenance records of industrial equipment contain a large amount of unstructured textual data (such as repair technician comments) that contain valuable insights. However, extracting groupings of maintenance records that are similar (e.g., in terms of failure mode or affected components) is a challenging problem. We present a novel approach for unsupervised clustering that combines the semantic information from the maintenance records with industry-specific taxonomy. We demonstrate the efficacy of our model on a real-world dataset and provide a comparison with state of the art methods.

■ VSA25

Virtual Room 25

Sustainability and Emerging Technologies

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Saed Alizamir, Yale University, New Haven, CT, United States

Co-Chair: Michael Blair, Yale University, 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 - Analysis of Farm Equipment Sharing in Emerging Economies
Can Zhang, Duke University, Durham, NC, 27708-9972, United States, Olufunke Adebola, Priyank Arora

In this paper, we study farm equipment sharing platforms in emerging economies. In particular, because of the small land size owned by smallholder farmers and the high transportation cost of heavy farm equipment, a critical player in such a platform is booking agents who exert costly effort to aggregate demand before submit it to the platform. We first study the pricing and commission decisions faced by the platform in the presence of booking agents, and show that the optimal platform decisions can significantly differ compared to other sharing settings without booking agents. We further study the design of government subsidies for encouraging the sharing the farm equipment, and derive insights on the effectiveness of different subsidy programs.

3 - 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.

4 - 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.

■ VSA27

Virtual Room 27

Modeling and analytics in On-Demand Transportation

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Raghav Singal, Columbia University, New York, NY, 10027, United States

1 - Share or Solo? Individual and Social Choices in Ride-hailing
Hengda Wen, Rotman School of Management, University of Toronto, Toronto, ON, Canada, Ming Hu, Jianfu Wang

Ride-hailing platforms offer riders pooling services to share rides with other riders. On the one hand, pooling service mitigates congestion and reduces rider wait times in rush hours, and sharing riders benefit from reduced prices. On the other hand, sharing riders may compromise on privacy and space when riding with strangers, and may take more time to reach their destinations. We derive a queueing model that considers solo ride and shared-ride together, where riders are strategic in choosing which ride to participate in. We analyze and compare the decentralized rider decisions and the centralized social planner decisions.

2 - A Tale of Timescales: Surge Pricing and Dynamic Matching for Hotspot Demand Shock in Ridehailing Networks
Philipp Afèche, University of Toronto, Rotman School of Management, Toronto, ON, M5S 3E6, Canada, Zhe Liu, Costis Maglaras

We study a ride hailing platform that matches price- and-delay sensitive riders with strategic drivers in the presence of an unpredictable demand shock at a hotspot. Our model captures the interplay of non-stationary demand, geographically distributed strategic supply, and delayed and risky supply response and incentives. We consider dynamic policies that jointly determine surge prices for riders, surge wages for drivers, and the spatial matching of riders to drivers. We characterize and compare the performance of various policies that differ in terms of three attributes, temporal differentiation, spatial differentiation and risk sharing. Our results identify how system performance depends on three key timescales, for rider patience, shock duration, and driving speed.

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.

4 - Dimensioning On-Demand Vehicle Sharing Systems
Saif Benjaafar, University of Minnesota, Minneapolis, MN, 55455-0150, United States, Shining Wu, Hanlin Liu, Einar Gunnarsson

We consider the problem of optimal fleet sizing in a vehicle sharing system. We model the dynamics of the system using a closed queueing network and obtain explicit and closed form lower and upper bounds on the optimal number of vehicles (the minimum number of vehicles needed to meet a target service level). We use features of the bounds to construct a simple and closed form approximation that we show to be always within the generated lower and upper bounds and is exact under various asymptotic regimes. The approximation is highly interpretable with buffer capacity expressed in terms of three explicit terms that can be interpreted as follows: (1) standard buffer capacity that is protection against randomness in demand and rental times, (2) buffer capacity that is protection against vehicle roaming, and (3) a correction term.

5 - Mechanism Design for Workforce Scheduling in On-demand Transportation
Raghav Singal, Dartmouth College, Hanover, NH, 10027, United States, Omar Besbes, Vineet Goyal, Garud N. Iyengar

Motivated by the substandard drivers' welfare in on-demand platforms, we propose a mechanism design framework for workforce scheduling. The platform maximizes profit by gathering supply via an admission control policy, which allocates hourly slots ("right to drive") to drivers. Each driver maximizes her expected utility, which depends on her temporal preference regarding when to drive, the slots she receives, and the time she spends on-road. We use our framework to evaluate existing policies and show they can result in highly suboptimal effective wage. Then, we propose a mechanism and establish tight performance guarantees with respect to both profit and wages.

■ VSA28

Virtual Room 28

Empirical Healthcare

Sponsored: MSOM/Healthcare

Sponsored Session

Chair: Guihua Wang, The University of Texas at Dallas, Richardson, TX, 75080-1037, United States

1 - 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.

2 - Impact Of Transitions of Care on Healthcare Operations
Krista Foster, University of Notre Dame, Notre Dame, IN, 46556, United States

We construct a measure of transitions of care and empirically estimate its impact on healthcare outcomes.

3 - The Impact of Patient Online Self-scheduling on Patient Access to Hospital Services
Lesley Meng, Assistant Professor, Yale University, New Haven, CT, 06519-2851, United States, Hummy Song, Christian Terwiesch

Recent innovation in healthcare access has led to the launch of online patient platforms where patients are now able to digitally schedule and manage their own medical appointments within a health system. Previously, medical appointments were scheduled over the phone, requiring an average of 8 minutes per call. In many large academic medical centers, digital scheduling has become the default method for patients to request and schedule appointments, and the majority of medical appointments are now made this way. In this study, we examine the impact of online self-scheduling access on patient scheduling and visit behavior at a large academic medical center.

4 - 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.

■ VSA29

Virtual Room 29

Commodity and Energy Market Operations

Sponsored: MSOM/iForm

Sponsored Session

Chair: Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States

Co-Chair: Bo Yang, Carnegie Mellon University, Pittsburgh, PA, 15213-4226, United States

1 - Spatial Price Integration in Commodity Markets with Capacitated Transportation Networks
Ian Yihang Zhu, University of Toronto, Toronto, ON, M5S 3G8, Canada, John R. Birge, Timothy Chan, Michael Pavlin

Spatial price integration is extensively studied in commodity markets as a means of examining the degree of integration between regions of a geographically diverse market. In this talk, we examine markets with well-defined transportation networks that have capacity constraints. We provide new theoretical results relating prices and price differences to the network structure, and outline an empirical methodology for analyzing prices in the presence of network bottlenecks. We conclude with a case study of gasoline prices in the southeastern U.S., where the methodology effectively characterizes the effects of a series of well-documented network disruptions on market prices, providing important implications for operations and supply chain management.

2 - Stochastic Optimization for Multi-market Bidding of Grid Energy Storage
Nils Löhndorf, Associate Professor, University of Luxembourg, Luxembourg, David Wozabal

We consider the problem of a storage owner who trades electricity in a day-ahead market and a continuous intraday market. We formulate the decision problem of day-ahead bidding and intraday trading as a multistage stochastic program. We show how tight upper bounds can be obtained based on calculating optimal bi-linear penalties for a novel information relaxation scheme. To calculate lower bounds, we propose a scenario tree generation method that lends itself to deriving an implementable policy based on re-optimization. A numerical comparison of lower and upper bounds based on a price model of the EPEX SPOT day-ahead and intraday market demonstrates that our policy is near-optimal for various storage assets.

3 - 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.

4 - Quadratic Hedging of Term Structure Risk in Merchant Energy Trading Operations
Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States, Bo Yang

We apply quadratic hedging to the management of term structure risk in merchant energy trading operations. We develop a model with pooled cash flows across dates, establish the structure of its optimal policy, and derive a computational efficient heuristic. Our method is provably optimal under a martingale assumption for the futures curve evolution. This technique performs near optimally in a realistic numerical study in the context of merchant energy storage in which this assumption does not hold.

■ VSA30

Virtual Room 30

Empirical Work in Service Operations

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Fanyin Zheng, Columbia University, New York, NY, 10027, United States

1 - Strategic Choices And Routing Within Service Networks: Modeling and Estimation Using Machine Learning

Kenneth Moon, University of Pennsylvania, Wharton School, 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 - The Unintended Labor Scheduling Implications of Minimum Wage

Qiuping Yu, Scheller College of Business, Georgia Tech, Atlanta, GA, 30308-1149, United States, Shawn Mankad, Masha Shunko

While there is a belief in the general public that a higher minimum wage improves worker welfare, the scholarly work investigating the impact of minimum wage on employment has been mixed. We contribute to this debate by showing the first empirical evidence that minimum wage leads to changes in firms' labor scheduling practices that reduce firms' labor costs but are detrimental to workers' welfare. Namely, using a dataset from a national fashion retailer, we estimate that a $1 increase in minimum wage, while having a negligible impact on the total labor hours used by the retailer, leads to a 27.7% increase in the number of workers scheduled per week, but a 20.8% reduction in weekly hours per worker. We also show that the minimum wage increase reduces the consistency of weekly and daily schedules for workers.

3 - Private Vs Pooled Transportation: Customer Preference and Congestion Management

Kashish Arora, Cornell University, Insead, 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.

4 - Countering Congestion in Online Marketplaces: Evidence From a Quasi-experiment

Ashish Kabra, University of Maryland-College Park, Robert H. Smith School Of Business, College Park, MD, 20740-3119, United States, Jun Li

We study the implications of adding frictions between ability of one side of a \marketplace to connect with another using a quasi-experiment. We study the implications on congestion, match rate, and quality of match due to this change.

■ VSA31

Virtual Room 31

Mechanism Design in Markets and Service Systems

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Krishnamurthy Iyer, University of Minnesota, Saint Paul, MN, 55114-1380, United States

1 - 3 Years, 2 Papers, 1 Course Off: Optimal Non-Monetary Reward Policies

Shivam Gupta, University of Nebraska Lincoln, Lincoln, NE, 68588, United States, Wei Chen, Milind Dawande, Ganesh Janakiraman

Motivated by practical examples from academia (a reduced teaching-load for achieving a certain research-productivity threshold) and industry (Supplier-of-the-Year awards in recognition of excellent performance), we consider a principal whose goal is to design a policy for giving non-monetary rewards to an agent. The following limited-term reward policy has been quite popular in practice: The principal evaluates each agent periodically; if an agent's performance over a certain (limited) number of periods in the immediate past exceeds a pre-defined threshold, then the principal rewards him for a certain (limited) number of periods in the immediate future. We identify a limited-term policy that is arbitrarily near-optimal. We also introduce and analyze the class of score-based policies and show that it always contains an optimal policy.

2 - Learning Product Rankings Robust to Fake Users

Jonathan Schneider, Google, Mountain View, CA, United States

In many online platforms, customers' decisions are substantially influenced by product rankings as most customers only examine a few top-ranked products. Concurrently, such platforms also use the same data corresponding to customers' actions to learn how these products must be ranked or ordered. These interactions in the underlying learning process, however, may incentivize sellers to artificially inflate their position by employing fake users, as exemplified by the emergence of click farms. Motivated by such fraudulent behavior, we study the ranking problem of a platform that faces a mixture of real and fake users who are indistinguishable from one another. We develop efficient learning algorithms under two informational environments: where the platform is aware of the number of fake users, and where it is agnostic to the number of fake users.

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.

4 - How Do We Control Misinformation?

Mohamed Mostagir, University of Michigan, Ann Arbor, MI, 48109, United States, James Siderius

We use a simple model to analyze several policies currently proposed in the public sphere to stop the spread of misinformation. We show that the efficacy of these policies crucially depends on the strategic sophistication and reasoning abilities in the population. We focus on the following policies: censorship, content diversification, accuracy nudging, and performance targets (where media outlets try to regulate the amount of misinformation on their platforms). We show that policies that work well for naive agents can perform poorly or completely backfire for sophisticated agents and vice versa. This highlights the importance of sophistication as a factor that regulators should consider when deploying policies to fight misinformation.

■ VSA32

Virtual Room 32

Customer-Centric Revenue Management

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Arian Aflaki, University of Pittsburgh, Pittsburgh, PA, 15260, United States

1 - Pricing for Satisficing Customers Under Stockouts
Varun Gupta, Penn State Erie, Erie, PA, 16563-1400, United States, Metin Cakanyildirim

Retail customers are generally satisfied with the purchase of a preferred and in-stock product priced below their willingness-to-pay. We develop a choice model for these behaviors and use it for pricing applications under stockouts.

2 - Stochastic and Dynamic Analysis of Strategic Customers Decision Model Facing a Nonlinear Price Trajectory
Roozbeh Yousefi, Queen's University, Kingston, ON, K7K 7M3, Canada, Jue Wang, Mikhail Nediak, Yuri Levin

We study the optimal dynamic pricing offered to strategic customers who after the purchase become inactive in the market. We modeled the stochastic problem and proved its convergence to a fluid limit. We also used continuous optimal control problem to solve optimal dynamic pricing offered to heterogeneous customers with different strategic behavior, under either unlimited usage subscriptions or per-usage purchase and used that to formulate the firm's profit maximization. We derived the optimality conditions and investigated the turnpike property of the solution, studied the dynamic aspects, optimize the length of the contract and demonstrate how subscription helps firm to exploit strategic behavior.

3 - Online Learning and Decision-making Under Generalized Linear Model With High-dimensional Data
Mike Mingcheng Wei, University at Buffalo, Buffalo, NY, 14260-4000, United States, Xue Wang, Tao Yao

We propose a minimax concave penalized multi-armed bandit algorithm under the generalized linear model (G-MCP-Bandit) for a decision-maker facing high-dimensional data in an online learning and decision-making process. We demonstrate that the G-MCP-Bandit algorithm achieves the optimal cumulative regret in the sample size dimension T, O(log T), and further attains a tight bound in the covariate dimension d, O(log d).

4 - Strawberry or Vanilla This Week? How to Optimize Tailored Assortments for Consumers with Variety Seeking/avoiding Behavior
Ismail Kirci, University of Texas at Dallas, Richardson, TX, 75082, United States, Sumit Kunnumkal, Dorothee Honhon, Sridhar Seshadri

We consider the problem of a retailer personalizing the assortment of products in a category where the consumer is variety-seeking (or variety-avoidant), which means she is less (or more) likely to buy the product she bought in the previous period. We characterize the optimal solution in a single period, finite and infinite horizon settings.

■ VSA33

Virtual Room 33

Innovative Incentives in Sustainable Operations and Supply Chain Management

Sponsored: MSOM/Supply Chain

Sponsored 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 - Competing to Discover Compliance Violations: Self-inspections and Enforcement Policies
Yu Shi, Yale University, New Haven, CT, United States, Saed Alizamir, Sang-Hyun Kim

To achieve compliance of environmental standards while relieving monitoring burden, regulatory agencies have been encouraging firms to engage in self-policing activities, i.e., voluntary detection and correction of compliance violations. In this paper, we investigate how governmental agencies such as EPA can influence firms' self-regulatory behavior in complying by environmental and social standards. We consider various forms of policy interventions and different types of violations. Our analysis shows that the rates of inspections chosen by the firm and the regulator can be complements or substitutes under different settings. Further, we find that improper setting of penalties may lead to unintended consequences due to the firm's incentive misalignment.

3 - Sustainable or Not? Role of Valuation Uncertainty and Operational Cost Structure on Product Line Design
Iva Rashkova, Washington University-St Louis, St Louis, MO, 63130, United States, Lingxiu Dong

Serving sustainability-conscious consumers is both profitable due to high demand for products such as organic, eco-friendly, etc and challenging due to lack of information on consumers' valuation of sustainability and increased technological costs. We present a model of a monopolist developing and producing conventional and green products to serve a two-segment market of sustainability-conscious and -neutral consumers. A two-dimensional segmentation framework of contingency and differentiation represents the rich set of the firm's possible optimal strategy. The firm's operational cost structure further leads to prioritization of one of the green product's quality dimensions.

■ VSA34

Virtual Room 34

Operational Issues at the Bottom of the Pyramid

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Bhavani Shanker Uppari, Singapore Management University, Singapore, 178899, Singapore

1 - Impact of Store Choice on Demand Distribution and Welfare In Public Sector Supply Chains - Evidence from India's Food Security Program
Maya Ganesh, Indian School of Business, Hyderabad, 500032, India, Sarang Deo, Sripad K. Devalkar

Advances in technology such as digital identity verification have enabled public welfare programs to offer choice of service provider to beneficiaries. However, absence of reliable data before implementation of such technologies makes it difficult to rigorously evaluate the impact of providing choice on program performance. In the context of India's food security program, we develop a structural model for beneficiaries' store choice, use its estimates to construct the baseline scenario of "no choice" and evaluate the impact of choice provision. We estimate the impact of choice provision on welfare improvement. Our findings imply that a large portion of potential welfare gain is not achieved due to the absence of complementary replenishment policy modifications which can account for demand variation resulting from the provision of choice.

2 - Restricting Mobile Data Can Accelerate Digital Development - Evidence From a Smartphone Experiment
Kamalini Ramdas, London Business School, 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.

4 - Battery Business Model Innovation to Reduce Lead Poisoning and CO2 Emissions

Amrita Kundu, Stanford Graduate School of Business, Stanford, CA, NW1 4SA, United States, Erica Plambeck

In Bangladesh, our field research shows that recycling of batteries for electric-three-wheelers is causing catastrophic lead poisoning. To triple the useful life of batteries and (by Little's Law) eliminate 2/3 of annual lead and CO2 emissions from recycling and manufacturing, we are piloting a business model innovation. The manufacturer provides a loan and conditional warranty, enabling the garage owner to purchase high-quality batteries and rent them out to vehicle owners and drivers, while incentivizing best practices in maintenance and charging. This innovation provides general insight on how to improve the efficiency of durable goods markets in developing economies.

■ VSA35

Virtual Room 35

Sharing Economy in Energy Networks

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Yue Chen, The Chinese University of Hong Kong, Tsinghua University, Beijing, China

Co-Chair: Yunhe Hou, The University of Hong Kong, Hong Kong

1 - Approaching Prosumer Social Optimum Via Energy Sharing With Proof of Convergence

Changhong Zhao, The Chinese University of Hong Kong, Shatin, Hong Kong, Yue Chen, Steven Low, Shengwei Mei

With the advent of prosumers, the traditional centralized operation may become impracticable due to computational burden, privacy concerns, and conflicting interests. In this talk, an energy sharing mechanism is presented to accommodate prosumer strategic decision-making on their self-production and demand in the presence of capacity constraints. Under this setting, prosumers play a generalized Nash game. We prove main properties of the game: an equilibrium exists and is partially unique; no prosumer is worse off by energy sharing and the price-of-anarchy tends to 1 with a growing number of prosumers. We also propose a bidding process that converges to the energy sharing equilibrium. Illustrative examples are provided to validate the results.

2 - Mobile Storage for Demand Charging Reduction

Junjie Qin, Purdue University, West Lafayette, IN, United States, Kameshwar Poolla, Pravin Varaiya

EV batteries, an increasingly prominent type of energy resources, are largely underutilized. This talk discusses a new business model that monetizes underutilized EV batteries to significantly reduce the demand charge portion of many commercial and industrial electricity users' electricity bills. This business requires minimal hardware to enable discharging batteries of electric vehicles and a sharing platform that matches EVs to commercial electricity users in real time. Using real meter data, we establish the financial viability of the business by studying the temporal distribution of user requests. We then discuss user-side and platform-side challenges for implementing this business.

3 - Regression Markets and Applications in Energy Networks

Pierre Pinson, Technical University of Denmark, Kgs Lyngby, Denmark, Liyang Han, Jalal Kazempour

The operation of energy networks heavily relies on data, where most agents would benefit from also accommodating data for other agents. There does not exist, however, a general framework that incentivise information sharing - this may be rethought within a sharing economy framework. We consequently propose to explore designs for data markets of relevance to energy-related applications. Emphasis is placed on markets linked to specific analytics tasks e.g. regression as a support to forecasting (may be least-squares or quantile regression for instance). Our proposal specifically focuses on yielding the right market properties, e.g., budget balance, incentive compatibility, etc. Those proposals are made within both batch and online learning setups, to accommodate different analytics tasks within energy system operation. Various applications are finally discussed.

4 - A Trusted Energy Trading Framework by Marrying Blockchain and Optimization

Sijie Chen, Shanghai Jiao Tong University, China

Trading based on distributed optimization is becoming a world-wide trend in energy markets. Without proper trading mechanism design, however, participants might act dishonestly, which further leads to potential trust crisis. Blockchain, known as the enabler of trust, is promising to address this challenge. However, current studies have not detailed how blockchain can disable dishonest participants in energy trading. Here, we propose an energy trading framework by marrying blockchain and distributed optimization, where blockchain enables check and balance among participants and disables dishonesty. Our results on a multi-energy district demonstrate in a quantitative way how our proposed framework can help prevent energy market failures caused by dishonest participants.

■ VSA36

Virtual Room 36

Modeling Deep Decarbonization in the Electricity Sector

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Qingyu Xu, Princeton University, Baltimore, MD, 21218-2625, United States

1 - Bitcoin's Future Carbon Footprint

Shize Qin, Tsinghua University, Beijing, China

In this paper, we present a framework to project Bitcoin's electricity consumption and carbon footprint in the long-term. If we assume Bitcoin's future market capitalization growth rate in the long-term falls within the range of historical growth rates of several comparable mainstream financial assets, we find that the annual electricity consumption of Bitcoin may increase from 190 to 7500 TWh between 2021 and 2100. The future carbon footprint of Bitcoin strongly depends on the decarbonization pathway of the electricity sector. If the electricity sector achieves carbon neutrality by 2060, Bitcoin's annual carbon footprint will peak in 2023, with cumulative emissions of about 1 GtCO2 by 2100.

2 - 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.

3 - Decarbonizing the Power Grid: The Role of Energy Storage

Audun Botterud, Argonne National Laboratory, Argonne, IL, 02140-2610, United States
Audun Botterud, Massachusetts Institute of Technology, Cambridge, MA, United States, Jonghwan Kwon, Todd Levin, Zhi Zhou

The electricity system is projected to play an increasingly important role for energy supply across different sectors as countries around the world are setting ambitious goals for reductions in carbon emissions. At the same time, energy storage can be a key enabler of variable renewable energy in a low-carbon grid. We discuss how energy storage is typically represented in capacity expansion models used in decarbonization studies of the electric power system. In a scenario-based analysis of decarbonization of the power grid in the United States, we illustrate how different representations of energy storage impact storage technology choice, investment levels, and the computational burden of the resulting optimization problems.

4 - Deep Decarbonization of the European Power Sector and the Role of Flexibility

Anneke Vries, Netherlands Environmental Assessment Agency (PBL), Den Haag, Netherlands, Paul Koutstaal, Ozge Ozdemir

The European Union has formulated ambitious CO2-emission reduction targets in its Fit for 55 package. In order to meet these goals, there will be a large increase in electricity demand with electrification in sectors such as industry, the residential sector and transport which is needed for the decarbonisation of these sectors. Flexibility from dispatchable generation, demand side response, storage and interconnections will be needed to accommodate the growth of electricity production from renewable intermittent sources such as solar and wind. We use COMPETES, a transmission-constrained optimization model of the European power market, to investigate the role of flexibility options such as EV, P2X, DSR and optimized transmission capacity on e.g. electricity prices and volatility, trade, curtailment.

■ VSA38

Virtual Room 38

Renewable and Emerging Technologies

Sponsored: ENRE/EnergyClimate

Sponsored 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.

■ VSA39

Virtual Room 39

Modeling the Environmental Impacts of Emerging Transportation Technologies and Systems

Committee Choice: ENRE/Environment and Sustainability

Committee Choice Session

Chair: Hua Cai, Purdue University, West Lafayette, IN, United States

1 - Modeling Greenhouse Gas Impacts of Vehicle Electrification in The U.S. and China

Zhenhong Lin, Oak Ridge National Laboratory, Knoxville, TN, 37932-1563, United States

As the largest two carbon emitters, the United States and China have pledged to achieve carbon neutrality by 2050 and 2060, respectively. Vehicle electrification is now widely viewed as an inevitable part of the roadmap. However, it is not yet clear to what necessary or realistic extent, vehicle electrification can contribute to the carbon neutrality goals in the two countries. In this study, we address this question by using MA3T and NEOCC to simulate adoption of electric vehicles in the two countries and considering consumer acceptance, supply decision, vehicle efficiency, battery cost, charging infrastructure, and policy forcing. The resulting greenhouse gas emissions are calculated with consideration of electricity carbon intensity over time under different grid decarbonization scenarios.

2 - Incentives Design Optimization for Plug-in Electric Vehicles Diffusion and Target Emissions Reduction

Eleftheria Kontou, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Yen-Chu Wu

Electric vehicles (EVs) are expected to reduce environmental externalities of transportation and contribute to the sector's decarbonization. We aim to increase EV adoption with monetary incentives (i.e., rebates and charging infrastructure investments) and achieve a target emissions reduction. A mathematical model is proposed to optimize the budget allocation of charging infrastructure deployment and EV purchase rebates over a set planning horizon. We implement a metaheuristic algorithm based on simulated annealing to solve the nonlinear programming problem. To provide comprehensive policy recommendations, we conduct sensitivity analyses to evaluate changes in the investment portfolio.

3 - Emission Reduction Potentials of Shared Micro-mobility in Global Cities

Hao Luo, Purdue University, West Lafayette, IN, United States

The operation of shared micro-mobility systems includes rebalancing and charging processes, which leads to additional greenhouse gas (GHG) emissions. Shared micro-mobility systems can only reduce emissions when replacing car trips or integrating with transit. But the system operation relies on local travel patterns and the mode replacement relies on travel behavior. We will use a data-driven framework to assess GHG emissions of shared micro-mobility, which includes a life cycle assessment model for emission generation and a simulation model for emission reduction based on mode replacement. We will apply the model to global cities and compare different systems based on real-world travel patterns and riders' travel behaviors.

4 - High-impact Locations for Electric Vehicle Charging Based on Travel Behaviors and Technology Limitations

Jessika Trancik, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Wei Wei

In this paper we examine travel behaviors and technological capabilities to identify high-impact locations for locating electric vehicle charging stations. We compare potential charging locations based on their ability to serve vehicle charging needs without interrupting personal travel schedules throughout the day and year. Charging locations are also compared alongside vehicle costs and battery capacities to evaluate the extent to which they provide equitable access to electric vehicles. Finally, we examine how technology improvement trajectories can be accounted for in technology and policy planning for expanding electric vehicle charging.

■ VSA40

Virtual Room 40

Stochastic Optimization and Machine Learning Applied to Power Systems

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Joaquim Masset Lacombe Dias Garcia, PSR Inc, Rio de Janeiro, 22250-040, Brazil

Co-Chair: Luiz Augusto Barroso, PSR, Rio de Janeiro, Brazil

1 - Batch Learning in Stochastic Dual Dynamic Programming

Daniel Felipe Avila, Universite Catholique de Louvain, Bogota, Louvian-La-Neuve, 12345, Belgium

We consider the stochastic dual dynamic programming (SDDP) algorithm, which is a widely employed algorithm applied to multistage stochastic programming, and propose a variant using batch learning, a technique used with success in the reinforcement learning framework. We cast SDDP as a type of Q-learning algorithm and describe its application in both risk neutral and risk averse settings. We demonstrate the efficiency of the algorithm on a lost sales inventory control problem with lead times, as well as a real-world instance of the long-term planning problem of inter-connected hydropower plants in Colombia. We find that the proposed technique is able to produce tighter optimality gaps in a shorter amount of time than conventional SDDP, including the PSR SDDP commercial software. We also find that parallel computation of SDDP backward passes benefit from batch learning.

2 - Efficient Strategies for the Representation of Non-convexities in the Operation Planning of Energy Systems

Luiz Carlos da Costa, PSR, Rio de Janeiro, Brazil, Fernanda Thomé

The solution of multi-stage stochastic problems with non-convexities remains a very challenging task. Recently, many interesting methodologies have been proposed with important mathematical advances. In this work, we explore different strategies for the efficient representation of non-convexities in the Stochastic Dual Dynamic Programming algorithm with numerical experiments applied to real case energy systems.

3 - FI

ELD: A Cooperative Deep Reinforcement Learning Tool for Effective Hydrothermal Dispatch

Adriano Veloso, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

We present FIELD, a deep cooperative multi-agent reinforcement learning framework which is leveraged to learn hydrothermal dispatch policies. Empirical inflow data is supplied to a generative model, which tries to maximize the probability of the empirical data. After a sufficient number of iterations, we can sample from this probability distribution to generate new, synthetic inflow data with different complexities. Training happens by showing synthetic inflow scenarios in an increasing order of complexity, thus imposing a specific learning regimen. Agents work independently, but they share the network parameters and follow the guidance from an evaluation of the joint policy. Efficiency and flexibility of the proposed framework are demonstrated through experiments on a complex topology involving many hydro- and thermal-power stations.

4 - Leveraging Grid Topology in Machine Learning Assisted Optimal Power Flow: A Systematic Comparison of NN Architectures for Predicting OPF Solutions

Thomas Falconer, University College London, London, United Kingdom, Letif Mones

Machine learning assisted optimal power flow (OPF) aims to reduce computational costs by transferring expensive (online) optimisation to offline training. The majority of work in this area typically employs fully-connected neural networks (FCNNs), however recently convolutional (CNN) and graph (GNN) NNs have been investigated, in effort to exploit topological information within the grid. Although promising results have been obtained, there lacks a systematic comparison between these architectures. Accordingly, we asses the performance of a variety of FCNNs, CNNs and GNNs for both regression (i.e. predicting optimal generator set-points) and classification (i.e. predicting the active set of constraints). For a several synthetic grids, we show locality properties are scarce, hence find limited applicability of CNNs and GNNs for this problem.

■ VSA41

Virtual Room 41

Managing Uncertainty and Scarcity in Energy Systems: Part II

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Samuel Chevalier, Technical University of Denmark, Denmark

Co-Chair: Dongchan Lee, Cambridge, MA, United States

1 - Applications of Polynomial Chaos Expansion-based Methods in Power System Probabilistic Security Assessments

Xiaozhe Wang, McGill University, Montreal, Canada

The increasing integration of renewable energy sources introduces a growing uncertainty level to power systems. In this talk, I will present my group's recent works in utilizing polynomial chaos expansion (PCE)-based methods in power system probabilistic security assessments. In contrast to Monte Carlo-based simulations that require a large number of scenarios and model evaluations, the polynomial chaos expansion method can build a surrogate model for assessing the model response (e.g., available transfer capability) from a small number of scenarios and model evaluations, which thus saves huge computational efforts. I will also introduce the efforts to relax the assumption of knowing marginal probability distributions of random variables. Insights for decision-making to reduce the negative impacts of uncertainty on power system security will also be discussed.

2 - Multi-Stage Investment Decision Rules for Power Systems: Sensitivities, Deterministic Equivalents and Performance Guarantees

Dvorkin Vladimir, Massachusetts Institute of Technology, Cambridge, MA, United States, Dharik Mallapragada, Audun Botterud

We develop multi-stage decision rules to assist generation investment in power systems under uncertainty. We formulate them as linear functions of uncertainty, enabling new insights and modeling opportunities. First, akin to regression, the optimized decision rules explain the sensitivity of investment decisions to the uncertainty of engineering, economic, and policy parameters. Second, we introduce the notion of deterministic equivalent of stochastic investment planning — the deterministic decision rules that are insensitive to uncertainty but robust with respect to its realizations. Last, we provide a priori performance guarantees for the optimized decision rules to ensure generation adequacy and investment optimality.

3 - Balancing Wildfire Risk and Power Outages

Noah Rhodes, University of Wisconsin - Madison, Madison, WI, United States, Lewis Ntaimo, Line Roald

Electric grid faults can cause catastrophic wildfires, particularly in regions with high winds and low humidity. In real-time operations, electric utilities are left with few options for wildfire risk mitigation, leading to the use of disruptive measures such as public safety power shut-offs. This work proposes the optimal power shut-off problem, an optimization model to support short-term operational decision making in the context of extreme wildfire risk. This is the first optimization model to consider how preventive measures impact wildfire risk and power systems reliability at a short-term, operational time-frame. The method is demonstrated on an augmented RTS-GMLC test case, and compared against two approaches based on simple risk thresholds. The proposed optimization-based model reduces both wildfire risk and load shed relative to the benchmarks.

4 - The Calibration of ORDCS for a Scarcity Pricing Mechanism in Belgium

Jacques Cartuyvels, UCLouvain, Louvain-la-Neuve, Belgium

In this presentation we compare the incentives induced by different shapes of an Operating Reserve Demand Curve (ORDC) in a scarcity pricing scheme by simulating the short-term (day-ahead and real-time) operation of the Belgian market. We analyze the tension between wide ORDCs that result in high fixed costs due to their conservative procurement of reserve and narrower ORDCs that are exposed to higher shortage costs. Results show that the cost differential is minor between the different variants, nevertheless there are notable differences concerning the resulting price signal. This analysis serves as input to the ongoing stakeholder process for implementing scarcity pricing in Belgium.

■ VSA42

Virtual Room 42

Advances in Power Systems Planning

Sponsored: Computing Society

Sponsored 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 - Hydropower Representation Tradeoff Between Hydroscheduling Models and Production Cost Models Using Bivariate Functions

Quentin Ploussard, Argonne National Laboratory, Lemont, IL, United States, Nathalie Voisin, Thomas Veselka, Konstantinos Oikonomou

This research work aims to assess the discrepancy in hydropower representation between conventional PCMs and hydro scheduling tools and propose a new method to account for hydrological and environmental aspects in PCMs. To achieve this, three scenarios are simulated. The first scenario simulates water releases and hydropower generations using a conventional PCM. The second scenario uses the hydropower operation output from a hydro scheduling tool to integrate into a PCM. The third scenario explores a hybrid alternative in which hydropower operations are simulated based on evolving hydropower parameters extracted from "surfaces". These surfaces consist of bivariate functions generated in advance by the hydro scheduling tool used in the second scenario under numerous hydrological conditions.

3 - Accelerating Power Systems Optimization with MIPLearn - An Open-source Framework for Learning Enhanced Optimization

Alinson Santos Xavier, Computational Scientist, Argonne National Laboratory, Lemont, IL, 60439, United States, Feng Qiu

In many power system applications, it is often necessary to find optimal or high-quality solutions to a large number of Mixed-Integer Linear Programs (MIPs) that share very similar problem structure. This situation arises, for example, in power generation scheduling under uncertainty, where multiple scenarios must be solved to find a stochastic solution. In this talk, we introduce MIPLearn, an open-source software package which can use state-of-the-art ML methods to accelerate the performance of existing open-source and commercial MIP solvers (e.g Gurobi, CPLEX, XPRESS) based on previously solved instances.

4 - Robust Power Systems Planning Against Rising Temperatures With Discrete Transmission Considerations

Kyle Skolfield, Arizona State University, 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.

■ VSA44

Virtual Room 44

Economics and Computation I

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Shuze Liu, VSC55- Rensselaer Polytechnic Institute, United States

1 - Evolutionarily Stable (Mis)specifications: Theory and Applications

Kevin He, University of Pennsylvania, Philadelphia, PA, United States, Jonathan Libgober

We introduce an evolutionary framework to evaluate competing (mis)specifications in strategic situations. Agents with heterogeneous specifications coexist in a society and repeatedly match against random opponents to play a stage game. The learning channel leads to novel stability phenomena compared to frameworks where the heritable unit of cultural transmission is a single belief instead of a specification. We apply the framework to linear-quadratic-normal games where players receive correlated signals but possibly misperceive information structure. The correct specification is not stable against a correlational error, whose direction depends on matching assortativity.

2 - In Congestion Games, Taxes Achieve Optimal Approximation

Dario Paccagnan, Imperial College London, London, United Kingdom, Martin Gairing

We consider the problem of minimizing social cost in atomic congestion games and show, perhaps surprisingly, that efficiently computed taxation mechanisms yield the same performance as the best polynomial time algorithm, even if the latter has full control over the players. Three contributions underpin this conclusion. First, we show that computing the minimum social cost is NP-hard to approximate within a factor depending solely on the resource costs. Second, we design a tractable taxation mechanism whose efficiency (price of anarchy) matches the hardness factor. As these results extend to coarse correlated equilibria, no-regret algorithms provide optimal approximations in polynomial time.

3 - The Privacy Paradox and Optimal Bias-variance Trade-offs in Data Acquisition

Guocheng Liao, The Chinese University of Hong Kong, Hong Kong, Hong Kong

While users claim to be concerned about privacy, often they do little to protect their privacy. One prominent explanation for this ''privacy paradox" is that when an individual shares her data, the privacy of other individuals with correlated data is also compromised. This information leakage encourages oversharing of data. In this paper, we study the mechanism for data acquisition in settings with information leakage. We design an incentive-compatible mechanism that optimizes the worst-case bias-variance trade-off of the estimation subject to a budget constraint. Additionally, we characterize the structure of the optimal mechanism in closed form and study some properties of the mechanism.

4 - Optimal Pricing of Information

Shuze Liu, PhD Student, University of Virginia, Charlottesville, VA, United States, Weiran Shen, Haifeng Xu

A decision-maker looks to take an active action (e.g., purchase) or a passive action. The payoff of the active action depends on the private type and a state of nature that is only known to the seller. We fully characterize the optimal pricing mechanism for the seller in closed-form. We show a threshold mechanism that reveals the realized state is above some threshold or not is optimal. The payment and the threshold are generally different from different buyer types and are carefully tailored to accommodate the different amount of risks each buyer type can take. The proof of our results proposes novel concepts, such as the mixtures of upper/lower virtual values which may be of independent interest.

■ VSA45

Virtual Room 45

Forecasting, Ordering and Allocation under Strategic Behavior

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Pelin Pekgun, University of South Carolina, Columbia, SC, 29205-2648, United States

Co-Chair: Minseok Park, PhD, Salisbury University, Salisbury, MD, 21801, United States

1 - Inventory Transshipment Game with Limited Supply: Trap or Treat

Ziteng Wang, Northern Illinois University, Dekalb, IL, 60115, United States

We investigate an inventory transshipment game with two newsvendor type retailers under limited total supply. We derive the ordering strategies for the retailers and show that a pure Nash equilibrium only exists under certain conditions. Furthermore, we show that inventory transshipment may not always benefit both retailers. Although one of the retailers is guaranteed to be better off, the other could be worse off. The decision criteria are then provided for the retailers to determine if they will benefit from inventory transshipment. Transshipment prices play an important role in keeping inventory transshipment beneficial to both retailers. Subsequently, a coordinating mechanism is designed for the retailers to negotiate transshipment prices that maximize the total profit of the two retailers while keeping each of them in a beneficial position.

2 - Information Asymmetry and Fairness Concerns

Ummuhan Akbay, Isik University, Istanbul, Turkey

We present the results of a human-to-human experiment which investigates the effects of information asymmetry on fairness concerns. We focus on a simple supplier-retailer supply chain where each firm determine their share of the selling price and have their private costs. We compare pricing decisions of the firms under perfect information, one-sided and two-sided asymmetry on the private cost information. Our findings show that contrary to earlier literature, suppliers' pricing decisions are not affected by having their private cost known. Yet knowing retailer's private cost leads to the supplier's offering lower than optimal prices. Retailers make higher than optimal pricing decisions and lower their prices if they know the supplier has a high private cost. Finally, the contract efficiency is positively affected by retailers' private cost being disclosed.

3 - Pulled in Opposite Directions: An Experimental Examination Linking Supply and Demand Uncertainty

Somak Paul, California State University, Hayward, CA, 94501, United States, Elliot Bendoly, Ken Boyer, Nathan C. Craig

Supply-chain inventory-management decisions are complicated by the presence of both downstream (demand) and upstream (supply) uncertainties. Prior research shows that each type of uncertainty leads to specific decision biases. Our research employs a controlled laboratory experiment to study the decision biases when both types of uncertainty are present. Our results show that the presence of both supply and demand uncertainty has a more nuanced effect on decision biases than does either type of uncertainty alone. Demand uncertainty can elicit the diversification bias, even in the absence of supply uncertainty. Moreover, supply uncertainty affects the magnitude of the pull-to-center bias. Our work reveals the need for further attention from supply-chain academics and managers on how supply and demand uncertainty jointly affect inventory managers' decisions.

4 - Ordering Behavior and the Impact of Allocation Mechanisms

Eirini Spiliotopoulou, Tilburg University, Amsterdam, 1057, Netherland, Karen L. Donohue, Mustafa Cagri Gurbuz

We study the impact of proportional, linear, and uniform allocation mechanisms on the ordering behavior of retailers serviced from a central distribution center (integrated setting). Consistent with theory that only the uniform allocation incentivizes retailers to set orders truthfully, our experimental results show that proportional and linear allocation mechanisms result in larger and more frequent order adjustments, with the degree of strategic ordering being largest under the linear mechanism. Across all rules, order adjustments not only decrease system efficiency but also a retailer's own profits. Motivated by these results we design and test a tailored uniform allocation mechanism that offers allocation flexibility without introducing incentives for order manipulation.

■ VSA46

Virtual Room 46

AI and Transfer Learning in Social Media Analytics

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Yifan Yu, University of Washington, Seattle, WA, United States

1 - Identification and Estimation of Heterogenous Treatment Effects Under Limited Overlap

Wendao Xue, PhD, University of Washington, Seattle, WA, United States

Unconfoundedness or selection-on-observables and overlap or common support assumptions are commonly adopted in the literature to identify various average treatment effect parameters. The overlap assumption is difficult to satisfy with many covariates, and even if the overlap assumption holds in population, there are typically non-overlap region in the sample on covariates in the treated and control groups. This hampers nonparametric estimates of average treatment effects reflected in large bias and variance. In this paper we rely on a domain shift assumption for the limited overlap region and comes up with a non-parametric estimator for the treatment effect for a subsample of the full sample. We also derive the semiparametric efficiency bound for the model.

2 - Impact of AI on Consumer Decision-making and Sales Diversity

Yu Kan, University of Washington, 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?

3 - Do Pictures in Online Reviews Affect Users' Attitudes? – Evidence from a Chinese Catering Platform

Xinyao Wang, Tsinghua University, Beijing, China, Yifan Yu, Jinghua Huang, Yong Tan

Although pictures are frequently used in online reviews, their impact on the attitudes of other users remains unclear. Our work applied stimulus-organism-response (SOR) paradigm and used data from a Chinese catering platform to examine the impact of pictures on attitudes of users towards online reviews. Results showed that domain-related features and aesthetics quality features of pictures affect users' emotions, which in turn, affect their attitudes. Namely, valence of pictures showed a positive impact while arousal of pictures showed a non-linear impact on users' attitudes. Our work enriched literature and provided implications for managers of both platforms and restaurants.

4 - Sales Prediction With Domain-adaptive Emotion Analysis

Yifan Yu, University of Washington, Seattle, WA, United States

Emotion artificial intelligence, the algorithm that recognizes and interprets various human emotions beyond valence (positive and negative polarity), is still in its infancy yet attracts much attention from both the industry and academia. Based on the discrete emotion theory and statistical language modeling, this work proposes an algorithm to enable automatic domain-adaptive emotion lexicon construction and multi-dimensional emotion detection in texts. With a large-scale dataset of China's movie market from 2012 to 2018, we construct and validate a domain-specific emotion lexicon and demonstrate the predictive power of eight discrete emotions in online reviews on box office. We find that representing emotions using discrete emotions yields higher prediction accuracy than using valence or latent emotion variables generated by topic modeling.

■ VSA47

Virtual Room 47

Big Data Finance

Sponsored: Finance

Sponsored Session

Chair: Paul Glasserman, Columbia University, New York, NY, United States

1 - Deep Learning Statistical Arbitrage

Markus Pelger, Stanford University, Stanford, CA, 94305, United States, Jorge Guijarro Ordonez, Greg Zanotti

We propose a general framework for statistical arbitrage. Our approach generalizes the idea of pairs trading and mean reversion by finding commonality and time series patterns in a flexible way. First, we remove all commonality based on observed and unobserved risk factors of individual stock returns. Second, we extract in a flexible and data driven way the time series patterns in the residual portfolios, which we use to form optimal arbitrage portfolios. One key contribution is a novel convolutional and attentional neural network architecture applied to the panel of residual portfolios. It detects mean reversion and trend patterns in the panel and constructs optimal trading strategies. We apply our model to daily US stock returns. Our optimal trading obtains a consistently high out-of-sample Sharpe ratio and remains profitable after taking into account trading costs.

2 - The Pricing and Hedging of Constant Function Market Makers

Ciamac Cyrus Moallemi, Columbia University, Columbia Business School, New York, NY, 10027, United States, Richard Dewey

Recently, there has been an explosion of interest in so-called "constant function market makers" (CFMMs). These are decentralized exchange mechanisms implemented as smart contracts on blockchains that allow for trading of one digital asset for another, and are one of the key mechanisms in decentralized finance. We present a pricing model for CFMMs. Our model provides a novel, combined treatment of CFMMs as a path dependent derivative security while also accounting for adverse selection, which is a dominant determinant of valuation in financial market settings. Our model is easily calibrated to market data, and can also be used to quantify sensitivities and risk factors. We demonstrate empirical results.

3 - The Causal Learning of Online Shopper's Delinquency Risk

Qi Wu, Associate Professor, City University of Hong Kong, Kowloon Tong, Hong Kong, China, Yiyan Huang, Leung Cheuk Hang, Xing Yan, Nanbo Peng, Dongdong Wang, Zhixiang Huang

Many e-commerce conglomerates provide financing services to retail shoppers who frequent their e-commerce marketplaces. Essential to the pricing of shoppers' delinquency risks is to correctly account for the impact of the lender's data-driven credit policies on consumers' repayment behavior, the so-called "action-response" causal relationship. This paper proposes generalized treatment-effect estimators that are regularized-unbiased at higher orders. They apply to linear regression models, tree models, and, importantly, neural networks. We tested our methods on observational records of 400,000 customers with 1159 feature dimensions from JD Digits, which operates in both e-commerce and retail lending businesses. We found that our methods substantially reduce the estimation error in shoppers' delinquency risks after accounting for these causal effects.

4 - Infinitely Imbalanced Linear Classifiers With Applications to Credit Risk

Mike Li, Columbia University, New York, NY, United States, Paul Glasserman, Columbia University, New York, NY, United States

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.

■ VSA48

Virtual Room 48

The Economics of Peer-to-Peer Markets

Sponsored: eBusiness

Sponsored Session

Chair: Zaiyan Wei, Purdue University, West Lafayette, IN, 47907, United States

1 - Information Disclosure And Lender Behaviors

Jiayu Yao, Georgia Institute of Technology, Atlanta, GA, 30308-1149, United States, Kai LU, Xing Huang, Mingfeng Lin

We study the effect of showing information about peer behavior on decision-making in the context of online peer-to-peer lending (P2P lending) using a natural experiment on one of the largest P2P lending platforms as well as complimentary online experiments. We find that when detailed information about peer behaviors is available, lenders spent more time before reaching decisions, but their likelihood of picking high-quality loans does not increase. Our study provides implications for information disclosure theory and market design.

2 - Estimating the Demand for Autonomous Driving Technologies

Siyu Shi, The Pennsylvania State University, State College, PA, United States

Autonomous driving (AD) is emerging in the automobile industry. While AI-enabled AD is expected to enhance safety, consumers yet hold heterogeneous opinions. Unlike prior literature based on surveys, we specify a BLP-style model to estimate the elasticity of AD. We construct the aggregate market share data in the US from 2000 to 2019 using multiple datasets. The results show that AD makes a significant impact on the demand. The cross-elasticities between AD and other features are also identified. These findings lead to several practical implications for manufactures and consumers.

3 - Experts vs. Non-experts in Online Crowdfunding Markets

Zaiyan Wei, Purdue University, West Lafayette, IN, 47907, United States, Mingfeng Lin, Richard Sias

The growth of crowdfunding markets is accelerating due to recent changes in Securities Exchange Commission (SEC) regulations. Although it is well-recognized that these markets benefit from the participation of expert and non-expert investors, theory suggests that experts will garner larger returns at the expense of non-experts. Via simulations, we demonstrate that the extent to which non-experts are worse off varies as a function of project success, experts' relative participation, the quality of information signal, and experts' diversification strategy. Empirically, we exploit a unique period in one crowdfunding market and find that the negative effects of expert participation are small. The findings contribute to both theory and practice as they reveal that experts and non-experts can peacefully coexist in crowdfunding markets.

4 - Estimate the Value of Internet Celebrity for Online Retailers: An Empirical Analysis

Weilong Wang, Purdue University, West Lafayette, IN, 47907-2056, United States, Jinyang Zheng, Karthik Kannan, Guoxin Li

In today's digital world, social content creators with niche audiences can often offer more value to brands. These online influencers have dedicated and engaged groups of followers on various social media platforms. The fast development of livestream platforms provides a great opportunity for them to engage in branding products for many online retailers. Both retailers and livestream platforms are experimenting with new ways of getting more audience's attention. We leverage the data from a leading streaming platform to answer this question. Our results provide empirical evidence for the effectiveness of engaging influencers. And our results give important managerial insights for retailers when forming a suitable combinatory strategy when selecting multiple potential influencers.

■ VSA49

Virtual Room 49

Advancing Theory and Methodology for Multiobjective Optimization

Sponsored: Multi Criteria Decision Making

Sponsored Session

Chair: Margaret M Wiecek, Clemson University, Clemson, SC, 29634-1907, United States

1 - An Approximation Approach for the Generalized Multi-objective Set Covering Problem.

Lakmali Weerasena, University of Tennessee at Chattanooga, Chattanooga, TN, United States, Aniekan A. Ebiefung, Anthony Skjellum

Set covering optimization problems (SCPs) are essential and of broad interest because of their extensive applications in the real world. We propose an algorithm to approximate the Pareto set of the generalized multi-objective SCP (GMOSCP). The algorithm consists of three main stages, and each of these stages contributes significantly to the algorithm's performance. We use an achievement scalarization approach to scalarize the objective vector of the GMOSCP. Uniformly distributed weight vectors, defined concerning this reference point, support to produce uniformly distributed Pareto set approximations. We propose multiple cost-efficient rules in the algorithm and investigate how they affect approximating the Pareto set. The computational results demonstrate that the algorithm efficiently solves the GMOSCP.

2 - Decomposition-based Decision-making in Many-objective Optimization

Philip de Castro, Clemson University, Clemson, SC, United States, Margaret M. Wiecek

The complexity of many-objective optimization problems (MOPs) makes tradespace analysis difficult for decision makers as they strive to make well-informed decisions. It is thus desirable to develop methods to decompose MOPs into biobjective subproblems making analysis and visualization much easier. We review the state-of-the-art in decomposition-based multiobjective optimization and propose methods of decomposition for more advanced problem structures that allow for global and local decision variables. We describe the interplay between Pareto and epsilon-Pareto solutions between the subproblems and the overall problem.

3 - On Solving Parametric Multiobjective Quadratic Programs With Parameters in General Locations

Andrew Pangia, Clemson University, Clemson, SC, United States, Margaret M. Wiecek

While theoretical studies on parametric multiobjective programs (MOPs) have been steadily progressing, the algorithmic development has been comparatively limited even though parametric optimization can provide a complete parametric description of the efficient set. We build on the premise that parametrization of the efficient set of nonparametric MOPs can be combined with solving parametric MOPs because the algorithms performing the former can also be used to achieve the latter. We focus on a linear interpolation of the optimal value function of the scalarized MOP, which, under certain constraint qualifications, can be applied to parametric MOPs with affine parameters anywhere.

4 - Supported Solutions as a Representation of the Nondominated Set: An Empirical Analysis

Serpil Sayin, Koc University, College of Admin Sciences and Economics, Istanbul, 34450, Turkey

We investigate the set of supported nondominated solutions and the set of extreme supported nondominated solutions as representations in multiobjective discrete optimization. Given a complete nondominated set, we use simple linear programming formulations to identify the supported nondominated solutions and extreme supported nondominated solutions respectively. In addition to solving knapsack and assignment problem test instances that are used widely in the literature, we generate new instances with different data generation schemes. We observe that the set of supported nondominated solutions and the set of extreme supported nondominated solutions are very good representations based on coverage error and hypervolume. Focusing on extreme supported solutions may help solve problems with a higher number of objective functions or variables.

5 - A Branch and Bound Algorithm for Biobjective Mixed Integer Quadratic Programs

Pubudu L. Jayasekara, Clemson University, Clemson, SC, United States, Margaret M. Wiecek

A branch and bound (BB) algorithm for biobjective mixed integer quadratic programs (BOMIQPs) is developed. At the initialization, a subset of the Pareto set to the BOMIQP is computed and then successively extended into the entire Pareto set to this problem. Biobjective quadratic programs (BOQPs) are solved for their Pareto sets at the nodes of the BB tree. The algorithm makes use of a fathoming procedure, which eliminates BOQPs that do not contain Pareto points to the BOMIQP, and a set dominance procedure, which examines the mutual location of two Pareto sets and determines the resulting nondominated set. Computational results are provided.

■ VSA50

Virtual Room 50

Simulation-based Sensitivity Analysis and Its Applications

Sponsored: Simulation Society

Sponsored Session

Chair: Xi Chen, Virginia Tech, Blacksburg, VA, 24061-1019, United States

1 - Learning and Deploying Active Subspaces on Black Box Simulators

Nathan Wycoff, Virginia Tech, Blacksburg, VA, United States, Robert B. Gramacy, Mickael Binois, Stefan Wild

Surrogate modeling of computer experiments via local models, which induce sparsity by only considering short range interactions, can tackle huge analyses of complicated input-output relationships. However, narrowing focus to local scale means that global trends must be relearned over and over again. We first demonstrate how to use Gaussian processes to efficiently perform a global sensitivity analysis on an expensive black box simulator. We next propose a framework for incorporating information from this global sensitivity analysis into the surrogate model as an input rotation and rescaling preprocessing step. We further discuss applications to derivative free optimization. Numerical experiments on observational data and benchmark test functions provide empirical validation.

2 - Information Density in Simulation Experiments

Xuefei Lu, University of Edinburgh Business School, Edinburgh, United Kingdom
Xuefei Lu, SKEMA Business School, Paris, France, Emanuele Borgonovo, Gordon B. Hazen, Elmar Plischke

In this work, we discuss the notation and graphical representation of information density in simulation experiments. The proposed tool complements uncertainty quantification revealing the region of the support of an input where such input becomes important. We formulate information density in such a way that the definition remains well-posed for any sensitivity measure defined as the expected separation between a marginal and a conditional distribution. We discuss a one-sample estimation strategy that keeps the computational burden under control for individual as well as joint analysis. The method is applied to the study of an epidemic model developed for risk management within the COVID-19 pandemic.

3 - Cluster Sampling for Morris Method Made Easy

Xi Chen, Virginia Tech, Blacksburg, VA, 24061-1019, United States, Wen Shi

We provide a thorough investigation of the cluster sampling scheme for Morris' elementary effects method (MM). We first study the sampling mechanism underpinning MM and unveil its nature as a two-level nested sampling process. This understanding sets up a foundation for tackling two important aspects of cluster sampling for MM: budget allocation and sampling plan. We further tackle the budget allocation problem for cluster sampling under the analysis of variance framework and devise an efficient cluster sampling algorithm with two variants to achieve enhanced statistical properties. The numerical evaluations demonstrate the superiority of the proposed cluster sampling algorithm and the budget allocations derived to existing cluster and non-cluster sampling schemes.

4 - Fast Factor Screening in Stochastic Simulation: Sequential Bifurcation and Multiarmed Bandit Combined

Wen Shi, Central South University, Changsha, China, Xi Chen, Kun Zhang

Sequential bifurcation (SB) is considered the most e cient and e ective screening method when some assumptions apply. In this paper, we propose a new fixed-budget SB (FSB) for stochastic simulation-based factor screening. FSB integrates (i) a thresholding arm identification procedure attributed to multi-armed bandit of reinforcement learning within a SB stage, and (ii) an adaptive budget partition strategy across SB stages. FSB enables simulation users to achieve high statistical power for the whole screening procedure with a given simulation budget prespecified. Numerical evaluations demonstrate the computational and statistical superiority of FSB.

5 - Identifying Influential Factors in Online Complaint-Recall Process Via Simulation

Xiang Xie, Central South University, Changsha, China, Wen Shi, Xi Chen

Despite product recalls increase significantly and defect complaints become the main source of recalls, how complaints evolve into recalls, what factors and in what ways the factors affect the evolvement process, are still an unexplored research question. Our study addresses the research question by considering the complaint-recall process as a complex multi-party interaction system and developing an empirically informed agent-based simulation model, which serves as a testbed to examine the impact of complaints on process and the factors affecting the recall performance significantly. To do so, we extend the nested Morris elementary effect-based method to setting of multiple outputs in the stochastic simulation in order of computational efficiency. The empirical results show that the proposed model framework can achieve desired recall performance.

■ VSA51

Virtual Room 51

Telecommunications and Network Analytics 1

Sponsored: Telecommunications and Network Analytics

Sponsored Session

Chair: Austin Buchanan, Oklahoma State University, Oklahoma State University, Stillwater, OK, 74078-5017, United States

1 - Heuristics for the Budget-Constrained Immobile Server Problem

Adam Quentin Colley, Southern Methodist University, 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 - Predicting Wireless Signal Penetration using Deep Learning

Abdullah Konak, Penn State Berks, Reading, PA, 19610-6009, United States

Normal 0 false false false EN-US X-NONE X-NONE MicrosoftInternetExplorer4 /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-pagination:widow-orphan; font-size:10.0pt; font-family:"Times New Roman",serif;} In this research, we present the use of Deep Learning Networks, in particular convolutional neural networks, to estimate signal strengths in wireless networks and compare the performance of alternative approaches. The proposed approach can be used for creating an accurate wireless coverage map from signal measurements taken rather sparsely, reducing the cost of data sampling.

3 - 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.

■ VSA52

Virtual Room 52

Simulation Analytics

Sponsored: Simulation Society

Sponsored Session

Chair: Enlu Zhou, Georgia Institute of Technology, Atlanta, GA, 30318, United States

1 - Generative Metamodeling

Jeff Hong, Fudan University, Shanghai, 200433, China, Yanxi Hou, Xiaowei Zhang

Stochastic simulation models that capture the dynamics of complex systems are often too slow for real-time decision makings. Metamodeling techniques are often used to learn the relationship between the summary statistics, e.g., mean or quantile, of the outputs and the inputs, so that they can be used in real time. However, this requires prior knowledge on what summary statistics to use and is not flexible for many practical problems. In this paper we propose a new metamodeling idea, called generative metamodeling. The goal is to create a metamodel that generates random outputs that resemble to those of real simulation outputs once the inputs are given. We also propose a quantile-regression based method for generative metamodeling and study its asymptotic behaviors.

2 - Simulation Analytics Enabled Digital Twin
Loo Hay Lee, National University of Singapore, Singapore, 119260, Singapore, Ek Peng Chew, Haobin Li, Xiao Jin

Most real-time decision problems in complex systems can be better addressed with a good understanding of the dynamics of the system. To achieve an online analysis based on system dynamics, we propose a framework named "Simulation Analytics" that integrates Simulation, Optimization, and Machine learning to provide real-time decision-making support. It simulates into the future of the system and uses that simulated information to synthesize an on-call model to fast deliver a decision that can lead us to the optimal future.

3 - Analysis of Convergence Rates for Optimal Computing Budget Allocation Algorithms
Yanwen Li, City University of Hong Kong, Siyang Gao

In this research, we focus on a well-known ranking and selection (R&S) framework, called optimal computing budget allocation (OCBA). We consider two OCBA algorithms with Gaussian samples and known variance for samples of each alternative design, and analyze their convergence rates with respect to different performance measures. We first demonstrate that the two OCBA algorithms achieve an optimal convergence rate in the correct selection of the best design. It fills the gap of convergence analysis for the OCBA algorithms. In addition, we show that the OCBA-type algorithms with minor modifications can asymptotically achieve an optimal convergence rate of cumulative regret, an objective widely studied in the field of multi-armed bandits. It enriches the OCBA framework and provides good insights into wider applications of efficient OCBA algorithms.

4 - Asymptotically Optimal Sampling Policy for Selecting Top-m Alternatives
Gongbo Zhang, Guanghua School of Management, Peking University, Beijing, China, Yijie Peng, Jianghua Zhang, Enlu Zhou

We consider selecting the top-m alternatives from a finite number of alternatives via Monte Carlo simulation. The large deviations rate of the probability of false selection for top-m alternatives has been rigourously defined. Under a Bayesian framework, we formulate the sampling decision as a stochastic dynamic programming problem and develop a sequential sampling policy that maximizes a value function approximation one-step look ahead. The proposed sampling policy is proved to be consistent and can achieve the asymptotically optimal sampling ratio that optimizes the large deviations rate. Numerical experiments demonstrate superiority of proposed sampling procedure over existing ones.

5 - A Bayesian Approach to Online Simulation Optimization With Streaming Input Data
Enlu Zhou, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Tianyi Liu, Yifan Lin

We consider simulation optimization under input uncertainty, where the unknown input parameter is estimated from streaming data arriving in batches over time. Moreover, data may depend on the decision of the time when they are generated. We take an online approach to jointly estimate the input parameter via Bayesian posterior distribution and update the decision by applying stochastic gradient descent (SGD) on the Bayesian average of the objective function. We show the convergence of our approach for both casesof decision-independent and decision-dependent input data. Our consistency result of Bayesian posterior distribution with decision-dependent data might be of independent interest to Bayesian estimation.

■ VSA53

Virtual Room 53

Social Media and Online Platforms

Sponsored: Social Media Analytics

Sponsored 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

Interactive social media campaigns, which ask consumers to create user-generated contents on behalf of a brand, have been a popular social media marketing strategy. In this work, we examine how the two common incentives (social cause; monetary rewards) influence engagement in these campaigns. Based on the self-determination theory, we propose that incorporating social cause or monetary rewards in a campaign will increase engagement, but adding both will be counter-productive due to the crowding-out of the conflicting motivations. Results from two laboratory experiments confirm our hypotheses. Our research provides insights on engagement in social media campaigns and content generation.

2 - The Impact Of Interactive Content On User Engagement In Live-streaming Videos
Gunwoong Lee, Korea University, Seoul, Korea, Republic of, Mingi Song, Jeongmin Kim, Jaebong Son

Unlike conventional video formats, live-streaming videos have enabled content creators to closely interact with content viewers and allowed the viewers to actively participate in (co-)creating content with creators. In line with this, the research aims to investigate how interactive content made by video creators influences the different levels of user engagement in live-streaming videos. Live-streaming videos and their live-chat records were collected from a leading video-sharing site for our empirical analyses. The research empirically substantiates that interactive video content by creators has a significant influence on high user engagement.

3 - Does Informative Content Indeed Matter in Online Review Videos?
Gunwoong Lee, Korea University, Seoul, Korea, Republic of, Heejin Joo, Alex Jiyoung Kim, Taekyung Kim

Online review videos are currently playing a pivotal role in guiding consumer decisions under high uncertainty about products and services, and generating considerable value to both viewers and content creators. With the importance of review videos, this study investigates how distinct formats in presenting product review content are differently associated with user engagement in product review videos. The research empirically substantiates the importance of matches between product types and review video formats in stimulating high user engagement.

4 - The Impact of Physical Attractiveness on Donation and Sharing in Medical Crowdfunding: A Large-scale Randomized Field Experiment
Yun Young Hur, Georgia Tech, 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.

■ VSA54

Virtual Room 54

Logistics Models for Disaster Response and Public Health Emergencies

Sponsored: Public Sector OR

Sponsored Session

Chair: Weijia Jing,, Northeastern University, Boston, MA, 02136-3830, United States

Co-Chair: Ozlem Ergun, Northeastern University, Boston, MA, 2115, United States

1 - Optimal Depot Locations for Humanitarian Logistics Service Providers Using Robust Optimization
Joris Wagenaar, Tilburg University, Tilburg, 3026 HG, Netherlands, Valentijn Stienen

We determine depot locations for humanitarian logistics service providers, while incorporating uncertainty in the location and scale of future disasters. We develop a practical, data-driven, approach that efficiently computes results regarding the number of depots and the locations of depots. Among other things, we show that incorporating uncertainty plays a crucial role when deciding upon these choices. For instance, this could significantly reduce the uncertainty in future costs, which enhances the decision-making regarding depot locations.

2 - Data-driven Workload Prediction And Resource Planning For COVID-19 Preparedness
Hang Wang, Purdue University, West Lafayette, IN, United States, Pengyi Shi, Jonathan Eugene Helm

Our research team aims to help hospitals in Indiana make quick adjustments and design strategies to meet the anticipated demand for resources during the disruptive pandemic of COVID-19. Based on sophisticated analyses of hospital data, we designed and fine-tuned a brute-force search algorithm that uses learned patient discharge rates to predict daily discharge and census. To further improve prediction accuracy, we developed multiple advanced machine learning models capable of making discharge and census predictions from both the individual and hospital level. So far, we've found that census prediction based on probability distributions predicted by neural networks are quite accurate for big hospitals.

3 - 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.

4 - Cost-effectively Responding to Forecastable and Unforecastable Food Aid Needs For USAID Food for Peace Program Operations — — A Supply Chain Optimization Tool

Lluvia (Weijia) Jing, Northeastern University, Boston, MA, 02136-3830, United States, Ozlem Ergun, Keziban Rukiye Tasci, Stephen A. Vosti

Millions of tons of food aid are distributed each year by the U.S. Agency for International Development's (USAID) Bureau for Humanitarian Assistance (BHA) and the legacy Office of Food for Peace (FFP). Yet, needs always exceed the food aid resources available to meet them. We developed a supply chain optimization tool to assess the range of potential efficiency and effectiveness gains associated with alternative investments in and management of the food aid supply chain, in terms of procurement, warehouse location, prepositioning, and shipping decisions. The tool addresses, separately and jointly, forecastable demand and unforecastable sudden-onset demand, estimates the costs of alternative policy choices in responding to demand, as well as implications for on-time delivery of food aid products.

5 - A Post-disaster Assignment and Scheduling Problem for Chronic Dialysis Services

Cem Deniz Caglar Bozkir, Ozyegin University, Istanbul, Turkey, Burcu Balcik, Evrim D. Gunes, Serhan Tuglular

Chronic dialysis patients must visit health care facilities (hospitals, private dialysis centers) to receive hemodialysis treatments regularly. After a severe disaster, there might not be sufficient capacity to provide regular dialysis services to all the patients in the system. We focus on a post-disaster health care planning problem, which assigns chronic dialysis patients to the available functioning facilities and schedules their sessions by considering different treatment options and accessibility of facilities. We develop an integer programming model and alternative solution methods. We present a case study to illustrate our approach.

6 - Inference of Poor-Quality Products in Pharmaceutical Supply Chains

Eugene Wickett, Northwestern University, Evanston, IL, 60208, United States, Matthew Plumlee, Karen Smilowitz

Substandard and falsified pharmaceuticals constitute at least 10% of supplies in low- and middle-income countries, driving significant levels of mortality and morbidity from otherwise preventable causes. Identification of the source of these products within a supply chain is a non-trivial problem. We propose a Bayesian inference model integrating supply chain and testing information that can augment regulatory decisions in low-resource settings. We then explore the effectiveness of this model using simulations of the private-sector pharmaceutical system of Liberia.

■ VSA55

Virtual Room 55

Analytics for Policing and Urban Public Service Operations

Committee Choice: Public Sector OR

Committee Choice Session

Chair: He Wang, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States

Co-Chair: Yao Xie, Georgia Institute of Technology, Atlanta, GA, 30327-3131, 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 - Reinforcement Learning For Fair Police Dispatch

Alexander Bukharin, Georgia Tech, Atlanta, GA, United States

We propose a reinforcement learning framework to determine the optimal dispatch policy for policing that takes into account proper and fair patrol coverage. Integrating results from patrol car GPS trajectory data provided by the Atlanta Police Department, we develop simulations modelling a real-world crime and policing environment. An agent treating this simulation as a Markov decision process will learn how to best dispatch individual patrollers to incidents. We will use a cross-entropy regularizer weighted by population and census demographics to prevent unfair, unbalanced policing that favors certain demographics. Maximizing the coverage of patrollers allows for faster response than greedy dispatch of the nearest car.

3 - Designing A General Framework For Solving School Bus Routing Problems

Min Fei, Northwestern University, Evanston, IL, United States, Karen Smilowitz, Sebastien Martin

School bus routing is a crucial challenge faced by many school districts. While advanced algorithms exist in the literature, they can be difficult for districts to implement and commercial software can yield poor solutions. Further, bus transportation impacts many aspects of education, so the "optimal" solution is often hard to define. In this work, we aim to develop a simple framework for optimizing transportation problems, starting from data analysis to optimization via visualization. We'll make use of well-developed tools such as Google OR-Tools, which can already provide near-optimal solutions. Specifically, we provide user-friendly visualizations to help decision maker understand their overall system and solutions, presenting results from a collaboration with Denver Public Schools as a case study.

4 - 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.

■ VSA56

Virtual Room 56

OR/MS in Industry Practice - I

Informs Special Session: Informs Section on Practice

Informs Special Session Session

Chair: Daniela Aguilera, AEO Inc., Pittsburgh, PA, United States

1 - 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

2 - 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.

3 - 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.

■ VSA57

Virtual Room 57

AAS Best Student Presentation Competition (1)

Sponsored: Aviation Applications

Sponsored Session

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

1 - 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.

2 - Multi-Objective, Multi-Stakeholder Airport Slot Scheduling Considering Expected Delays

Fotis A. Katsigiannis, Lancaster University, Lancaster, United Kingdom, Konstantinos G. Zografos

We present a multi-objective, multi-stakeholder decision making framework for airport slot scheduling decisions. The framework generates the complete set of non-dominated schedules for any triplet of linear slot scheduling objectives. To deal with the decision-making complexity arising from the large number of efficient schedules, we introduce a subtractive clustering algorithm to select a set of representative high-quality schedules. We estimate the expected delays associated with each representative schedule and we incorporate stakeholders' preferences to select the most preferable airport schedule using schedule displacement and operational delay metrics.

3 - Short Term Airport Throughput Prediction of Nationwide Air Traffic Network With Graph Attention Recurrent Neural Network

Xinting Zhu, City University of Hong Kong, Hong Kong, China, Lishuai Li

With growing air traffic demand and constrained resources, accurately predicting airport throughput is essential in air traffic management. To better capture the complex spatiotemporal dynamics of highly interacted air traffic systems, we propose a novel deep learning framework graph attention recurrent neural network to predict the short term nationwide airport throughput. Experiments are conducted with air traffic data collected from July to September 2017 involving 65 airports in China. Results show that our proposed model outperforms other reference methods in prediction accuracy, especially for busy airports. The spatial interpretability of the proposed model is further analyzed.

4 - 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, Mark M. Hansen, National Center of Excellence for Aviation Operations Research, Berkeley, CA, United States

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.

■ VSA58

Virtual Room 58

Election Logistics

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Dima Nazzal, ISyE Georgia Tech, Atlanta, GA, 30332-0205, United States

1 - Performance Management of the Voting Process from a System Perspective

Thibaut Cerabona, IMT Mines Albi, Albi, France, Nafe Moradkhani, Sandro Zangiacomi, Frederick Benaben, Benoit Montreuil, Ali Vatankhah Barenji, Dima Nazzal

Voting centers play a key role in the American voting system. Some recent elections (2020 primary, 2020 presidential) have clearly shown some disruption in the performance of these polling sites with queues up to four hours, inadequate number of resources, etc. Voting centers are complex systems evolving in a risky environment (cyberattacks, misinformation, breakdown of devices, voters mistakes), reinforced by the Covid-19 crisis. The research will demonstrate our work in using simulation modeling and performance visualization in intuitive dashboards, to anticipate and monitor the performance trajectory of voting centers along multiple criteria, and thus manage the election process from a system perspective.

2 - 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.

3 - Agent-Oriented Discrete-Events Election System Simulator

Ali Vatankhah Barenji, Sr Research Scientist, Georgia Technology, Atlanta, GA, United States, Benoit Montreuil, Sevda Babalou, Dima Nazzal, Thibaut Cerabona, Frederick Benaben

Managing the logistics of an election, from delivering voting machines to the right locations at the right time to ensuring that waiting lines do not grow too long requires complex mathematical models. These complexities grow with accounting for social distancing and the layout configuration in hundreds of polling locations. In such a context, we propose a comprehensive agent-oriented discrete-events simulation platform to simulate the logistics of election selections with consideration of resource allocation, polling location management and social distancing problems. We depict the application of the simulator in Georgia's Fulton County, USA, with 238 polling centers, using public available data, to guide decision-makers in allocating resources and laying out the centers to minimize waiting times excesses and pandemic contamination, and maximizing fairness.

■ VSA59

Virtual Room 59

Freight Transportation I

Sponsored: TSL/Freight Transportation

Sponsored Session

Chair: Zhijie Sasha Dong, Texas State University, San Marcos, TX, 78666-4684, United States

1 - Learning Driver Selection Behavior In Transportation Matching Problems

Rosemonde Ausseil, Rensselaer Polytechnic Institute, Troy, NY, United States, Jennifer A. Pazour, Marlin Wolf Ulmer

In crowdsourced transportation matching, the literature-based practice is to assume drivers' maximum detour values are known, such that drivers will select any request below their detour threshold. We model and solve a dynamic matching problem in which the platform learns the drivers' unknown detour thresholds via their fulfillment responses to offered requests.

2 - A Global-optimization Approach to Predicting Changes in Arctic Cargo Vessel Traffic

Wenjie Li, George Mason University, Fairfax, VA, United States, Elise Miller-Hooks

A risk-based, multi-objective optimization methodology is presented for predicting future Arctic vessel traffic under future climate and ice projections. A global cargo routing model that accounts for changing risk along shipping routes is formulated and a stochastic optimization solution methodology is presented for

its solution. The model is applied on a global maritime, container and bulk cargo network with over 160 ports.

3 - 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.

■ VSA60

Virtual Room 60

Modeling and Measuring Insider Threat

Committee Choice: Military and Security

Committee Choice Session

Chair: Paul L Goethals, United States Military Academy, West Point, NY, 10996-1606, United States

1 - Mitigating Behavior of Poll Workers as an Insider Threat to Elections Security
Natalie M. Scala, Towson University, Towson, MD, 21252-0001, United States, Josh Dehlinger, Yeabsira Mezgebe

Poll workers are on the first line of defense in elections security and are trusted insiders to the process. This research assesses personal computer security behaviors for poll workers using the Security Behavior Intentions Scale (SeBIS) survey and a sample of 2,213 poll workers from 13 states. An information theory model is developed to examine potential weaknesses in security behaviors and identify security practices to improve with poll workers. Outcomes from this research aid in identifying a poll worker who may pose an insider threat and mitigating unintentional consequence.

2 - Neural Network Detection for Insider Threats
Brooke Allen, United States Military Academy, West Point, NY, 10996, United States

Insider threats present one of the largest threats to defense capabilities and readiness, but their cost is difficult to value and frequently goes undiscussed. This presentation will address several operations research applications to the prevention, detection, and mitigation of insider threats within the Army, informed by the cadet's work with the Army G-3/5/7 at the Pentagon.

3 - Optimization of the DoD Insider Threat Program
Pier Bos, United States Military Academy, West Point, NY, 10996, United States

Absstract not available at this time

■ VSA61

Virtual Room 61

COVID-19 and U.S. Aviation: What Changed and What Did Not?

Sponsored: Aviation Applications

Sponsored Session

Chair: Arnold I Barnett, Massachusetts Institute of Technology, Cambridge, MA, 02139-9910, United States

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 - Pandemic and Post-pandemic Airport Traffic Forecasts for the San Francisco Bay Area
Kaijing Ding, University of California-Berkeley, Berkeley, CA, United States, Mark M. Hansen

The COVID-19 pandemic caused airport passenger traffic to plummet, with concomitant impacts on airport operations and revenue streams. There is a need for forecasting models that can predict the pace, magnitude, and composition of passenger traffic recovery. We report on an ongoing effort to develop such models for the San Francisco Bay Area.

3 - Airport Slot Allocation during the COVID-19 Pandemic
Amedeo R. Odoni, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States, Bazyli Szymanski

We review the impact of the pandemic on the airport slot allocation process at Level 3 ("coordinated") airports during the Summer 2020, Winter 2020/21, Summer 2021 and Winter 2021/22 scheduling seasons. "Use-it-or-lose-it" requirements were waived everywhere, but different regulators used different policies, shaping airline flight cancellation strategies in different ways. The policies adopted generally increased uncertainty for airport operators and passengers and failed to address persistent problems with the archaic rules currently in use.

4 - Something Toxic in the Air? Covid-19 Transmission Risk on US Domestic Jet Flights
Arnold I. Barnett, Massachusetts Institute of Technology, Cambridge, MA, 02139-9910, United States, Keith I. Fleming

Using various data sets, we estimate the chance that a US domestic jet passenger over 6/20-2/21 would contract Covid-19 in flight. Further taking into account follow-on infections caused by passengers infected on board , we estimate the mortality risk tied to in-flight transmissions of COVID-19.

■ VSA63

Virtual Room 63

Computational Optimal Control

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Christian Kirches

1 - Primal-dual Newton Proximal Method for Convex Quadratic Programs, and Beyond
Alberto De Marchi, Universität der Bundeswehr München, Munich, Germany

We introduce QPDO, a primal-dual method for convex quadratic programs which weaves together the proximal point algorithm and a damped semismooth Newton's method. The outer proximal regularization yields a numerically stable method, and we interpret the proximal operator as the unconstrained minimization of the primal-dual proximal augmented Lagrangian function. This allows the inner Newton's scheme to exploit sparse symmetric linear solvers and multi-rank factorization updates. The linear systems are always solvable independently from the problem data and exact line-search can be performed. QPDO handles degenerate problems, provides a mechanism for infeasibility detection, and exploits warm starting, while requiring only convexity. We report on numerical results against state-of-the-art solvers and propose extensions for general nonlinear programming.

2 - A Sequential Homotopy Method for Mathematical Programming Problems
Andreas Potschka, Prof. Dr., Clausthal University of Technology, Clausthal-Zellerfeld, Germany

We propose a sequential homotopy method for the solution of mathematical programming problems in Hilbert spaces under the Guignard constraint qualification. The method is equivalent to projected backward Euler timestepping on a projected gradient/antigradient flow of the augmented Lagrangian. The projected backward Euler equations can be interpreted as the necessary optimality conditions of a primal-dual proximal regularization of the original problem. The regularized problems are always feasible, satisfy a strong constraint qualification guaranteeing uniqueness of Lagrange multipliers, yield unique primal solutions provided that the stepsize is sufficiently small, and can be solved by a continuation in the stepsize. We demonstrate its efficiency for challenging PDE optimization problems using a semismooth Newton method.

3 - Mixed-Integer Optimal Control for Multimodal Chromatography

Dominik H. Cebulla, TU Braunschweig, Braunschweig, Germany, Christian Kirches, Andreas Potschka

Multimodal chromatography is a powerful tool in the downstream processing of biopharmaceuticals. In this talk, we employ a model-based approach to optimize this process with respect to different economic objectives. To this end, we present a nonlinear partial differential equation model for multimodal chromatography, incorporating process controls such as salt concentration and pH. The latter is treated as discrete to account for real-world technical limitations. We describe a numerical solution procedure for the resulting mixed-integer optimization problems and conclude our talk with numerical results.

4 - Solving Discrete Quantum Optimal Control Problems

Sven Leyffer, Argonne National Laboratory, Lemont, IL, 60439-4801, United States, Xinju Fei, Siqian Shen, Jeffrey Larson

We present a family of discrete optimal control problems that are motivated by quantum pulse optimization to design quantum gates. We solve the continuous relaxation using the gradient ascent pulse engineering (GRAPE) algorithm, and apply combinatorial integral approximation (CIA) techniques to obtain discrete optimal controls. To add constraints and more complex regularization terms, we develop an alternating direction of multiplier (ADMM) method. We show empirically that ADMM improves the rounding results of CIA compared to GRAPE.

■ VSA64

Virtual Room 64

Optimization Modeling Software

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Timo Berthold, FICO, San Jose, CA, 92130, United States

Co-Chair: Susanne Heipcke, FICO, Birmingham, B37 7GN, United Kingdom

1 - New Modeling and Programming Features in Xpress Mosel

Susanne Heipcke, FICO, Birmingham, B37 7GN, United Kingdom

We present examples of recent additions to FICO Xpress Mosel:

(1) Mathematical modeling: MIP constructs to formulate absolute/minimum/maximum value expressions, piecewise linear and logical relations, handled directly by the Xpress MIP solver. (2) Data handling: extensions to data input for text and database formats, including dataframe-style CSV reading and writing. (3) Programming: support of union types (container holding an object of one of a predefined set of types); use of date, time, or text types as index sets by declaring them as constant. (4) Distributed computing: cloning of submodels and sharing data between cloned models; new coordination mechanisms through remote use of memory pipes. (5) Documentation: extensions to the moseldoc tool for large Mosel projects and Insight apps.

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 - Best Practices for Using Mixed Integer Programming to Optimize Computer Systems

Pawel Lichocki, Google Research, Mountain View, CA, United States

Mixed-integer programming (MIP) is a powerful method of solving various combinatorial optimization problems. However, building an application that employs MIP entails many challenges. The MIP models must i) faithfully represent the reality of the problem, ii) remain "solvable" by the available solvers, and iii) be integrated with the production system in a clear and robust way. Here, we discuss each of these aspects on examples distilled from MIP applications at Google. In particular, we describe efficient MIP formulations for typical computer systems' feature requirements like fault tolerance or churn control, and we provide practical hints on how to encapsulate and verify them within a larger production environment.

4 - GAMS/Engine - A New System for Solving Models on Centralized Compute Resources

Steven P. Dirkse, GAMS 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.

■ VSA65

Virtual Room 65

Optimization for and with machine learning

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Karen Aardal, Delft University of Technology, Delft, 2628 CD, Netherlands

1 - Learning to Branch for Mixed Integer Programming

Lara V. Scavuzzo, Delft Institute of Technology, Delft, 2600 AA, Netherlands

Mixed Integer Programming is a powerful mathematical modelling tool for optimisation problems, with numerous applications in real-world scenarios. In spite of the NP-hardness of Mixed Integer Programs (MIPs), our capabilities to tackle such problems have dramatically increased as a result of advancements in the algorithms that solve them. However, in practice, solving large-scale MIPs to optimality remains challenging. In this talk, we will discuss the potential of Machine Learning (ML) tools to augment algorithms for Mixed Integer Programming. In particular, how ML can support decision-making for critical tasks within the solver, such as choosing a branching candidate.

2 - Enhanced Partitioning in Two-stage Robust Optimization Via (semi-)supervised Learning

Esther Julien, Delft Institute of Technology, Delft, 2600 AA, Netherlands

Robust optimization is a field in optimization theory where problems affected by uncertainty are solved for the worst-case scenario. This solution is robust to all scenarios that can occur. For two-stage robust optimization problems we can adapt the decisions to the scenarios to obtain better solutions. Such problems can be approximately solved with the K-adaptability algorithm, where we adapt the decisions in K different ways. Here, the uncertainty set, a set consisting of all scenarios, is partitioned in K subsets. For each of these subsets a corresponding decision is solved. How an uncertainty set is partitioned greatly depends on the problem we are solving. In this talk, we will discuss how to accelerate this algorithm by learning the structure of the partition. We will consider a supervised and a semi-supervised approach.

3 - Can ML Help in Solving Cargo Capacity Management Booking Control Problems?

Andrea Lodi, Polytechnique de Montréal, Cp 6079, Montreal, QC, H3C 3A7, Canada, Justin Dumouchelle, Emma Frejinger

Revenue management is important for carriers (e.g., airlines). We focus on cargo capacity management and, more precisely, we focus on the problem of controlling booking accept/reject decisions: Given a limited capacity, accept a booking request or reject it to reserve capacity for potential future, higher revenue, bookings. We can formulate the problem as a finite-horizon stochastic dynamic program. The cost of fulfilling the accepted bookings, incurred at the end of the horizon, depends on the packing and routing of the cargo. This is a computationally challenging aspect involving solutions of bin packing or vehicle routing. In this work, we propose to predict the solution costs to these discrete optimization problems using supervised learning. In turn, we use the predictions in an approximate dynamic programming algorithm to solve the booking control problem.

4 - A Unified Framework for Clustering and Regression Problems Via Mixed-integer Linear Programming
John Alasdair Warwicker, PhD, Karlsruher Institut fur Technologie, Karlsruhe, Germany

Clustering and regression are two of the most important problems in data analysis and machine learning. Recently, mixed-integer linear programs (MILPs) have been presented to solve these problems. Hence, they are solved very quickly by commercial solvers. In particular, MILPs for clusterwise linear regression (CLR) and piecewise linear regression (PLR) have appeared. We present these models in the context of a unifying MILP framework for clustering and regression problems. We present two new formulations within this framework, for ordered CLR, and for clusterwise PLR (CPLR). The CPLR model simultaneously clusters data, while modelling each cluster with a PLR function. We further discuss how outlier detection is implemented within the models, and how decomposition methods are used to find speedups in the runtime. Experiments show when each model is most effective.

■ VSA66

Virtual Room 66

Linear and Conic Programming

Sponsored: OPT/Linear and Conic Optimization

Sponsored Session

Chair: Negar Soheili, University of Illinois-Chicago, Chicago, IL, 60607, United States

1 - 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.

2 - Projection and Rescaling - The Flat Case
Negar Soheili, University of Illinois-Chicago, Chicago, IL, 60607, United States, Javier F. Pena

The projection and rescaling algorithm is a recently developed method that combines a basic procedure involving only low-cost operations with a periodic rescaling step. We propose a simple projection and rescaling algorithm that finds the most interior solutions to the pair of primal-dual polyhedral feasibility problems which is an extension of the original projection and rescaling algorithm that finds a solution to one of these problems when it's feasible. We also present extensive numerical experiments on synthetic problem instances with varied levels of conditioning for both polyhedral and second-order cone feasibility problems. Our computational experiments provide promising evidence for the effectiveness of the projection and rescaling algorithm.

3 - On Error Bounds for Conic Linear Programs
Bruno Figueira Lourenço, The Institute of Statistical Mathematics, Tokyo, Japan

In this talk we present some recent developments on error bounds for conic linear problems via the theory of amenable cones and facial residual functions. We will discuss our recent findings on those objects and present new error bounds for symmetric cones and for the exponential cone. Time allowing, we will also discuss some algorithmic consequences of our results. This presentation is based on the results developed on following arxiv preprints:2010.16391, 2008.12968 and 1712.06221. Co-authors: Scott Lindstrom (Curtin University), Tianxiang Liu (Tokyo Institute of Technology), Ting Kei Pong (Hong Kong Poly U.)

4 - Sums Of Separable and Quadratic Polynomials
Cemil Dibek, Princeton University, Princeton, NJ, 08540-6541, United States, Amir Ali Ahmadi, Georgina Hall

While optimizing over the set of nonnegative polynomials is generally intractable, it is possible to use sum of squares (sos) polynomials as surrogates and solve an approximation using semidefinite programming. It is thus important to understand the relationship between nonnegative and sos polynomials under additional structure. We study separable plus quadratic (SPQ) polynomials. We provide a characterization of the gap between nonnegative and sos polynomials of this structure based on the degree and dimension. We further extend our study to convex SPQ polynomials and show that convex SPQ polynomial optimization problems can be solved by small semidefinite programs. Finally, we present applications of SPQ polynomials to upper bounding sparsity of solutions to linear programs, polynomial regression problems in statistics, and a generalization of Newton's method.

■ VSA67

Virtual Room 67

Recent Advances in Nonconvex Optimization II

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

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

Co-Chair: Madeleine Udell, Stanford University, 350 Serra Mall, Stanford, CA, 94305, United States

1 - Three Operator Splitting With a Nonconvex Loss Function
Alp Yurtsever, Massachusetts Institute of Technology, Cambridge, MA, 2139, United States
Alp Yurtsever, Umeå University, Umeå, Sweden, Varun Mangalick, Suvrit Sra

We consider the problem of minimizing the sum of three functions, one of which is nonconvex but differentiable and the other two are convex but possibly nondifferentiable. We investigate the Three Operator Splitting method (TOS) of Davis & Yin (2017) with an aim to extend its theoretical guarantees for this nonconvex template. We prove convergence of TOS with nonasymptotic bounds on its nonstationarity and infeasibility errors. Our guarantees do not require additional smoothness assumptions on the terms comprising the objective; hence they cover instances where the nondifferentiable terms are indicator functions. We also extend our results to a stochastic setting where we have access only to an unbiased estimator of the gradient. Finally, we illustrate the effectiveness of the proposed method through numerical experiments on quadratic assignment problems.

2 - TenIPS: Inverse Propensity Sampling for Tensor Completion
Chengrun Yang, Cornell University, Ithaca, NY, 14850, United States

The recovery of missing entries in a tensor has been extensively studied, generally under the assumption that entries are missing completely at random (MCAR). However, in most practical settings, observations are missing not at random (MNAR). In this paper, we study the problem of completing a partially observed tensor with MNAR observations, without prior information about the propensities. To complete the tensor, we assume that both the original tensor and the tensor of propensities have low multilinear rank. The algorithm first estimates the propensities using a convex relaxation and then predicts missing values using a higher-order SVD approach, reweighting the observed tensor by the inverse propensities. We provide finite-sample error bounds on the resulting complete tensor. Numerical experiments demonstrate the effectiveness of our approach.

3 - 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 over specified 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.

4 - An Adaptive Sampling Sequential Quadratic Programming Method for Equality Constrained Stochastic Optimization
Albert Solomon Berahas, University of Michigan, Ann Arbor, MI, 48109, United States, Baoyu Zhou, Raghu Bollapragada

Stochastic gradient and related methods for solving stochastic optimization problems have been studied extensively in recent years. While these algorithms (and their associate convergence and complexity guarantees) can be extended in straightforward ways to problems involving simple constraints, the setting of general nonlinear constraints is not as well explored. In this work, we propose and analyze an adaptive sampling stochastic optimization method based on the sequential quadratic optimization (commonly known as SQP) paradigm. The method adaptively sets the accuracy of the gradient approximation employed as the optimization progresses, has sound theoretical properties, and is efficient in practice. We discuss advantages and disadvantages of our proposed techniques.

■ VSA68

Virtual Room 68

Derivative Free Optimization Algorithms and Applications

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Liyuan Cao, Lehigh University, Bethlehem, PA, 18015-3704, United States

1 - A Derivative-free Algorithm for Least-squares that Exploits Prior Simulation Outputs

Shima Dezfulian, Northwestern University, Evanston, IL, United States, Frank E. Curtis, Andreas Waechter

We propose a model-based algorithm for solving black-box least-square problems when the aim is to find parameters in an expensive simulation procedure that best match known observations. We assume that we have available to us outputs from prior simulations that we will exploit to reduce the number of simulations required by our algorithm. Using this prior information, we approximate simulation outputs when possible in order to build local models of the objective function and test the acceptability of trial points. We discuss the convergence properties of our algorithm and provide the results of numerical experiments.

2 - VSBBON — Line Search in Noisy Black Box Optimization

Morteza Kimiaei, University of Vienna, Vienna, Austria

A new randomized solver for noisy unconstrained black-box optimization, called VSBBON, is discussed. Complexity bounds are investigated in the presence of noise for nonconvex, convex, and strongly convex functions. Two effective ingredients of VSBBON are an improved derivative-free line search algorithm with many heuristic enhancements and quadratic models in adaptively determined subspaces. Numerical results are given showing that VSBBON is robust and efficient.

3 - 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.

4 - On The Numerical Performance Of Derivative-free Optimization Methods Based On Finite-difference Approximations

Melody Qiming Xuan, Northwestern University, Evanston, IL, United States, Hao-Jun Michael Shi, Figen Oztoprak, Jorge Nocedal

The finite-difference approach has been largely dismissed in the derivative-free optimization literature as being too expensive in terms of function evaluations or impractical in the presence of noise. In this talk I will present results that investigate the finite-difference method for both noiseless and noisy settings. Our numerical experiments suggest that finite-differencing can be competitive with state-of-the-art DFO solvers on unconstrained, nonlinear least squares and constrained problems.

■ VSA69

Virtual Room 69

Stochastic First-order Methods for Constrained Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Afrooz Jalilzadeh, The University of Arizona, State College, PA, 16801-4415, 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 - Distributed Gradient Tracking Methods for Bilevel Optimization Over Networks

Farzad Yousefian, Oklahoma State University, Stillwater, OK, 74074, United States

Motivated by applications in image processing and machine learning, we consider a class of optimization problems over networks where the agents cooperatively seek among the optimal solutions with respect to a primary objective, one that minimizes a secondary objective. We develop iteratively-regularized distributed gradient tracking methods for addressing this class of problems in both deterministic and stochastic cases. We derive new convergence rates for suboptimality, infeasibility, and consensus violation. These results appear to be new in addressing this class of bilevel problems in the distributed regime. Further, they improve the known rate results in the centralized regime. Preliminary numerical results for image deblurring, a distributed SVM model, and a sensor network are presented.

3 - Stochastic Compositional Optimization in the Absence Of Lipschitz Continuous Gradient

Sam Davanloo Tajbakhsh, The Ohio State University, Columbus, OH, 43210, United States

We consider the optimization of nested composition of two functions where at least the inner function involves an expectation. Obtaining unbiased estimates of the gradient of the composition is complicated in nested structures. Stochastic compositional optimization has gained popularity mainly due to applications in reinforcement learning and meta learning. In the absence of the Lipschitz continuity of the gradient of the inner and/or outer functions, we develop stochastic algorithms to optimize the composition function. The sample complexity of the proposed algorithms to obtain first-order stationary points are investigated and will be presented.

4 - A Stochastic Variance-reduced Accelerated Primal-dual Method 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.

■ VSA70

Virtual Room 70

Applications of Reinforcement Learning to Operations Management

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Henri Dehaybe, Universite Catholique de Louvain, Gembloux, 5030, Belgium

1 - 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.

2 - Reward Shaping to Improve the Performance of Deep Reinforcement Learning in Inventory Management
Bram J. De Moor, KU Leuven, Leuven, Belgium, Robert Boute, Joren Gijsbrechts

Deep reinforcement learning (DRL) has proven to be an effective, general-purpose technology to develop `good' replenishment policies in inventory management. Yet, despite formidable computational effort, DRL cannot always beat the state-of-the-art heuristics for stylized problems. We show how transfer learning from existing, well-performing heuristics may stabilize the training process and improve the performance of DRL in inventory control. Specifically, we apply potential-based reward shaping to improve the performance of a deep Q-network (DQN) algorithm to manage inventory of perishable goods. Applying our approach using existing replenishment policies may not only reduce firms' replenishment costs, the increased stability may also help to gain trust in the policies obtained by black box DRL algorithms.

3 - Analyzing the Usefulness of Deep Reinforcement Learning in a Humanitarian Setting: Determining Lateral Transshipment Policies for a Zambian Health Supply Chain
Nathalie Vanvuchelen, KU Leuven, Leuven, Belgium, Kim De Boeck, Robert Boute

Deep reinforcement learning is a promising solution method that can model a variety of complex problems without relying on restrictive assumptions or domain knowledge but at the expense of an often unstable and computationally/time expensive learning process. In this paper, we analyze whether it is useful to put effort into deep reinforcement learning methods for policy-making in humanitarian settings as resources such as time and computational power are often limited here. We deploy the deep reinforcement learning algorithm 'Proximal Policy Optimization' to determine lateral transshipment policies to improve service levels between health care facilities. We verify our methodology on a Zambian health supply chain of a malaria medicine.

4 - Approximating Multi-Level Stochastic Inventory Policies with Deep Reinforcement Learning
Henri Dehaybe, Universite Catholique de Louvain, Gembloux, 5030, Belgium

We study the use of Deep Reinforcement Learning as a novel approach to approximate the optimal policies of multi-item multi-level capacitated lot sizing problems under demand uncertainty. We use a conservative actor-critic algorithm to train a neural to predict per-item (s,S) policy parameters with respect to the state of the complete inventory system. Shared-resource capacity constraints are implicitly learned by using arbitrary projections of unfeasible production plans into the feasible space. The use of neural network estimators allows the approach to leverage their high expressive power to approximate complex policies while being able to scale to large inventory systems and long forecasts horizons. Once trained, the model is able to predict policy parameters given previously unseen demand forecasts in real time.

■ VSA71

Virtual Room 71

Stochastic Programming

Contributed Session

Chair: Ding (Aaron) Zou, Hong Kong Polytechnic University, Hong Kong

1 - Modeling Environment Dependency in Partially Observable Markov Decision Processes for Maintenance Optimization
Ragnar H. Eggertsson, Eindhoven University of Technology, Eindhoven, Netherlands, Rob Basten, Geert-Jan Van Houtum

Partially Observable Markov Decision Processes (POMDPs) are studied in the maintenance literature because they can take uncertainty of information into account. Motivated by the problem of scheduling maintenance and inspections for a heating, ventilation and air-conditioning unit in a train, we introduce an environment-dependent POMDP. Theoretical results are presented for the optimal solution of the environment-dependent POMDP. We further perform numerical experiments that lead to interesting insights.

2 - 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.

3 - A Sampling-based Branch and Cut Algorithm for Two-stage Stochastic Mixed Integer Programs
Harsha Gangammanavar, Southern Methodist University, Dallas, TX, 75275, United States, Siavash Tabrizian, Halit Uster

Stochastic mixed-integer programs are among the most challenging class of optimization problems that finds many applications in practice. In this presentation, we describe a novel sampling-based branch and cut algorithm for two-stage stochastic mixed-integer programs. In this algorithm, observations are generated within the optimization step on the fly.

4 - Designing Emergency Response Network for Rail Hazmat Shipments Under Uncertainties
Jyotirmoy Dalal, Indian Institute of Management Lucknow, Lucknow, India, Ali Vaezi, Manish Verma

Designing an emergency response network capable of providing a proper response is important to contain the adverse consequences from rail hazmat incidents. We propose a two-stage stochastic programming model to determine the location of response facilities and equipment packages to be stockpiled. We explore several trade-offs in our model, evaluate the incremental benefit of establishing (and stockpiling) additional response facilities. Our analyses highlight that the mean coverage can be improved by redistributing the equipment in the network, purchasing equipment with higher containment capacity, and making use of a disutility multiplier factor.

5 - Single Observation Adaptive Search for Two-stage Mixed-integer Stochastic Programming With Recourse
Pariyakorn Maneekul, University of Washington, Seattle, WA, United States, Zelda B. Zabinsky, Seksan Kiatsupaibul

A computational challenge in solving a two-stage stochastic Mixed-integer Program (MIP) with recourse is calculating the expected value of the second-stage MIP problem over many scenarios. Choosing the number of scenarios involves a trade-off between tractability and problem representation. We propose a hybrid method that only requires one scenario per first-stage design point by integrating the single observation search algorithm (SOSA). Since SOSA is known to converge to a global optimum with probability one, our hybrid method reduces the need for many scenarios while preserving convergence. We provide numerical examples as empirical support of applying SOSA to this class of problems.

6 - Vehicle Rebalancing in the Shared Micromobility System With Crowdsourcing Relocation Riders
Ding (Aaron) Zou, Hong Kong Polytechnic University, Hong Kong, Hong Kong

A service provider can crowdsource individual riders and/or outsource to a third-party logistics provider (3PL) to relocate vehicles. We build a time-space network and a two-stage stochastic programming model with riders' demand uncertainty. We find rider crowdsourcing more efficient than 3PL in mitigating the vehicle supply-demand mismatch. The two together further reduce the demand loss. As crowdsourcing budget grows, the two relocation means are first complements and then substitutes. Crowdsourcing relocates more vehicles under a unimodal demand pattern than a bimodal one. Last, we develop a solution algorithm that beats the commercial solver to derive solutions with the real-world data.

■ VSA72

Virtual Room 72

Passenger Rail II

Committee Choice: Railway Applications

Committee Choice Session

Chair: Jiateng Yin, Beijing Jiaotong University, Kowloon, China

1 - Rolling Stock Allocation and Timetabling for Rail Transit Network With Multiple Depots
Fan Pu, Beijing Jiaotong University, Beijing 100044, China

Rolling stock management and service timetabling are two challenging but very related issues in urban rail networks. The former is to allocate a certain fleet of trains to each depot, while the latter designs the arrival/departure times of train services according to the available trains at each depot. In this study, we develop an integer linear programming (ILP) to jointly optimize the allocation of rolling stocks and train timetables for the involved lines in an urban rail network. Considering that the problem with a large time horizon involves numerous integer variables which cannot be handled efficiently, a Benders decomposition method is introduced to decompose our ILP model (whole network) into a group of small subproblems (each line). Furthermore, numeric experiments derived from the Beijing rail transit network are conducted to validate our model and algorithm.

2 - Timetable Optimization For Minimizing Transfer Costs under Through-operation
Yi Zheng, Peking University, Beijing, 10000, China

In public passenger rail systems, passengers often need to make several transfers to reach their destination, which leads to increased travel time and safety risks. In this paper, we adopt a through-operation model, which allows trains from different lines to travel on other lines, and propose a mixed integer programming model. By adjusting trains' dispatch times and headways at the stations, the model can obtain an optimal timetable, providing the minimum dwell time for on-board passengers and minimizing the transfer waiting time for all transfer passengers. The proposed model are validated by some numerical experiments based on the operational data derived from the Beijing urban rail network.

3 - Dynamic Passenger-centric Railway Traffic Management
Yongqiu Zhu, Dr., ETH Zurich, Zurich, Switzerland

Railway traffic management refers to the monitoring and rescheduling of train services that are affected by disturbances. In practice, traffic management relies on traffic controllers who manually adjust train services and do not have any tools to consider passenger needs. Thus, minimizing train delays is their main goal for traffic management. However, train delays differ from passenger delays that also depend on other factors like the path choice of passengers. Hence, I will show a recent work on Passenger-Oriented Railway Traffic Management (PORTM), which focuses on the impact of decisions on passengers. The PORTM problem is formulated into a MILP model that integrates timetable rescheduling and passenger assignment. The model dynamically reschedules the timetable for disturbances that emerge over time aiming to minimize passengers' generalized travel times.

4 - Trains Rescheduling Method During Multi-disturbances Under a Quasi-moving Block System
Peijuan Xu, Chang'an University, Xi'an, China, Francesco Corman

It is critical to reschedule trains timely in Chinese high-speed railway system. This paper presents a rescheduling model which can deal with multi-disturbances by retiming, reordering, rerouting and train speed adaptation under a quasi-moving block system. The alternative arcs and alternative arrival/departure paths are designed in constraints to figure out the siding lines blockage. A custom-designed two-step method based on a commercial solver is applied to solve instances from Chinese high-speed networks quickly. The experimental cases with/without the siding line blockage are studied respectively. The outputs demonstrates that the proposed approach can achieve a reduction of train delays by 70% compared to the solution without reordering, and the application of resetting routes can mitigate traffic tardiness and speed up rescheduling process effectively.

5 - Train Scheduling Optimization With Virtual Coupled Vehicles for Integrated Commuter Rail and Underground Metro Network
Simin Chai, Beijing Jiaotong University, Beijing, China

With the increasing of passenger demand and the saturated operations of trains, the planning process is attracting more and more attention. In this paper, we study the integration of train scheduling and virtual coupling planning under various passenger demands for integrated commuter rail and underground metro network, where the practical train operation constraints, e.g., the number of available rolling stocks, the running time of different train composition and the entering/exiting depot operations, are considered. In order to optimize the train scheduling, we extend a job-shop scheduling model to a MINLP model. We propose an equivalent MILP formulation and develop a Benders' decomposition algorithm to improve the computational efficiency. Two sets of numerical experiments are conducted to verify the effectiveness and efficiency of our practical methods.

■ VSA74

Virtual Room 74

Bridging Between Data Science and Decision Science

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Neil Hamlett, Vectrus, Vienna, VA, 22180-7390, United States

1 - Decision-quality Framing: A Case Study in Sustainable Capital Investment
Luis Mendoza, Decision Frameworks, Dallas, TX, United States

Abstract not available at this time.

2 - High-confidence Machine Learning: A Clinical Decision-making Case Study
Erkin Otles, Verona, WI, United States

3 - Applying Metalog Distributions to Machine-learning Residual Errors in Support of Decision Analysis
Neil Hamlett, International Consulting Associates, Vienna, VA, 22180-7390, United States

Data science and decision science apply probability and statistics from opposite sides of the same epistemic coin. Influenced by classical statistics, data scientists focus on their degree of certainty. Machine-learning model scores exemplify. Decision scientists — and operation researchers — characterize the degree of uncertainty. They prefer probability distributions. The advent of metalog distributions provides a practical mechanism to bridge this gap in some circumstances. The "empirical" distributions of machine-learning model residual errors can be represented by analytic functions. In addition to more-rigorous statistical inference, decision and operations analysts obtain greater insight into the degree of residual uncertainty.

4 - The Role of Social Learning on Pricing Decisions under Impending Regime Shifts
Sreyaa Guha, IE Business School, IE University, Madrid, 28004, Spain, Matthias Seifert, Canan Ulu

We investigate the effect of social learning on pricing decisions under impending regime shifts using buyer-seller dyads. Data from four multi-period trading games suggests that social learning attenuates under/-overreaction in pricing decisions for unstable environments with precise signals regardless of the type of regime shift (Dreaded vs. Desirable). However, it does not affect under/-overreaction in probability judgments of regime shift.

■ VSA75

Virtual Room 75

Large-scale Optimization in Practice

Informs Special Session: Practice Curated Track

Informs Special Session

Chair: Cristiana L. Lara, Amazon, Seattle, WA, United States

1 - Solving Large Scale Linear Problems With Lagrangian Decomposition
Ozlem Bilginer, Amazon, Seattle, WA, United States

Various Amazon systems optimize shipment-path assignment decisions with capacitated resources. In this process, every shipment is unique, the shipments are assigned to paths, and paths have many capacity constraints. As such, these are very large scale assignment problems, not easily solvable in their canonical form. They consume a lot of memory and they take a lot of time to solve due to their single-node memory and CPU footprint. As Amazon is constantly growing, the challenge is to keep the solution time and memory under control, without compromising the solution quality. In this talk, we present an algorithm to solve these large scale linear assignment problems with Lagrangian decomposition techniques. We discuss the strategies for fast convergence, including problem reformulation and mixed use of cutting planes and subgradient updates.

2 - Joint Order Assignment and Last Mile Routing
Weihong Hu, Amazon, Seattle, WA, 30318, United States, Andrea Qualizza, Rohit Malshe

Our Order Assignment systems do not account for multi-faceted economics of last-mile deliveries, where the costs depend on all shipments being delivered on the same day in the same area by the same van. We introduce a global optimizer to bridge the existing gaps between Order Assignment and Last-Mile Routing. To ensure scalability we use a combination of Math Optimization, Local Search, Capacitated Vehicle Routing Problem solvers as well as decomposition approaches. We test the framework across diverse last-mile delivery stations and show a substantial entitlement. We demonstrate more balanced driver time and truck cube utilization as well as more clustered demand locations at each solve time.

3 - Genesys: Simulating Power Systems by Solving Millions of MIP's
André Dias, PSR

The objective of the Genesys software is to assess the operational performance and supply reliability of large-scale power systems. Detailed replication of the actual system operation is performed: Each simulation run starts with yearly planning, continues with week-ahead and day-ahead scheduling, and finishes with the actual operation for the first hour of the year. The simulation then advances to the next hour, with updated forecasts, with the long-term through short-term decision process is repeated for the year's 8760 hours.The stochastic simulation process requires the solution of more than two hundred million mixed-integer programs to simulate a real case study of the US Pacific Northwest with thousands of scenarios.

4 - Timing Optimization, Part 1: Size Reduction Techniques for Timing Aware Network Design
Jochen Koenemann, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

In this talk, we introduce Amazon's toolkit for the systematic analysis of timing aware network design optimization problems. The central task of this timing optimization tool is the solution of certain constrained, time-indexed, fixed-charge multicommodity flow problems. These problems are notoriously difficult, and their size renders their direct solution infeasible. In this first talk of a two-part series, we present two techniques that exploit the combinatorial problem structure in order to reduce the size of the basic mixed integer model: model condensation, and pruning.

5 - Timing Optimization, Part 2: Algorithmic Strategies to Efficiently Solve Large-scale Timing-aware Network Design Problem
Cristiana L. Lara, Amazon, Seattle, WA, United States

Model condensation as introduced in the previous talk is insufficient to solve our Timing Optimization instances for continental areas (e.g., North America). In this talk we describe the algorithmic strategies we have combined in a heuristic solution algorithm to be able to solve instances with hundreds of millions of variables and constraints. We discuss graph decomposition techniques, and show how these can be used in a Lagrangian framework, as well as linear programming filtering heuristics, and fine tuning of commercial solver parameters.

■ VSA76

Virtual Room 76

Applied Operations Research at Facebook

Informs Special Session: Practice Curated Track

Informs Special Session

Chair: Vashist Avadhanula, Facebook Research, Facebook Research, CA, United States

Co-Chair: Deeksha Sinha, Facebook, Facebook, CA, United States

1 - Multi-step Budgeted Bayesian Optimization With Unknown Costs
Daniel Jiang, Facebook Core Data Science, Menlo Park, CA, United States, Raul Astudillo, Max Balandat, Eytan Bakshy, Peter Frazier

Most Bayesian optimization algorithms ignore how evaluation costs may change over the optimization domain. However, these costs, which are often unknown, vary substantially in many practical settings, such as hyperparameter tuning of machine learning algorithms, or physics-based simulation optimization. Moreover, those few algorithms that acknowledge cost heterogeneity do not accommodate the common situation of a budget constraint on the total evaluation cost. This combination of an unknown cost function and a budget constraint introduces a new dimension to the exploration-exploitation trade-off, where learning about the cost incurs the cost itself. We propose budgeted multi-step expected improvement, a non-myopic acquisition function that generalizes classical expected improvement to the setting of heterogeneous and unknown evaluation costs.

2 - Presenter
Amine Allouah, Columbia University, York, NY, 10027, United States

3 - Presenter
Vashist Avadhanula, Facebook, CA, United States

4 - Presenter
Varun Sharma, Facebook, CA, United States

Recurring batch data pipelines are a staple of the modern enterprise scale data warehouse. As a warehouse scales, a growing number of interdependent pipelines can give rise to periodic resource bottlenecks and variable landing times for data artifacts. The variability gets compounded by the dependency structure of the workload, and the resulting unpredictability can disrupt systems which consume this data. We present Clockwork, a scheduling framework for data pipelines which optimizes for stability in task completion times while also targeting predifined pipeline SLOs. We present this formulation and design a list scheduling algorithm based on its analytic properties. Online experiments comparing this novel algorithm and a previously proposed greedy heurstic show tasks complete almost an hour earlier on average, while exhibiting lower landing time variance.

■ VSA77

Virtual Room 77

New Challenges in Today's Educational Environment

Informs Special Session: INFORMS Committee on Teaching and Learning

Informs Special Session

Chair: Samuel Larsen, Technical University of Denmark, Denmark

1 - Teaching Data Science in the Post-Covid "Normal": Tactics for Simultaneous On-Campus and Virtual Instruction
Kitty Chan, Columbia University, New York, NY, 10019, United States

During the COVID-19 pandemic, many postsecondary institutions suspended on-campus classes and moved to fully remote instruction to support social distancing practices. With the rollout of the vaccine, campuses around the world are re-opening. Returning to on-campus classes calls for new ways to teach as the transition often requires educators to simultaneously deliver materials to students and engage with them across both on-campus and virtual classrooms. To help address this challenge, this presentation will cover tactics to teach in an on-campus and virtual classroom simultaneously, including discussion of special challenges for teaching data science.

2 - Create-Rank-Compete as an Engagement/enjoyment Driver in Remote Learning
Courtney J. Burris, University at Buffalo, Buffalo, NY, 14216-2808, United States, Alexander Nikolaev, Himangshu Kumar Paul, Lan Peng

Tasking students with creating Multiple Choice Questions (MCQs) is a constructivist teaching method. Prior research shows that students can create high quality MCQs, however, they do not find the task stimulating: a lack of interest in and engagement with this activity limits its practical appeal. Leveraging the research linking learner engagement with the perceived usefulness of a task, we hypothesize that by having learners interact with self-generated MCQs in multiple phases, their valuation of working with MCQs would increase, resulting in higher engagement/enjoyment outcomes. This is explored in a modified Bruner's spiral curriculum where students iteratively create and interact with MCQs through the method ``Create-Rank-Compete". Students perceived the multi-phase work with MCQs as stimulating, evidenced by high participation rates and survey data.

3 - Recruiting for Transportation Engineering and Other Narrow Engineering Disciplines
Samuel Brüning Larsen, Technical University of Denmark, Kongens Lyngby, Denmark

Transportation is one of the top resource consumers and a significant management challenge for sustainable development. In Denmark, the secondary education system offers a large program that combines geography with mathematics and the study of society. This presentation discusses a collaboration between the Technical University of Denmark and secondary education programs in geography, and evaluates the impact of the collaboration on the recruiting of students to the transportation program.

■ VSA78

Virtual Room 78

Undergraduate Operations Research Prize 1

Informs Special Session: Undergraduate Operations Research Prize

Informs Special Session Session

Chair: Kayse Lee Maass, Northeastern University, Boston, MA, 02115-5005, United States

Co-Chair: Trilce Encarnacion, University of Missouri- St. Louis, Saint Louis, MO, 63121, United States

1 - The Bicycle Network Improvement Problem: Optimization Algorithms and a Case Study in Atlanta
Jisoon Lim, Georgia Institute of Technology, Atlanta, GA, United States

2 - A Vehicle Routing Problem for Livestock Feed Distribution
Theodore Morissette, University of Waterloo, Waterloo, ON, Canada, Andrew Veldhuis, Razi Sayed, Eric Entz

3 - Optimal Charging Station Siting to Support Electric Vehicle Evacuation Planning
Simon Balisi, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Denissa Sari Darmawi Purba

4 - Static Bike Relocation Optimization Applied to Montreal's Bikesharing System
Imad Mechmachi, University of Montreal, Montreal, QC, Canada,

Philippe Lavoie, Reda Kzaz

■ VSA79

Virtual Room 79

Data Analytics in Agriculture

Informs Special Session: Agriculture

Informs Special Session Session

Chair: Lizhi Wang, Iowa State University, Ames, IA, 50011, United States

Co-Chair: Guiping Hu, Iowa State University, Ames, IA, 50011, United States

1 - Presenter

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 - 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.

3 - 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.

4 - A Hybrid Model for Maize Yield Prediction in U.S. Corn Belt States Using the Planting Process and Environment Data

Yanbin Chang, Iowa State University, Ames, IA, United States, Lizhi Wang

The accurate estimation of crop yield predictions is of great importance for food security under the impact of climate change. In this study we propose a hybrid model that combines the knowledge advantage of process-based modeling and the computational advantage of regression modeling. Computational studies using crop yield, field area, planting process record and corresponding environmental data were conducted on 1,073 maize growing counties in the U.S. corn belt from 1981 to 2020. Results suggest that the hybrid model is able to achieve a comparable prediction performance and provides useful insight for the maize planting in practice.

5 - A Deep Learning Framework for Estimating Soybean Relative Maturity from a Time Series of UAV Images

Saba Moeinizade, Iowa State University, Ames, IA, 50014-3495, United States, Hieu Trung Pham, Ye Han, Guiping Hu, Austin Dobbles

In this paper, we develop a robust and automatic approach for estimating the relative maturity of soybeans using time-series of UAV images. An end-to-end hybrid model combining Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) is proposed to extract features and capture the sequential behaviour of time-series data. The proposed deep learning model was tested on six different environments across the United States. We compared the CNN-LSTM model with a local regression model that models greenness decay over time using RGB values. Results suggest the effectiveness of our proposed CNN-LSTM model compared to the local regression method. Furthermore, our proposed approach is more robust in terms of image quality and the number of image acquisition dates.

■ VSA80

Virtual Room 80

Education I

Contributed Session

Chair: Fernanda Araujo Maciel, California State University, Sacramento, Sacramento, CA, 95825, United States

1 - Training Analytics Students to Work in Cloud Computing Environments

Cody Baldwin, Director (MS 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.

2 - Engaging In Collaborative Externship Experiences Across Institutions

Brian Petrus, Westminster College, New Wilmington, PA, United States, Christie Nelson, Benjamin Nelson

The Wall Street Boot Camp and Financial Analyst Program team up in a collaborative joint-institute externship program; an experiential hands-on learning project revolving around indoor farming. Guided by industry professionals, students will learn and engage in financial analysis, STEM concepts surrounding food science and aero-farming, as well as business SWOT concepts. Designed to mirror the training and development progression of an associate analyst working for a Wall Street financial institution, students will gain real-world experience and professional development in partnership with industry and graduate student mentors, all within a virtual class/Extern environment.

3 - 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

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.

4 - Case Study: Using Videos to Increase Motivation and Improve Learning Outcomes Of Students

Maria Vlasiou, Eindhoven University of Technology, Eindhoven, Netherlands

In this case study, we an intervention to a graduate-level course. A series of videos was added to the course, half focusing on extracurricular material related to stochastic processes and half focusing on traditionally difficult points in the curriculum. We evaluate a) the self-reported usefulness to the students of the additional material in terms of improving their engagement with the course compared to the control group and b) the difference to learning outcomes as evidenced by test results. Last, we estimate whether students willing to explore new resources intrinsically due to their novelty or whether these resources have an inherent added value to students.

5 - 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.

■ VSA81

Virtual Room 81

Future Mobility and Urban Community

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Sang Jin Kweon, Ulsan National Institute of Science and Technology, Ulsan, 15213, Korea, Republic of

1 - Increasing Equity in Public Transit Services through Optimization

Taylor Bonner, George Mason University, Fairfax, VA, United States

Abstract not available at this time.

2 - 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.

3 - 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.

4 - 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.

5 - 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.

■ VSA82

Virtual Room 82

Managing Facility Performance

Sponsored: TSL/Facility Logistics

Sponsored Session

Chair: Hong Kisuk, Pohang University of Science and Technology, Pohang, Korea, Republic of,

1 - Scattered Storage Assignment: Mathematical Model and VNS Meta-heuristic To Optimize The Intra-order Item Distances

Mauricio Gámez, University of Antwerp, Antwerp, Belgium, Trijntje Cornelissens, Kenneth Sörensen

This paper addresses the scattered storage assignment (SSA) problem. In SSA, products of the same type can be stored in different locations throughout the warehouse. In this policy, travel times can be reduced during order picking since it increases the probability of finding items belonging to the same order in nearby locations. Such type of storage policy is adequate when customers demand more than one type of item. We propose an efficient variable neighborhood search that can get nearly optimal solutions in reasonable computational times. We prove that the sum of pairwise distances between the same order items is better for our storage allocation than a more traditional storage allocation policy.

2 - Imitation Learning For Product Allocation In Warehouses

Kisuk Hong, Pohang University of Science and Technology, Pohang, Korea, Republic of, Bongjun Ji, Hyunseop Park, Hyunbo Cho

The traditional product allocation methods require various information regarding product and location. However, collecting the various information is currently labor-intensive and time-consuming. This study proposes a novel product allocation method using an imitation learning approach that requires warehouse states and product ID only. We conducted a case study to validate the proposed method with inventory data from a global appliance company. The result showed more than 90% similarity to experts' decisions. This study will contribute to reducing information management costs for product allocation in manufacturing and logistics industries.

■ VSA83

Virtual Room 83

George B. Dantzig Dissertation Prize Session

Award Session

Chair: Hamid Nazerzadeh, USC Marshall and Uber, San Francisco, CA, 94103-1331, United States

1 - Making Automatic Intervention Decisions Using Machine Learning

Carlos Fernández, New York University, New York City, NY, United States

This thesis reveals several distinctions between decision making and causal effect estimation that have critical implications for learning treatment assignment policies from data. First, decisions can be greatly improved by modeling them as a classification task rather than an effect estimation task. Second, confounding bias does not necessarily hurt decision making, and that even when it does, the benefits of larger data may outweigh the detrimental impact of confounding. Finally, causal modeling may not be necessary to make good decisions when there is a suitable proxy for causal effects.

2 - Data Mining and Causal Analyses: A Healthcare Operations Approach to Understanding the Patient Journey
Katherine Bobroske, Cambridge Judge Business School, Arvada, CO, 80005, United States

Building upon methodologies in operations research, econometrics, and data mining, this thesis provided novel insights into the patient journey - the process of how patient seek and receive care from the healthcare system. It leveraged a large medical and pharmaceutical administrative claims dataset to investigate two clinical contexts where there exists high variation of care: (1) patients initiating opioid prescription-based treatment and (2) patients experiencing a new onset of back or neck pain. This thesis provided insights into the importance of care delivery design in the early stages of treatment and proposed how health insurance plans can promote more efficient, quality care.

3 - Sharing the Sharing Economy: Policy Design for Social Good
Scott Rodilitz, Yale University, New Haven, CT, 90278, United States

Private-sector firms like Amazon, Google, and Uber have successfully harnessed the power of the sharing economy to improve profit margins (efficiency) and market share (growth). However, their strategies cannot always be directly applied in the public and civic sectors: governmental and nonprofit organizations often require new policies tailored to their unique objectives and constraints. This dissertation sheds light on how such organizations can implement policies to improve their efficiency and growth, with a particular focus on the utilization of crowdsourcing and platform-based markets.

4 - Causal Inference: A Tensor's Perspective
Dennis Shen, MIT, Cambridge, MA, 02139, United States

There is a growing wave towards personalized decision-making, where the aim is to select the optimal intervention for each unit from a collection of interventions. In policy evaluation, for instance, one may want to design a governmental policy (intervention) that is particularly suited to the socio-economic realities of a geographic location (unit). The key challenge in doing so—and indeed the fundamental problem of causal inference—is that we often only get to observe a unit undergo a single intervention or stay under control (i.e., no intervention). This is true not only in observational studies such as policy evaluation, but also in experimental studies such as clinical trials or A/B testing in e-commerce. In this thesis, we present a causal framework and furnish an algorithm to address the challenge laid out above. Key to our approach is reinterpreting the classical potential outcomes framework of Neyman and Rubin through the lens of tensors. Formally, each entry of the potential outcomes tensor is associated with a tuple of entities; namely, the measurement (e.g., time), unit (e.g., patient type), and intervention (e.g., drug). In doing so, each study (be it experimental or observational) can then be characterized by a unique sparsity pattern, which allows us to translate the age old problem of estimating counterfactuals into one of tensor estimation. As an added benefit, our tensor formulation also opens the door to discussions about the computational and statistical trade-offs of causal inference methods, a conversation (to the best of our knowledge) that has largely not yet been had. Through numerous real-world experimental and observational case studies, we demonstrate that the framework and algorithm collectively bear implications towards contingency planning, drug development, and data-efficient randomized control trials with personalized treatments. Methodically, we furnish a data-driven hypothesis test to check when our algorithm can reliably recover the underlying tensor. The key technical contribution of this thesis advances the state-of-the art analysis for principal component regression.

5 - Improving Farmers' and Consumers' Welfare in Agricultural Supply Chains via Data-driven Analytics and Modeling: From Theory to Practice
Somya Singhvi, USC Marshall School of Business, Los Angeles, CA, 90007, United States

The upstream parts of the agricultural supply chain consists of millions of smallholder farmers who continue to suffer from extreme poverty. The first stream of research in this thesis focuses on online agri-platforms and provides empirical and field evidence that operational and behavioral factors are important considerations affecting their impact. The second stream of research work in the thesis turns to consumer welfare and identifies effective policies to tackle structural challenges of food safety and food security that arise in traditional agricultural markets.

■ VSA84

Virtual Room 84

Doing Good with Good OR: I

Award Session

Chair: Renata Alexandra Konrad, Worcester Polytechnic Institute, Worcester, MA, 01609, United States

Co-Chair: Taewoo Lee, University of Houston, Houston, TX, 77204-4008, 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.

■ VSA86

Virtual Room 86

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 methods By 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.

■ VSA86-2

Virtual Room 86

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.

Sunday, 7:00AM - 7:30AM

■ VS85-1

Virtual Room 85

Technology Showcase: ODH|CPLEX - An Optimizer for Hard MIPs & A case study on solving Hard Redistricting problems

Technology Showcase

1 - ODH|CPLEX - An Optimizer for Hard MIPs & A case study on solving Hard Redistricting problems

Alkis Vazacopoulos, Optimization Direct, Inc., Harrington Park, NJ, 07640, United States, Robert Ashford

Mixed Integer Programming Models (MIPs) commonly solved are becoming larger and more complex in response to much more readily available data and cheaper computer resources. ODH|CPLEX handles large models by co-running a set of heuristics within a traditional branch-and-cut optimizer so as to find good, usable solutions to problems that would otherwise be intractable. We outline the structural decomposition technology used and demonstrate its effectiveness on many user instances as well as its ability to find solutions to standard test models to which no solution has been previously known. We also present results from solving complex State Redistricting problems.

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, Eindhoven University of Technology, London, WC1E 6BT, United Kingdom

1 - Moderator

Gizem Korpeoglu, Eindhoven University of Technology, Gower Street, London, WC1E 6BT, United Kingdom

2 - Panelist

Anant Mishra, Carlson School of Management, University of Minnesota, 321 19th Ave S, Minneapolis, MN, 55455, United States

3 - Panelist

Cheryl Gaimon, Georgia Institute of Technology, Scheller College Of Bus. 800 W. Peachtree St Nw, 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, 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, University of Edinburgh, Edinburgh, EH9 3JL, United Kingdom
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, V6T 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, Philadelphia, PA, 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, 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, MI, 48108-1020, United States

4 - Panelist

Vikrant Vaze, Dartmouth College, Hanover, NH, 03755-3560, United States

■ VSB02

Virtual Room 02

Data Analytics in Business Applications

Sponsored: Data Mining

Sponsored Session

Chair: Marcos Machado, Ontario Tech University, Oshawa, ON, L1G 4X8, Canada

1 - Customers' Risk-Adjusted Revenue Assessments Through a Hybrid Machine Learning Framework.

Marcos Machado, Ontario Tech University, Oshawa, ON, Canada, Salma Karray

Customer lifetime value metrics, specifically for loan services, are undeniably linked to the financial risk of default. Accordingly, an adjusted measure that takes into account customers' financial risk is important to accurately evaluate their value. We model customers' risk-adjusted revenues (RAR) using approaches suggested in the literature and then proposing new formulations that develop these approaches further. We predict RAR by applying, for the first time, different machine learning (ML) algorithms, these include individual and hybrid frameworks. Our results show that more than half of the tested individual ML models achieve an R2 score over 90%. We compare the performance of our ML methods using different metrics, and find that, in most cases, the hybrid ML models outperform the individual ones in predictive performance and in processing time.

2 - Econometric Analysis of Textual Data Underlying Customer Sentiments

Gokul Bhandari, University of Windsor, Windsor, ON, Canada

In this study, we conducted the econometric analysis of online review of amazon products sold by BestBuy.com. Initial dataset contained 34,660 reviews of 42 amazon products during the period from 2010-07-09 to 2018-04-18. The dataset contained id, name, asins, brand, categories, keys, manufacturer, review, data, recommend or not, rating, review, review title, and username. The dataset was then filtered to the top three products having the largest number of reviews. For each product, sentiment score across various lexicons was computed. Using the review data as the time dimension, sentiment scores were converted into time series data and several econometric analyses were performed using the sentometrics package available in R.

3 - Adaptive Trading System Integrating Machine Learning and Back-testing: Korean Bond Market Case

Misuk Kim, Sejong University, Seoul, Korea, Republic of

Because the bond market is affected by several variables, it is a good candidate for machine learning applications. Specifically, traders create trading strategies that involves the difference between long- and short-term bond yields to minimize market risks; hence, if this spread can be predicted, it can serve as the data-driven long-term direction of the bond market and generate additional profits. Therefore, a prediction model that predicts the spreads between 10- and 3-year treasury bonds is proposed herein; subsequently, back-testing is applied to verify the performance of the prediction model. Consequently, when back-testing was applied based on the results of predictive models, we achieved up to 54.2% in return on investment over 6-month.

4 - Arbitrage Opportunities Predictions in Retail Markets and the Role of User-generated Content

Jitsama Tanlamai, HEC Montreal, Canada, Warut Khern-am-nuai, Yossiri Adulyasak

This study utilizes the data from Amazon Marketplace to demonstrate the feasibility to leverage predictive analytics to identify arbitrage opportunities in retail markets. We develop a machine learning model using the random forest algorithm to analyze the price movement and predict the buying points where arbitrage opportunities arise. We also incorporate user-generated content to examine their predictive powers in this domain. Our finding indicates that machine learning algorithms are applicable to predict arbitrage opportunities even in retail markets and user-generated content possesses significant predictive powers in arbitrage opportunities classification.

■ VSB03

Virtual Room 03

Data and Modeling Applications in Response to COVID-19 Pandemic

Sponsored: Data Mining

Sponsored 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.

■ VSB04

Virtual Room 04

Machine Learning for Spatio-temporal Data Modeling and Analysis

Sponsored: Data Mining

Sponsored Session

Chair: Shixiang Zhu, Georgia Institute of Technology, Atlanta, GA, 30318-2990, United States

1 - Adversarial Anomaly Detection for Marked Spatio-Temporal Data

Henry Yuchi, Georgia Institute of Technology, Atlanta, GA, United States, Shixiang Zhu, Yao Xie

Spatio-temporal event data are becoming ubiquitous in a wide range of applications, for instance, electronic transaction records, social network data, and crime incident reports. This leads to the question how we may efficiently detect anomalies in dynamic systems using streaming event data. We propose a novel anomaly detection framework for such event data combining the Long Short-Term Memory (LSTM) and marked spatio-temporal point processes. The detection procedure can be computed in an online and distributed fashion via feeding the streaming data through an LSTM and a neural network-based discriminator. We will discuss the false-alarm-rate and detection delay and show that it can achieve weak signal detection by aggregating local statistics over time and networks. Finally, we will demonstrate the strong performance of our method using real-world data sets.

2 - Additive Tensor Decomposition Considering Structural Information

Shancong Mou, Georgia Institute of Technology, Atlanta, GA, 30318-5742, United States, Andi Wang, Chuck Zhang, Jianjun Shi

Tensor data with rich structural information becomes increasingly important for Spatio-temporal modeling. To reveal useful information from tensor data, we propose to decompose the tensor into the summation of multiple components based on their different structural information. In this paper, we provide a new definition of structural information in tensor data. We then propose an additive tensor decomposition (ATD) framework to extract useful information from tensor data. An alternating direction method of multipliers (ADMM) algorithm is proposed to solve it. Two simulation examples and a real case study in medical image analysis illustrate the versatility and effectiveness of the ATD framework.

3 - Equivariant Neural Networks for Learning Spatiotemporal Dynamics

Robin Walters, North Eastern University, Boston, MA, United States

Applications such as climate science and transportation require learning complex dynamics from large-scale spatiotemporal data. Existing machine learning frameworks are still insufficient to learn spatiotemporal dynamics as they often fail to exploit the underlying physics principles. Representation theory can be used to describe and exploit the symmetry of the dynamical system. We will show how to design neural networks that are equivariant to various symmetries for learning spatiotemporal dynamics. Our methods demonstrate significant improvement in prediction accuracy, generalization, and sample efficiency in forecasting turbulent flows and predicting real-world trajectories. This is joint work with Rose Yu, Rui Wang. and Jinxi Li.

4 - An Adaptive Sampling Strategy for Online Monitoring and Diagnosis of High-dimensional Streaming Data

Kamran Paynabar, ISyE Georgia Tech, 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.

■ VSB05

Virtual Room 05

Data Mining in Medical Informatics

Sponsored: Data Mining

Sponsored Session

Chair: Zhuqi Miao, Oklahoma State University, Stillwater, OK, 74078-4015, United States

1 - Multi-branching Temporal Convolutional Network for Sepsis Prediction

Zekai Wang, Oklahoma State University, Stillwater, OK, United States, Bing Yao

Sepsis is among the leading causes of morbidity and mortality in modern intensive care units. Accurate sepsis prediction is of critical importance to save lives and reduce medical costs. The rapid advancements in sensing and information technology provide an unprecedented opportunity for data-driven diagnosis of sepsis. However, real-world medical data are often complexly structured with a high level of uncertainty (e.g., missing values, imbalanced data). In this paper, we propose a novel predictive framework with Multi-Branching Temporal Convolutional Network (MB-TCN) for robust prediction of sepsis. The MB-TCN framework efficiently handles the missing value and imbalanced data issues. We evaluate the performance of the proposed MB-TCN using real-world medical data. Experimental results show that MB-TCN outperforms existing deep learning methods.

2 - Synthesizing Data-driven Sepsis Treatment Strategy Using Longitudinal EHR Data

Akash Gupta, California State University-Northridge, 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.

3 - Performance Comparison of Models for Mining Clinical Notes

Suhao Chen, Oklahoma State University, Stillwater, OK, 73071, United States, Dzung Le, Thanh Thieu, Tieming Liu, Zhuqi Miao

Medical billing is challenging while data mining of clinical notes has great potentials to relieve the billing burden. This study compiles a rule-based algorithm on top of existing clinical natural language processing (NLP) tools to extract essential information needed for medical billing. We also train state-of-the-art NLP machine learning models on annotated datasets for tasks including named entity recognition. Performances of the two models are compared and discussed.

4 - User-Centered Displays of Explainable Artificial Intelligence in Healthcare: A Case Study of Heart Disease Prediction

Enrico Laoh, Oklahoma State University, Stillwater, OK, 74075, United States, Joseph Nuamah

Research in explainable artificial intelligence (XAI) seeks to find innovative ways to make human users understand the results generated by artificial intelligence (AI) systems. While prior XAI studies have explored alternative approaches to model explanation, most of them are not informed by end-user evaluations of model interpretability. In this study, we built on existing human-computer interaction and human factors research to develop four prototype explainable displays for predictions from the Cleveland heart disease dataset. We used a model-agnostic method, Shapley Additive exPlanations, to explain individual predictions of an XGBoost heart disease prediction model.

5 - 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.

■ VSB06

Virtual Room 06

Strategies of Handling Marketing Data and Analytics Challenges

Sponsored: Data Mining

Sponsored Session

Chair: Lili Zhang, Kennesaw State University, Kennesaw, GA, 30144, United States

1 - B2B Prospect Account Prioritization for Marketing and Sales
Swarup Chandra, PhD, Hewlett Packard Enterprise, TX, United States

In a B2B business setting, prioritizing prospective customers is key for optimizing marketing and sales ROI. Typically, historical transactions are used to learn future purchase behavior. However, this type of data is only available for customers who have made a purchase in recent history. With the lack of transaction data, one can look into alternative data sources for purchase signals. Unfortunately, data coverage challenges exists. In this talk, we will discuss technical challenges in handling various data sources in formulating a prospect prioritization model.

2 - Multi Layered Propensity Engine for HPE's as a Service Offering
Jyoti Khare, Hewlett Packard Enterprise, Bengaluru, India, Aswin Govindaraj

A multi layered data driven solution to identify target segments for HPE's IT as-a-Service offering -Greenlake.Rooted in Segmentation, Targeting and Positioning ,the solution has 4 modules:1a) Propensity to Buy, Installed Base: Models prioritizing HPE customers who have not purchased GreenLake. 1b) Propensity to Buy, Prospects: Models prioritizing acquisitions from prospects pool.2) Digital Visitor Intelligence: Models comparing digital interest for HPE products and solutions among web visitors.Modules above are integrated to create targetable account segments.3) Greenlake Potential Index: Model to assign potential score to target accounts resulting in differentiated tiers for targeting. 4) Workload Categorization: Quantitatively assessing accounts on the intended usage of GreenLake at the customer site to prescribe optimal positioning.

3 - Machine Learning Approach to Automated Qualified Lead Scoring
Lili Zhang, HPE, San Jose, CA, 30144, United States, Swarup Chandra, Zainab Jamal, Sreeja Guha

Identification of good marketing leads would enable the sales organization to optimize their resources, and eventually generate revenue to the company. In this talk, we will look into the technical challenges of using machine learning algorithms to identify such leads in a digital B2B marketing world. Particularly, we will look into the issues that influence the performance of ML models, including high dimensional data, effect of account-level and contact-level hierarchy, latent relationship between influencers and buyers, data quality and privacy, and incorporating business expertise.

4 - Touchpoint Mix Modeling: An Automated Digital Marketing Optimization System
Tong Geng, JD.com, Mountain View, CA, United States

Touchpoint Mix Modeling (TMM) is an automated digital marketing optimization system at JD.com that optimizes bid prices and budgets for real-time bidding campaigns across multiple digital channels according to a business objective (e.g., max conversions) and constraints (e.g., budget). TMM applies a non-linear program and uses an efficient customized active set-based solution method to guarantee global optimality. It also exploits a large amount of bidding information and a multi-touch attribution model to improve its efficacy. TMM achieves 16% better outcome than advertisers' manual setting.

5 - Approximate Algorithm for Dynamic Assortment Planning With Opaque Selling Option
Yukai Huang, Washington University in St. Louis, St Louis, MO, United States, Jacob Feldman

Opaque selling is an efficient marketing strategy when the firm wants to dispose of the excess inventory, especially when the selling season comes to an end. Under a price markdown, the customer will purchase an opaque product by receiving one of the available products that the seller assigns. The firm could also balance the inventory by dynamically altering the set of the product available to the customers. We formulate the firm's optimal assortment and opaque product assignment decision by a bellman equation to combine the two options. Because of the high dimensionality nature of the problem, we propose an approximation method that guarantees a 1/2-competitive bound to the optimal solution.

■ VSB07

Virtual Room 07

The Interplay Between Optimization and Statistics

Sponsored: Data Mining

Sponsored Session

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

Co-Chair: Yingjie Fei, Ithaca, NY, 14850, 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 - Structured Local Solutions in Nonconvex Problems
Yuqian Zhang, Rutgers University, Piscataway, NJ, 08854, United States

This talk focuses on the investigation of structure of the local minima of some nonconvex problems. We consider 1) short and sparse blind deconvolution and 2) K-means clustering problem. The short and sparse blind deconvolution problem aims to recover a short signature pattern from its repeated occurrence, which arises from several important applications, including microscopy image analysis, neural spike sorting and image deblurring. The K-means problem aims to partition observations into k clusters such that the within-cluster variation is minimized. Both problems are nonconvex, and our research shows that all the local solutions are structured under conditions. By investigating the structure of these local solutions gives reliable algorithms to infer the global solution from the a local solution.

3 - A New Dimension-Insensitive Zeroth Order Algorithm
Hung Yi Lee, University of Florida, Gainesville, FL, 32603, United States

We consider a stochastic zeroth-order optimization problem in which the gradient of the objective function is inaccessible or could not be accessed tractably. Traditional techniques for this type of problems often result in a query complexity that grows polynomially with dimensionality. As a result, those methods may perform poorly in many larger-scale real-world applications. In this talk, we will discuss a novel algorithm with dimension-insensitive query complexity. Some potential theoretical advantages of the proposed algorithm will be articulated in comparison with the alternative dimension-insensitive schemes.

4 - The Efficiency of Kernel Methods On Structured Datasets
Song Mei, UC Berkeley, Berkeley, CA, United States

Inspired by the proposal of tangent kernels of neural networks (NNs), a recent research line aims to design kernels with a better generalization performance on standard datasets. Indeed, a few recent works showed that certain kernel machines perform as well as NNs on certain datasets, despite their separations in specific cases implied by theoretical results. Furthermore, it was shown that the induced kernels of convolutional neural networks perform much better than any former handcrafted kernels. These empirical results pose a theoretical challenge to understanding the performance gaps in kernel machines and NNs in different scenarios. In this talk, we show that data structures play an essential role in inducing these performance gaps. We consider a few natural data structures and study their effects on the performance of these learning methods.

■ VSB08

Virtual Room 08

Data Analytics and Machine Learning in Intelligent Decision

Sponsored: Data Mining

Sponsored Session

Chair: Chunyan Duan, Tongji University, Shanghai, 200092, China

1 - Enhance Decision Support to Hazardous Weather Events With Machine Learning
Qi Zhong, China Meteorological Administration Training Center, Beijing, China, Zu-Liang Fang, Zhi-Cha Zhang, Zhuo Sun, Hong-li Liang

Flash heavy rain is one of the most hazardous weather with great social and economic impact. However, it has a low predictability. With the application of AI, a decision support enhancement to hourly forecast in severe weather events is shown. This presentation firstly describes a multi-source ML dataset, which combines the vast amount of weather observations and numerical forecasts. Further, we focus on the increase of the hour-scale forecast accuracy at heavy rain with ML methods. Finally, the collaboration of better forecasts, decisions and machine learning community is prospected.

2 - Matrix Methods and Theory for Ranking Decision Making in Web Information Retrieval Model

Yongxin Dong, Tongi University, Shanghai, China, Jianxin You, Chunyan Duan

The topics on matrix methods in data mining and pattern recognition have attracted a large number of researches. In web information retrieval models, PageRank, HITS and SALSA are very popular. In this paper, motivated by the web information retrieval model ideal, we develop a robust dominant eigenvector approach of a positive data matrix. Finally, a practical healthcare example demonstrates the effectiveness and reliability of the matrix eigenvector approach.

3 - Data-driven Intelligent Decision Making Based on Machine Learning

Chunyan Duan, Tongji University, Shanghai, 200092, China, Siqi Li, Zhenwei Dong

Machine learning are widely used in proving support for complex decision-making process because of their capability in discovering complicated patterns in data. In this paper, a data-driven intelligent decision-making model based on machine learning is constructed to assist doctors to make precision radiotherapy decisions for lung cancer patients. The effectiveness and accuracy of the model are tested by adopting the comparison with other related representative methods.

■ VSB09

Virtual Room 09

Distinguished Lectures: COVID - Production, Supply Chain, Analytics

Committee Choice: Health Applications Society

Committee Choice Session

Chair: Stephen E Chick, INSEAD, Fontainebleau Cedex, F-77305, France

1 - COVID-19, the Global Supply Chain for Medical Products, and Operations Research

Prashant Yadav, INSEAD, Fontainebleau, 48109, France

The supply chain for medical products including PPE, vaccines, testing supplies and therapeutics has faced intense public scrutiny in the last 18 months. Companies with vaccine, therapeutic, and diagnostic technologies have to make their future supply chain network design decisions against this backdrop of high policy and demand uncertainty, intense public scrutiny, and strong demands for meeting their social contract. This talk will share a few examples of how operations research models which are deeply embedded in context can help both public agencies and individual firms in making decisions related to health product purchasing, portfolio design, network design and manufacturing flexibility. It will also include findings from work on healthcare supply chain design for future pandemic preparedness.

2 - Supply Chain Resiliency and the Need for Stress-Tests

David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

As hospitalizations decrease and vaccinations increase, some see the end of the COVID-19 pandemic somewhere on the horizon. With that, many of us in the data science community are analyzing "lessons learned" from the pandemic to better prepare and more efficiently and effectively respond to the next disaster. At the center of this discussion must be how to fix our supply chains to prevent disruptions where possible and to identify - before a disaster occurs - where vulnerabilities exist. This is the focus of my presentation.

■ VSB10

Virtual Room 10

Data, Learning, and Decision-Making in Healthcare Management

Sponsored: Health Applications Society

Sponsored Session

Chair: Mohsen Bayati, Stanford University, Stanford, CA, 94305-7216, United States

Co-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.

3 - Machine Learning Methods Applied to Cancer Treatment Planning

Jacqueline Jil Vallon, Stanford University, Stanford, CA, United States, Neil Panjwani, Xi Ling, Sush Vij, Mark Buyyounouski, Mohsen Bayati

Cancer treatment planning is complex, requiring the integration of many parts. Traditional analyses to guide cancer treatment decisions have several shortcomings: 1) Models often only incorporate covariates readily available in the EMR. However, texts such as biopsy reports include rich covariates used in clinical practice but missed in analyses because of their unstructured nature. 2) Advanced machine learning (ML) models trade off variance by injecting bias to increase estimation accuracy, potentially recommending decisions inconsistent with clinical intuition. We study these challenges by applying recent ML and causal inference methods to prostate cancer treatment planning.

4 - Optimal Experimental Design For Staggered Rollouts

Ruoxuan Xiong, Stanford University, Stanford, CA, 94305-4121, United States, Susan Athey, Mohsen Bayati, Guido Imbens

Multi-period experiments have been widely used to study the effect of treatments or decisions that can impact outcomes for multiple periods. We focus on the setting with multiple units, such as geographical locations, where all units start in the control state at the initial period. The experiment designer chooses a particular point in time for each unit to allocate the treatment of interest. Then the unit remains exposed to this treatment in subsequent periods. We study the optimal allocation of treatments to units in order to maximize the experiment's statistical power. We study a general data model and provide the optimal treatment schedules that minimize the variance, where the corresponding fraction of treated units takes an S-shaped curve in time. In addition, we propose a data-driven local search algorithm to leverage historical data to improve the treatment schedule.

5 - Interpretable Markov Decision Process: Application to Triage and Reassessment Guidelines for Ventilator Rationing

Julien Grand-Clément, Columbia University, New York, NY, 11206, United States, Carri Chan, Vineet Goyal, Elizabeth H. Chuang

Algorithms for sequential decision-making in healthcare often suffer from a lack of interpretability. Decision trees have gained interest in recent years, due to their performances and their interpretability. We focus on computing MDP policies that have a tree structure, called tree policies. We characterize the properties of optimal tree policies in the case of finite-horizon MDP and show that optimal policies may be history-dependent but can be chosen deterministic. We introduce an algorithm to compute a Markovian tree policy. We apply our model to learn triage and reassessment guidelines for ventilator allocations to patients affected by Sars-Cov-2. Our tree policies improve upon First-Come-First-Served guidelines and New York State guidelines by reducing the number of excess deaths associated with various hypothetical levels of ventilator shortage.

■ VSB11

Virtual Room 11

Incentives and Payment Models in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: Sasa Zorc, University of Virginia, Darden School of Business, Charlottesville, VA, 22903, United States

Co-Chair: Ozge Yapar, Indiana University, Kelley School of Business, Bloomington, IN, 47405-5308, United States

1 - Reducing Non-urgent Visits and Emergency Department Congestion: Perception-Improvement and Pricing

Shrutivandana Sharma, Singapore University of Technology and Design, Singapore, 138682, Singapore, Ying Xu, Manu Kumar Gupta, Costas Courcoubetis

We present a queueing games framework to investigate how patients' choice between an expensive/congested emergency department (ED) and general practitioners (GP), who refer urgent patients to the ED, are influenced by patients' imperfect perception of urgency. We then investigate how perception-improvement measures (e.g. tele-advice) and financial incentives may impact non-urgent ED visits and social cost. We find that exclusive perception-improvement may worsen these, but this limitation can be overcome by inducing optimum patient flows at equilibrium. To achieve this, we design a novel differential pricing mechanism (leveraging GP-referral feature), and discuss its benefits over traditional pricing mechanisms.

2 - The "Netflix Model": A New Payment Model for Asymptomatic Disease Management

Zhaowei She, Georgia Institute of Technology, Atlanta, GA, 30067-7980, United States, Yueran Zhuo, Jagpreet Chhatwal, Turgay Ayer

Several state governments (e.g. Louisiana and Washington) recently entered into Netflix-style contracts with drug manufactures (Gilead and AbbVie), where the state Medicaid programs make a fixed lump-sum payment to a drug manufacturer in exchange for unlimited access of hepatitis C virus (HCV) drugs for its Medicaid patients. We analyzed this novel Netflix-style payment model from a mechanism design perspective, and characterized the conditions under which such a contract would be beneficial to both manufacturer or payer. This study shows that the emergence of Netflix-style contracts improves the overall efficiency of pharmaceutical market. However, only those states with comprehensive HCV screening programs in place should considering switching to Netflix-style contracts.

3 - Coordinating Mechanisms for Allogeneic Stem Cell Transplantation

Sundara Natarajan Panchanatham, INSEAD, Singapore, 600036, Singapore, Michael Freeman, Harry Groenevelt, Sameer Hasija

Treating many blood-related diseases require transplantation of genetically compatible hematopoietic stem cells (HSCs) extracted from the bone marrow (BM) of live donors or the umbilical cord blood (CB) of babies. The two sources vary along dimensions like supply, costs, processing, matching requirements and effectiveness, thereby giving rise to important trade-offs such that neither is preferred exclusively to the other. We derive a simulation-based joint optimization model that estimates the temporal variation in the matching probabilities and provides the optimal capacity allocation. We find that 17.5 million BM donors and 335 thousand CB units are optimal for the U.S. population.

4 - Conditional Approval Vs Discount Schemes for New Medical Treatments

Ozge Yapar, Indiana University, Kelley School of Business, Bloomington, IN, 47405-5308, United States, Stephen E. Chick, Noah Gans

Healthcare payers have been implementing conditional approval schemes in which a treatment's reimbursement is conditional on the successful demonstration of the health-economic value through post-marketing data captured after the treatment has entered the market. Payers also allow companies to apply for discount schemes which lead to a reduction in the price of the treatment. As a result, companies can choose between applying for a discount, which decreases the budget impact, and applying for a conditional approval, which decreases the uncertainty. Using a game-theoretic model, we investigate whether there is a systematic difference between treatments that enter these two types of schemes.

5 - Pricing The COVID-19 Vaccine: A Mathematical Approach

Banafsheh Behzad, California State University, 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.

■ VSB12

Virtual Room 12

Healthcare Delivery

Sponsored: Health Applications Society

Sponsored Session

Chair: Diwas S Kc, Emory University, Atlanta, GA, 30322-1059, United States

1 - Matching Patients with Surgeons: Heterogeneous Effects of Surgical Volume on Surgery Duration

Behrooz Pourghannad, University of Minnesota, Rochester, MN, 55901-4841, United States, Guihua Wang

We study the heterogeneous effects of surgical volume on surgery duration and address the challenges of matching patients with surgeons to improve hospitals' operational efficiency. We apply the causal forest approach to generate patient-specific information that captures the heterogeneous volume effects for different patients. Finally, we develop an optimization model to compare the same hospital's operational efficiency with and without patient-specific information.

2 - 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.

3 - 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.

■ VSB13

Virtual Room 13

Data Analytics in Opioids Use/misuse

Sponsored: Health Applications Society

Sponsored Session

Chair: Hyojung Kang, University of Illinois at Urbana-Champaign, Champaign, IL, United States

1 - Presenter

MD Noor E. Alam, Northeastern University, Boston, MA, 02136-3831, United States

This talk will shed light on how analytics and operations research techniques could be useful to address the nationwide opioid epidemic crisis. We will briefly discuss a system approach to tackle the problem, and ways to make effort to minimize opioid use disorder and opioid overdose.

2 - Examining Variation in Opioid-based Doctor Shopping Patterns in a Medicaid Population: Pre- and Post-policy Implementation

Carolina Vivas Valencia, Purdue University, West Lafayette, IN, United States, Paul Griffin, Nan Kong

Prescription drug monitoring programs and other legislative acts have been enacted in several states as an attempt to reduce opioid prescribing and doctor shopping behavior. This study estimates the impact of state-based interventions enacted in Indiana among Medicaid enrollees. We applied network analysis to investigate the changes in the provider-provider network (PPN) impacted after legislation implementation. This study provides insight into opioid seeking behavior and facilitates targeted surveillance of prescriber communities

3 - 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.

4 - COVID-19 Outcomes for Patients With Opioid Use Disorders

Hyojung Kang, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, Peng Zhang, Jinha Lee

Opioid-related overdoses and deaths have increased during COVID-19. Vulnerable groups with opioid use disorders (OUD) may be at a higher risk of developing more severe health outcomes due to COVID-19. The goal of this study is to develop a predictive model that identifies high risk individuals with poor outcomes.

5 - 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.

■ VSB14

Virtual Room 14

Learning and Data-driven Algorithms

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Negin Golrezaei, Massachusetts Institute of Technology, Lexington, MA, 02421-5830, United States

Co-Chair: Jason Cheuk Nam Liang, MIT Operations Research Center, Cambridge, MA, 02139-4230, United States

1 - Corruption-robust Exploration in Episodic Reinforcement Learning

Thodoris Lykouris, Assistant Professor, Massachusetts 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, 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.

4 - Bidding And Pricing in Budget and ROI Constrained Markets

Jason Cheuk Nam Liang, MIT Operations Research Center, Cambridge, MA, 02139-4230, United States, Negin Golrezaei, Patrick Jaillet

In online advertising markets, setting budget and return-on-investment (ROI) constraints can help buyers utilize limited monetary resources efficiently. We study the buyer's bidding problem subject to both budget and ROI constraints in repeated second-price auctions. We show the optimal hindsight bidding policy has a simple threshold-based structure. We take advantage of this structure to design an online bidding algorithm that achieves sublinear regret while satisfying both constraints. We then study the seller's pricing problem against an ROI and budget-constrained buyer and establish that the seller's revenue function admits a bell-shaped structure. Building on this fact, we propose a pricing algorithm that utilizes an episodic binary-search procedure, and show that it results in sublinear seller regret when the buyer adopts an adaptive bidding algorithm.

5 - Regularized Online Allocation Problems: Fairness and Beyond

Santiago Balseiro, Columbia University, New York, NY, 10027, United States, Haihao Lu, Vahab Mirrokni

We introduce the regularized online allocation problem, a variant the classical online allocation problem with resource constraints that includes a non-linear regularizer acting on the total resource consumption. Our primary motivation is the online allocation of internet advertisements wherein firms seek to maximize additive objectives such as the revenue or efficiency of the allocation. By introducing a regularizer, firms can account for the fairness of the allocation or, alternatively, punish under-delivery of advertisements—-two common desiderata in internet advertising markets. We design an algorithm when arrivals are drawn independently from a distribution that is unknown to the decision maker. Our algorithm is simple, fast, and attains the optimal order of sub-linear regret compared to the optimal allocation with the benefit of hindsight.

■ VSB15

Virtual Room 15

Empirical Research in Retail Operations

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ozge Sahin, Johns Hopkins University, Baltimore, MD, 21202, United States

Co-Chair: Sahar Hemmati, University of Maryland, College Park, MD, United States

1 - Data Analytics to Detect Panic Buying and Improve Products Distribution Amid Pandemic

Ahmed Chaouachi, Senior Data Scientist, IVADO Labs, Montreal, QC, Canada, Yossiri Adulyasak, Omar Benomar, Maxime Cohen, Warut Khern-am-nuai

We partnered with a large North American retailer to alleviate the adverse effects of panic buying. Retailers are no strangers to unexpected spikes in high-demand products, but no one was prepared for the massive disruption caused by the COVID-19 pandemic. We first show that our proposed anomaly detection model, which leverages internal and external data sources (e.g., Google Trend and Twitter) can successfully detect pertinent anomalies before it's too late. We then present a prescriptive analytics simulation tool that can help retailers improve products distribution for essential products during uncertain times.

2 - Damned If You Buy, Damned If You Wait: An Empirical Investigation of Customer Regret Under Markdown Pricing and its Implications to Retailing

Inki Sul, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Ozalp Ozer, A. Serdar Simsek

We study the effect of anticipated regret on purchasing decisions of customers facing a markdown pricing structure. We model a customer's purchasing decision under markdown pricing using a utility based economic model that captures the effect of anticipated regret, and empirically estimate the product-level parameters of our model at the product level with a data obtained from the online channel of a luxury fashion retailer. We find significant heterogeneity in regret characteristics across product categories, and that stockout regret generally dominates high-price regret in magnitude. Our counterfactual analysis shows that retailers can increase their profits up to 8.17% if they account for the customer regret in their pricing strategy. Further, we introduce a parsimonious way to disentangle and order the rank of two types of regret.

3 - Strategic Visual Merchandising of New and Open-box Products: Evidence From Experiments and Retail Data

Yuanyuan(Amy) Ding, University of Minnesota, Minneapolis, 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.

4 - 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.

5 - Effort Provisioning in Direct-selling Firms Under Push vs. Pull Systems: Theoretical Predictions and Empirical Evidence

Canan Savaskan Ebert, Cox School of Business, Dallas, TX, United States, Sreekumar R. Bhaskaran, Fangyun Tan

In this paper, we examine the impact of the allocation of inventory risk on the sales effort decisions of independent agents in a direct selling network. Building upon a game-theoretic model of a seasonal product whose demand is uncertain, we compare the optimal sales effort, sales volume and firm profitability under a push vs. pull strategy. Subsequently, the key theoretical predictions are tested using a novel dataset to understand and validate the key drivers of the firm's and agent's decision-making. The empirical analysis uses multi-year cookie sales data from a large local council of the Girl Scout organization ,Our findings have important implications for direct-selling firms that offer unique products through non-traditional distribution channels.

■ VSB16

Virtual Room 16

New Challenges in Pricing and Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Adam Elmachtoub, Columbia University, New York, NY, 10027-3241, United States

Co-Chair: Xiao Lei,

1 - Employees, Contractors, or Hybrid: An Operational Perspective

Haotian Song, NYU, New York, NY, United States, Sebastien Martin, Ilan Lobel

We consider a platform's problem of how to staff its operation given the options of hiring employees, setting up a contractor marketplace or perhaps pursuing a hybrid solution. We consider several different models that vary in their assumptions regarding stochasticity, equilibrium and dynamics. In static models, we find that that exogenous stochastic contractor supply leads to a hybrid solution, while a game-theoretic model leads to a single source of labor solution. With dynamic models, we are able to characterize the optimal solution if contractor wages are adjustable, but solutions become counterintuitive if wages are rigid. We argue that contractors provide the right kind of flexibility for fast-growing platforms.

2 - 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.

3 - Online Display Optimization Under Quality Uncertainty

Daniela Saban, Stanford University, Palo Alto, CA, United States, Ali Aouad

Motivated by online labor markets, we consider the online assortment optimization problem faced by a two-sided matching platform that hosts a set of suppliers waiting to match with a customer. Arriving customers are shown an assortment of suppliers, and may choose to issue a match request to one of them. After spending some time on the platform, each supplier reviews all the match requests he has received and, based on his preferences, he chooses whether to match with a customer or to leave unmatched. We study how platforms should design online assortment algorithms to maximize the expected number of matches in such two-sided settings. We first establish the conceptual differences between this problem and the online assortment problem in retail settings. We then provide algorithms for assortment planning in matching platforms.

4 - 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.

■ VSB17

Virtual Room 17

Revenue Management for Marketing and Advertising

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: John G Turner, University of California - Irvine, Irvine, CA, 92697, United States

1 - Data-driven Optimization of Personalized Reserve Prices in Multi-unit Auctions

Mahsa Derakhshan, University of Maryland at College Park, College Park, MD, United States

We study the problem of finding personalized reserve prices for unit-demand buyers in multi-unit eager VCG auctions with correlated buyers. The input to this problem is a dataset of submitted bids of n buyers in a set of auctions. The goal is to find a vector of reserve prices, one for each buyer, that maximizes the total revenue across all auctions. Roughgarden and Wang (2016) showed that this problem is APX-hard but admits a greedy 0.5-approximation algorithm. In this work, we provide a polynomial-time algorithm with a significantly better approximation factor of 0.63. Our solution is based on a novel linear programming formulation, for which we propose two different rounding schemes. We prove that the best of these two and the no-reserve case (all-zero vector) is a 0.63-approximation.

2 - Dynamic Two-part Pricing and Bidding for Display Ad Campaigns on Advertising Exchanges

Sami Najafi-Asadolahi, Santa Clara University, Leavey School of Business, Morgan Hill, CA, 95037, United States, Naren Agrawal, Stephen A. Smith

Display advertising has a 48% share of the US online advertising market and is its fastest-growing section. This paper considers an online display advertising framework in which an advertising agency manages multiple ad campaigns on behalf of advertisers by bidding for targeted viewers on an ad exchange. The ad agency faces uncertain demand from ad campaigns, uncertain supply of impressions by the ad exchange, and uncertain outcomes for impression purchase made through first-price auctions. We formulate this system as a Markov Decision Process. We determine the optimal fixed price to charge each campaign at the time of entry and the optimal price to charge per delivery of each impression (two-part pricing), and the optimal dynamic bidding policy to serve campaigns. These policies are dynamic and reveal interesting managerial insights.

3 - Improved Revenue Bounds for Posted-price and Second-price Mechanisms

Balasubramanian Sivan, Google Research, New York, NY, United States

We study revenue maximization through sequential posted-price (SPP) mechanisms in single-dimensional settings with n buyers and independent but not necessarily identical value distributions. Our SPP mechanisms use the best of two simple pricing rules: one that imitates the revenue optimal mchanism, namely the Myersonian mechanism, via the taxation principle and the other that posts a uniform price. Our generelizable pricing rules, analyzed via factor-revealing mathematical programs, yield the first improvement over long-established approximation factors in several settings. These include the single-unit, k-units, position auctions and eager second-price auctions settings.

4 - Online Marketplaces: Auctions or No Auctions?

Noureddine El Karoui, University of California, Berkeley, CA, 94720, United States

Modern online marketplaces are fascinating objects of studies, marrying rich topics from auction theory, control theory, machine learning and statistics. In this talk I will discuss questions related to auction theory in this context, relating practical problems encountered by practitioners (on both sides of the market), recent academic work and will question the centrality of auctions in this context, at least for “closed” online marketplaces. Based on joint work with Omar Besbes (Graduate School of Business, Columbia University)

■ VSB18

Virtual Room 18

Economic and Operational Considerations in Cloud Computing Market

Sponsored: Information Systems

Sponsored Session

Chair: Leila Hosseini, Temple University, Philadelphia, PA, United States United States

1 - Capacity Reservation and Leasing Plans for Periodic Random Demand Surges

Shi Chen, Associate Professor of Operations Management, University of Washington, Foster School of Business, Seattle, WA, 98195, United States, Junfei Lei, Kamran Moinzadeh

How to reserve and deploy capacity of resources to meet demand that has periodic surges with random magnitude and duration? Such a problem is common in cloud computing where a firm leases computing capacity from a cloud provider to meet demand from end customers. The firm can utilize a reservation contract to meet its long-term capacity needs, supplemented by short-term and on-demand contracts to meet the surges in demand. We first develop procedures for determining the optimal capacity levels and the lengths of the contracts. Through a numerical study, we find that the firm should optimally acquire more capacity through a supplementary contract with a longer duration, if the unit discount rate increases, the transaction fee decreases, and the average surge and inter-surge durations increase. In such cases, the firm benefits more from a marketplace for trading contracts.

2 - Pricing Cloud Computing Instances: Reserved, On-demand, or Hybrid Model?

Tarun Jain, Indian Institute of Management Bangalore, Bangalore, India, Jishnu Hazra, Subodha Kumar

Public cloud providers offer various pricing models: on-demand pricing, reserved pricing, and a hybrid of these two pricing models, which help businesses to handle demand uncertainties. Besides, the buyer firms seeking cloud solutions also invest in some private cloud infrastructure. Therefore, one of the challenges that have emerged at the public cloud provider’s end is pricing cloud instances under demand uncertainties. This paper addresses this gap by studying various pricing models offered by cloud providers. We develop a game-theoretic model to determine the cloud provider’s pricing schemes and the buyer firm’s capacity portfolio decision.

3 - When Free Can Be Costly: An Analysis of Webspeed Competition in the Presence of Cloud Computing

Leila Hosseini, Assistant Professor, Fox School of Business, Temple University, Philadelphia, PA, United States, Vijay S. Mookerjee

The prominent search engines such as Google use Webspeed as an important input in their ranking of search results. We adopt a game-theoretic approach to examine two Webspeed competition regimes: (1) Capacity-based, (2) Response-based. In capacity-based competition, two firms choose their computing capacity and the market traffic splits between the competing firms based on response time. On the other hand, another traffic game can occur based on website response time and the market traffic splits based on their chosen response time. In this game, the response time derives the capacity. We show that competition can intensify under response-based competition. Thus, the provider of computing capacity (cloud provider) earns more under response-based competition. This explains why existing cloud providers offer capacity adjustment services (e.g., Autoscaling) for free.

■ VSB19

Virtual Room 19

Advances on Queueing and Learning

Sponsored: Applied Probability Society

Sponsored 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, 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 - Explicit Steady-state Approximations for Parallel-server Systems

Yaosheng Xu, Cornell University, Ithaca, NY, United States, Jim Dai

The weighted-workload-task-allocation (WWTA) load-balancing policy is known to be throughput optimal for parallel-server systems. This work concerns the steady-state performance approximation of WWTA policy in heavy traffic. Instead of proving a stochastic process limit followed by a limit interchange — a method that dominates the literature, our method works directly with pre-limit BAR that characterizes the stationary distribution of each pre-limit system. Under a complete-resource-pooling condition, we prove that WWTA achieves a "strong form" of state-space collapse in heavy traffic and that each scaled workload converges in distribution to an exponential random variable, whose parameter is explicitly given by system primitives. Various steady-state performance measures are shown to be approximated from this exponential random variable.

3 - On the Convergence Rate of Entropy-regularized Natural Policy Gradient with Linear Function Approximation

Semih Cayci, University of Illinois, 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.

4 - 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.

■ VSB20

Virtual Room 20

APS - Advances in Stochastic Modeling and Control

Sponsored: Applied Probability Society

Sponsored Session

Chair: Harsha Honnappa, Purdue University, West Lafayette, IN, 47907-2023, United States

1 - A Stochastic Control Approach to Quasi-stationary Distributions

Pierre Nyquist, KTH Royal Institute of Technology, 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.

2 - Controlled Jump Diffusions with Mean Field Interaction and Regime Switching

Prakash Chakraborty, University of Michigan, Ann Arbor, MI, 47907, United States, Erhan Bayraktar

We consider the optimal control of a regime switching McKean-Vlasov jump diffusion. The switching is modelled by a continuous time Markov Chain. The dynamic programming Hamilton-Jacobi-Bellman equation is obtained, and we show that the value function is the appropriately interpretated unique viscosity solution. In order to obtain finite-dimensional particle approximations we consider the large population cooperative problem with mean field interaction under a common regime switch.

3 - Markovian Equilibria in Ergodic Many-Player Games and Mean-Field Games.

Asaf Cohen, University of Michigan, Ann Arbor, MI, 48109, United States, Ethan Zell

We consider a symmetric stochastic game with weak interactions between many players. Time is continuous, the number of states is finite, and costs are ergodic. We prove the existence of a unique Nash equilibrium in the game and show that its limiting behavior (as the number of players goes to infinity) is governed by the unique mean-field equilibrium of the corresponding mean-field game.

4 - Information Projections On Banach Spaces with Applications to KL Weighted Control and a Feynman-Kac Formula for ODEs

Zachary Selk, Purdue University, West Lafayette, IN, United States, Harsha Honnappa, William Haskell

In this talk, we discuss a portmanteau theorem establishing the equivalence between information projections on a Banach space, constrained Kullback-Leibler weighted control, finding the mode of a measure through Onsager-Machlup formalism and in the classical Wiener space case, an Euler-Lagrange equation. As one example of an application of our theorem, we discuss a Feynman-Kac type formula, showing that the solution to a second order linear ODE (or system of ODEs) is the mode of a particular diffusion. Our portmanteau theorem along with our Feynman-Kac result provides numerics and insight for solving these ODEs.

■ VSB21

Virtual Room 21

APS Special Session on 'Bandits and Reinforcement Learning'

Sponsored: Applied Probability Society

Sponsored Session

Chair: Siva Theja Maguluri, ISyE Georgia Tech, Atlanta, GA, 30339, United States

1 - Bandits and Reinforcement Learning

Shipra Agrawal, Columbia University, New York, NY, 10027-6623, United States

In this tutorial, I will discuss some recent theoretical results in bandits and reinforcement learning and their applications to operations management problems.

■ VSB22

Virtual Room 22

Applying for SBIR/STTR Grants

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, 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.

■ VSB23

Virtual Room 23

Data Analytics for Structured Data from Advanced Sensing Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Andi Wang, Georgia Institute of Technology, Atlanta, GA, 30318-5546, United States

Co-Chair: Jianjun Shi, ISyE Georgia Tech, Atlanta, GA, 30332-0205, United States

1 - Porosity Prediction for Metal Additive Manufacturing Based on Sparse Labeled Data

Ayantha Senanayaka, Mississippi State University, Mississippi State, MS, United States, Wenmeng Tian, Linkan Bian

The objective of this study is to develop an effective porosity prediction method for metal additive manufacturing. Recently, many studies have utilized machine learning to map thermal history of the AM process to the porosity of resultant part. Supervised learning requires a large number of expensive labeled porosity data, whereas unsupervised learning only identify process anomalies that do not necessarily result in porosity. We propose a new non-destructive porosity prediction scheme based on transfer learning, which allows to transfer the thermal-porosity relationship between parts with reduced efforts on porosity characterization. We validate the method using a real-world case study of powder blown additive manufacturing process. Equivalent prediction accuracy is achieved with significantly reduced labeled data.

2 - Robust Tensor PCA Based Background/foreground Separation in Noisy Videos and its Applications in Additive Manufacturing

Bo Shen, Virginia Tech, Blacksburg, VA, 24061, United States, Zhenyu James Kong

Background/foreground separation is one of the most fundamental tasks in computer vision, especially for video data. In real-world applications, the video data is contaminated with noise. For example, in metal additive manufacturing (AM), the processed X-ray video to study melt pool dynamics is very noisy. To achieve the three terms decomposition, a smooth sparse RTPCA (SS-RTPCA) model is proposed to decompose the data into the static background, smooth foreground, and noise, respectively. An efficient algorithm based on alternating direction method of multipliers (ADMM) is implemented to solve the proposed model. Extensive experiments on both simulated and real data demonstrate that the proposed method significantly outperforms the state-of-the-art approaches for background/foreground separation in noisy cases.

3 - 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.

4 - A DL-based Approach for Reconstruction and Prediction of Multi-Modal Physiological Signals

Huiyu Huang, Northeastern University, Boston, MA, United States, Shaodi Qian, Chun-An Chou

In this work, we propose a new deep learning-based approach to model and analyze physiological data for a human body network of multiple modalities (e.g., ECG, EDA, respiration, etc.) in response to external stimuli. Specifically, we develop a new auto-encoder framework based on the Koopman theory and dynamic system theory to fuse multi-modal non-linear physiological data and learn the linear dynamics in the intrinsic space. The proposed method is applied to recognizing physiological responses to distracted driving. The computational results demonstrate the capability to reconstruct multi-modal data with incomplete information and noises, and in turn the significant effectiveness with minimized errors in prediction within a short time.

■ VSB24

Virtual Room 24

High-Dimensional Data Analytics for Systems Informatics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL, 32608-1047, United States

Co-Chair: Ruizhi Zhang, University of Nebraska- Lincoln, Lincoln, NE, 68583, United States

1 - Anomaly Detection in Streaming Unstructured High-Dimensional Data using Graph Laplacian Based Regularization

Qian Wang, Georgia Institute of Technology, Atlanta, GA, United States

Anomaly detection is widely applied in numerous manufacturing applications for quality control purposes like rolling process. The literature have been focused on detecting the anomalies under some underlying intrinsic trends of data. However, these methods mainly focus on the structured data like images, videos, or structured point cloud, and they cannot be applied in the case of missing data, non-rectangular images or point cloud of more complex unstructured shape. Traditional methods, however, don't focus on removing those underlying trends. In this paper, we propose a novel anomaly detection method using autoencoder and Graph Laplacian Based smoothness regularization, focusing on removing the underlying trends in the unstructured data. We specially focus on the type of clustered anomalies, and use convolutional methods for stronger detection power and a novel Graph Laplacian Based Fused Lasso regularization method on the anomaly part to have better post-diagnosis results.

2 - Physics-constrained Deep Learning for High-dimensional Predictive Modeling

Jianxin Xie, Oklahoma State University, OK, United States, Bing Yao

The rapid developments in advanced sensing and imaging facilitate the effective modeling and control of complex systems. However, the high-dimensional sensing data are generally complexly structured, and realizing the full data potential depends on advanced analytical and predictive methods. Our work presents a physics-constrained deep learning framework for high-dimensional predictive modeling. The proposed P-DL approach is implemented to solve the inverse ECG problem. Experimental results show that the proposed P-DL method significantly outperforms existing methods that are commonly used in current practice.

3 - Season-dependent Parameter Calibration in Building Energy Simulation With Multi-dimensional Parameters

Cheoljoon Jeong, University of Michigan, Ann Arbor, MI, United States, Ziang Xu, Eunshin Byon, Kristen Cetin

A building energy simulator enables us to predict and analyze building energy consumption which consists of a large portion of the U.S. electricity loads. To accurately simulate a building's energy response, several simulation parameters need to be carefully calibrated. Among those parameters, some parameters are season-dependent, whereas other parameters should be globally employed throughout a year. Existing studies in parameter calibration ignore such seasonal dependency, which causes suboptimal calibration results. This study casts the problem into a multi-objective optimization problem and presents a new solution procedure.

4 - Physics-guided Spatio-Temporal Super-Resolution of an Advection-diffusion Process

Kyongmin Yeo, Research Scientist, IBM Research, Yorktown Heights, NY, United States, Andres Codas, Levente Klein

Reconstructing high-resolution (HR) information from a low-resolution (LR) data has been of great interest. While most of the so-called super-resolution (SR) models rely on a supervised training with high-resolution ground truth data, in many real-life problems, such ground truth data is either difficult to create or nonexistent. Here, we present a deep learning model for a space-time SR from a sequence of LR images for advection-diffusion problems without the ground truth HR data. We use a state-space representation to reconstruct the HR fields with the mass conservation constraints. The proposed method is verified by using two-dimensional CFD simulations.

■ VSB25

Virtual Room 25

Frontiers in Stochastic Models and Simulation

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Opher Baron, University of Toronto, Toronto, ON, M5S 3E6, Canada

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

3 - Mining Simulation Models from Event Data

Arik Senderovich, University of Toronto, Toronto, ON, M5S 3G6, Canada, Dmitry Krass, Opher Baron

Analytical and simulation models have been used extensively to analyze service systems. These models always require substantial manual effort: one must hire an outside expert or develop in-house capabilities for modeling the system. The process of modeling is time-consuming and demanding. Moreover, human-constructed models are inherently subjective - two experts looking at the same system may well come up with very different representations. With the availability of ample event data, the field of queue mining has been attempting to automate the process of modelling systems. Specifically, the idea was to replace the modeler, or at least assist the modeler by converting the modelling process into a semi-automated procedure. In this work, we present ServiceMiner, a queue mining approach and tool that constructs queueing models automatically from event data.

4 - Obtaining Inter-departure Times for Two Customer Types

Eliran Sherzer, Post-doc, University of Toronto, Toronto, ON, Canada, Opher Baron, Oded Berman, Dmitry Krass

Queueing networks that do not fall under the BCMP product form are quite complex. One of the main challenges is inter-departure times, which are also the inter-arrival times of the next queue. In an attempt to evaluate the distribution of the inter-departure times, the following queue is considered. There are two customer types, 0 and 1, which arrive from a Poisson process with different rates. Both customer types require exponential service but with different services. We propose a decomposition method to obtain the inter-departure times for each type. We show that this method is both fast and accurate.

■ VSB26

Virtual Room 26

Information Design and Incentive Management

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Peng Sun, Duke University, Durham, NC, 27708-0120, United States

Co-Chair: Saed Alizamir, Yale University, New Haven, CT, 6520, 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 - Presenter

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.

3 - Informing the Public About a Pandemic

Francis de Vericourt, ESMT Berlin, Berlin, Germany, Huseyin Gurkan, Shouqiang Wang

This paper explores how governments may efficiently inform the public about an epidemic to induce compliance with their confinement measures. Using an information design framework, we find the government has an incentive to either downplay or exaggerate the severity of the epidemic if it heavily prioritizes the economy over population health or vice versa. Importantly, we find that the level of economic inequality in the population has an effect on these distortions. The more unequal the disease's economic impact on the population is, the less the government exaggerates and the more it downplays the severity of the epidemic. When the government weighs the economy and population health sufficiently equally, however, the government should always be fully transparent about the severity of the epidemic.

■ VSB27

Virtual Room 27

Operations Models for Omni-Channel Settings and Developing Economies

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Opher Baron, University of Toronto, Toronto, ON, M5S 3E6, Canada

Co-Chair: Gonzalo Romero, Rotman, University of Toronto, Toronto, ON, M4K 1Y5, Canada

1 - Clearing Model of Interbank Payments

Shuzhen Chen, University of Toronto, Toronto, ON, Canada, Opher Baron, Ningyuan Chen

We study a dynamic debt clearing problem for interbank payment systems, when minimizing the total liquidity and clearing costs. We show that the dynamic program has a state-space reduction and it is not necessary to track all pairwise debts. We show that the optimal policy always clears the offsetting debt first. Under certain conditions, it is optimal to either clear all debts in the system or not to clear at all in each period. Our results provide guidelines on the clearing frequency and magnitude for central banks.

2 - Store Sequencing for Online Order Fulfillment in an Omni-Channel Retailer
Sinem Kinay, Rotman School of Management, Toronto, ON, Canada, Opher Baron, Andre Augusto Cire

We investigate a data-driven approach to the online order fulfillment processes of a Canadian omni-channel retailer. Online orders are primarily satisfied by a distribution center and in case of insufficient inventory, brick-and-mortar stores can ship the order. However, stores can accept or reject a fulfillment request based on local information unknown to the retailer. The retailer must then establish a sequence of stores to request fulfillment to minimize expected transportation and delay costs. We investigate policies for single and multi-item order problems and evaluate different heuristics that leverage a large-scale data set provided by the retailer.

3 - An Operational Perspective on Micro-financing in Developing Countries
Elaheh Rashidinejad, Rotman School of Management, University of Toronto, Toronto, ON, Canada, Opher Baron, Gonzalo Romero

We study two microfinancing structures in developing countries where the people at the Base of Pyramid borrow loans to start their new business. Each borrower acts as a newsvendor and decides about her stocking quantity and effort levels. We compare community banks, which can apply social pressure on the newsvendor to pay all of its installment back, with social banks, which have no mechanism to recoup the loan in the newsvendor's bankruptcy scenario. We study the banks under profit maximization or zero profit objectives. We characterize conditions under which the community-based structure improves efficiency and generates higher individual and social welfare in equilibrium with respect to each objective.

4 - Rent to Own Models with Uncertain Income
Hosain Zaman, Toronto, ON, Canada

Abstract not available at this time.

■ VSB28

Virtual Room 28

Data Driven Applications in Healthcare Operations

Sponsored: MSOM/Healthcare

Sponsored 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 with 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%.

5 - Operational and Health Effects of HIV Screening in the Emergency Department
Craig Froehle, University of Cincinnati, Cincinnati, OH, 45221-0130, United States, David Rea, Michael Lyons

Early detection of HIV leads to improved patient outcomes and reduced transmission. Emergency departments are a challenging but highly prioritized venue for HIV screening. While a wide range of screening approaches have been implemented across the country, the impact of screening on usual ED operations is undefined and the best approach remains unclear. Using discrete-event simulation and process data from a large academic medical center, this research characterizes the tradeoff between efforts to increase HIV detection, improving public health, and the potential for increased congestion in emergency departments.

■ VSB29

Virtual Room 29

FinTech and Supply Chain Risks

Sponsored: MSOM/iForm

Sponsored Session

Chair: Fasheng Xu, Syracuse University, Syracuse, NY, 13244-4418, 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.

1 - Contract Tokenization in the Renewable Energy Market
Jingxing (Rowena) Gan, Cox School of Business, Southern Methodist University, Dallas, TX, 75225-4036, United States, Rong Li

Endorsed by the blockchain technology, supply chain contracts can be digitally recorded and stored in crypto tokens, which is referred to as being tokenized. Tokenized contracts offer new ways of financing, trading and owning an asset. Using the renewable energy market as a backdrop, we study the impact of contract tokenization on different parties in the supply chain based on their respective incentives.

2 - Corporate Social Responsibility in Supply Chain: Green or Greenwashing?
Jing Wu, Chinese University of Hong Kong, Decision Sciences and Managerial Economics, Hong Kong, Hong Kong, Yu Zhang

Perception regarding a focal firm's corporate social responsibility (CSR) depends not only on itself but also on its known suppliers. This paper provides the first empirical evidence linking CSR and supply chain information disclosure together. Specifically, it uncovers robust evidence that firms greenwash their CSR image via voluntarily disclosing environmentally responsible suppliers while concealing "bad" ones.

■ VSB30

Virtual Room 30

Service Operations, Strategic Customers and Queuing

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Chenguang Wu, Hong Kong University of Science and Technology, Clear Water Bay, 60208, Hong Kong

1 - Capacity Rationing in Multi-server, Non-preemptive Priority Queues

Tianshu Lu, University of Toronto-Rotman School of Management, Toronto, ON, M5S 3E6, Canada, Opher Baron, Jianfu Wang

Many service and manufacturing systems use both capacity rationing and priority to differentiate among their customers. We model these as a two-class non-preemptive priority M/M/c queueing model and the practice of capacity rationing. For these systems we separately address two important features: supply is narrowly matched with demand and heterogeneous service rates for different customer types. When the service times of both classes are identical, our asymptotic results indicate that the non-degenerative capacity rationing level does not exceed $O(\sqrt{c})$. When the service times of both classes differ, we derive exact solutions for different performance measures using queueing and Markov chain decomposition. We show that a low level of capacity rationing can significantly reduce the waits of high priority customers with little effect on low priority customers' wait.

2 - Signaling Demand via Queue Visibility

Qiuyi Yan, Hong Kong University of Science and Technology, Kowloon, Hong Kong, Ying-Ju Chen, Chenguang Wu

We consider a queuing system in which customers' arrival rate is uncertain and the realized arrival rate is the server's private information. We incorporate strategic customers and study the server's optimal queue visibility policy (i.e., whether to reveal the queue length or not) to maximize the throughput when the visibility decision itself serves as a signaling device to signal its demand, shape customers' beliefs, and affect their joining decisions. We show that the server behaves differently compared to the complete information case. For a certain range of demand parameters, a server who faces a low demand rate, and thus hides its queue length under complete information now chooses to reveal the queue length to differentiate itself from servers with high demand rate, who are still better off hiding the queue length.

3 - Capacity Allocation and Scheduling Control for Service Systems With Unknown Customers' Patience

Lun Yu, Tsinghua University, Beijing, 60208, China, Zeyu Zheng, Zuo-Jun Max Shen

We consider an online learning formulation of a capacity allocation and scheduling problem for an M/G/1+G queueing system. The system manager's goal is to minimize a long-run average operation cost. Due to customers' patience times are initially unknown, the system manager periodically reviews and updates the capacity allocation and scheduling policy based on observed customers' abandonment decisions. We propose a stochastic gradient descent algorithm to approximately solve the problem and conduct an asymptotic analysis of the algorithm. Based on a new finite-time bound of M/G/1+G queue, we show that, as the size of the system grows, our algorithm terminates at an asymptotically optimal policy with logarithmic regret.

4 - Add On Pricing: A Queuing Perspective

Chenguang Wu, Hong Kong University of Science and Technology, Clear Water Bay, 60208, Hong Kong

Motivated by the common practice of add-on pricing, we explore the optimal strategy to sell the main and add-on services in a queuing context with delay-sensitive customers. We focus on two pricing schemes: bundle pricing that charges a single price to sell two services altogether, and separate selling that charges distinct prices for each service. We show that in the absence of queuing, separate selling strictly dominates bundle pricing across the board. However, when there is queuing at the main service but not the add-on, bundle pricing is optimal under a large customer demand due to a capacity constraint and an endogenous queuing cost. When congestion takes place at both services, separate selling can dominate under a large customer demand, and when it does, we identify its strength in regulating congestion as the key driver.

■ VSB31

Virtual Room 31

Service Economics and Revenue Management

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Andrew E Frazelle, The University of Texas at Dallas, Dallas, TX, 75205-3685, United States

1 - Ownership Utility of Rental Products in Rent-to-own Businesses

Milad Armaghan, University of Texas at Dallas, Richardson, TX, 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 - Matching Impatient And Heterogeneous Demand And Supply

Levi DeValve, University of Chicago, Chicago, IL, 60637-1656, United States, Angelos Aveklouris, Amy R. Ward

Service platforms must determine rules for matching heterogeneous demand (customers) and supply (workers) that arrive randomly over time and may be lost if forced to wait too long for a match. For such systems, we characterize asymptotically optimal matching policies that balance the reward from making good matches against the cost of waiting, even for general (i.e., non-Markovian) reneging distributions. We show that the reneging distributions critically impact the optimal matching decisions, and therefore should be taken into account when designing a good policy. Further, we show that for a wide class of reneging distributions a static priority policy is optimal, which makes matches according to a fixed priority over supply-demand pairs.

4 - Multi-product Dynamic Upgrades

Xiao Zhang, Assistant Professor, Saint Louis University, Saint Louis, MO, 63108-3302, United States, Metin Cakanyildirim, Justin Goodson, Ozalp Ozer

Upgrades in travel industry are often static and offered either at the booking time or at the check-in time. In this paper, we study dynamically-offered upgrades by a multi-product firm via notifications (e.g., emails) between the booking and the check-in times.

■ VSB32

Virtual Room 32

Omnichannel Retail and E-tailing

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Leela Aarthy Nageswaran, University of Washington, Seattle, WA, 98195, United States

1 - The Effect of Offering Additional Fulfillment Options

Chloe Kim Glaeser, University of North Carolina at Chapel Hill Kenan-Flagler Business School, Chapel Hill, NC, 27514-5923, United States

We partner with an online grocery retailer and use data-driven analytics to answer the practice-based question of the optimal mix of delivery zones and fulfillment options. We investigate how consumers respond to the locally tailored fulfillment options made available to them by the online grocer. We document asymmetric effects on cross channels of the fulfillment introduction and investigate the source of this asymmetry.

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 - Offline Returns for Online Retailers Via Partnership

Leela Nageswaran, University of Washington, Seattle, WA, 98195, United States, Elina Hwang, Soo-Haeng Cho

Online shoppers often prefer to return items to stores than to mail them back. We study the emerging business practice where an online retailer and a store retailer partner to offer the store return option. Our results may explain partnerships that feature retailers with a high product range overlap as in the case of Amazon-Kohl's: the convenience of store returns causes more online shopping, but returning customers may also buy store products, making the partnership a win-win. In contrast, partnerships may also feature retailers with low overlap as in the case of Everlane-Paper Source.

4 - 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.

5 - The Impact of Strategic Consumer Behavior on Shipping and Return Policies of Omnichannel Retailers

Abhishek Roy, Fox School of Business, Philadelphia, PA, United States, Zhuping Liu, Subodha Kumar

By the virtue of its operations, an omnichannel retailer can select from a wider set of shipping and return options. These shipping and returns policies impact consumer behavior, and therefore the supply chain decisions. We address the following main research questions. First, how do different consumers change their purchasing behavior, based on an omnichannel retailer's shipping and returns policies? Secondly, how does an omnichannel retailer's choice of shipping and return policies affect supply chain and financial performance? We develop an analytical modeling framework to study the interaction between different shipping and returns policies of the retailer with the consumers' purchasing and returns behaviors, and their implications on supply chain decisions.

■ VSB33

Virtual Room 33

Emerging Pricing and Sales Promotion Strategies

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Bharadwaj Kadiyala, University of Utah, Salt Lake City, UT, 84112-8939, United States

1 - E-tailers' Inventory Storage Location and Pricing Decisions With Strategic Consumer Behavior Consideration

Chao Liang, Cheung Kong Graduate School of Business, Beijing, China, Yuxin Chen

We examine how strategic consumer behavior impacts e-tailers' inventory storage location, pricing and inventory level decisions. We build a stylized model where an e-tailer either has only a central warehouse, or add a local warehouse and thus has both warehouses. Central (Local) warehouse is away from (close to) consumer place so shipping cost to consumers is high (low) while inventory holding cost is low (high). We show that with strategic consumers, the firm lowers price after moving inventory locally. The behavioral impact from a higher local holding cost or a more perishable product can increase firm profit, and the firm may stop using local warehouse when local holding cost decreases. An e-tailer may want to add a local warehouse as demand uncertainty decreases, consistent with a recent practice by e-tailers that start building warehouses close to customers.

2 - 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.

3 - Retailer and Manufacturer Perspectives on Trade Promotions Involving In-store Promotional Displays

Oguz Cetin, Kelley School of Business, Bloomington, IN, 47405-1701, United States, Adam J. Mersereau, Ali Kemal Parlakturk

Manufacturers often provide incentives (trade deals) to induce retailers to feature their own products by displaying and discounting the retail price, but it is not always in a retailer's best interests to feature a particular product, because the retailer's objectives are more closely aligned with the overall category profits. We examine mainly two important questions in this context. First, how should a retailer respond to a manufacturer's trade promotion offer, where a response consists of decisions on how much of the trade promotion to pass-through to the customers and whether to feature the product on a promotional display? Second, how should a manufacturer design its trade promotion offer? We use multinomial logit to model customer choice and study a bi-level optimization framework to answer these questions.

4 - 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.

■ VSB34

Virtual Room 34

Social Responsibility and Sustainability in Supply Chains: Incentives, Monitoring, and Strategies

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Han Zhang, Michigan State University, East Lansing, MI, United States

1 - Going Green On Loans: The (In)Efficiency of Sustainability-linked Loans

Guitian Liang, Jinan University, Guangzhou, China, Vernon Hsu, Yang Li

We consider the efficiency of the thriving sustainability-linked loans (SLLs) which connect banks' lending interests to borrowing firms' environmental, social, and governance (ESG) performances. Although SLLs are effective in inducing firms to exert greater efforts in ESG, they also erode firms' profits. We thus suggest refined SLLs that protect borrowing firms' benefits while promoting ESG engagements. We also discuss the role of government subsidies under SLLs.

2 - Deadstock Fabric: The Role of Upcycling and Postponement Strategies

Xiaoyang Long, University of Wisconsin-Madison, 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.

3 - Plastic Recycling In Agriculture Industry

Wenli Xiao, University of San Diego, San Diego, CA, United States, Feifei Shan, Yinping Mu

In this study, we compare three prevailing forms of agricultural film recycling. In Penalty Scheme, the farmer collects the used film, pays for the recycling, and pay fines if missing the collection target. In Reward Scheme, the farmer receives rewards for collecting used film, while the social planner pays for recycling. In Service Scheme, the manufacturer is responsible for the entire life cycle of the product including producing, collecting and recycling. We show that the Service Scheme dominates with respect to social welfare if the penalty for missing the collection target is high. Our results suggest the social planner should set a sufficiently high penalty if the manufacturer is responsible for collecting and a moderate penalty if the farmer is responsible for collecting.

4 - The Effect of Supplier Delegation and Information Proximity on Multi-tier Responsible Sourcing

Sammi Tang, University of Miami, Coral Gables, FL, 33146, United States, Jeannette Song

Motivated by the Mattel recall incident, in this paper we develop an analytical framework to study under what situations supplier delegation is particularly vulnerable for responsibility risk and how to mitigate such risks. We consider a three-tier supply chain consisting of a buying firm, a Tier-1 contract manufacturer, and Tier-2 suppliers, where risk stems from irresponsible Tier-2 suppliers. Under a guided delegation approach, the buyer provides an authorized supplier list but the ultimate supplier selection and monitoring responsibility are delegated to the better informed Tier-1 firm. We examine the effect of the guided delegation approach on the buyer's profit and supply chain risk.

■ VSB35

Virtual Room 35

Operation Research for Emerging Resources: Hybrid Power Plants, Virtual Power Plants, Batteries and Beyond

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Evangelia Spyrou, National Renewable Energy Laboratory, Golden, CO, 80401, United States

1 - Data Analytics and Optimization for the Optimal Bidding of a Virtual Power Plant

Daeho Kim, Pohang University of Science and Technology (POSTECH), Pohang, Korea, Republic of, Hyungkyu Cheon, Dong Gu Choi, Seongbin Im

As distributed energy resources (DERs) continue the emerging trend, virtual power plant (VPP) has been introduced. Among operational problems of VPP, we focus on the optimal bidding problem in the Korean day-ahead market. We formulate a multi-stage stochastic programming model and use a stochastic dynamic programming-based solution approach. To describe the uncertainty of power supply from DERs, we establish frameworks to generate data-driven scenario trees or lattices. In addition, we apply heuristics and verify the performance and practicality through the test based on real data.

2 - Integration of Pumped Hydro Energy Storage and Wind Energy Generation

Emre Nadar, Bilkent University, Ankara, 6800, Turkey, Harun Avci, Ece Cigdem Karakoyun, Ayse Selin Kocaman, Parinaz Toufani

We study the energy generation and storage problem for a hybrid energy system that includes a wind farm and a pumped hydro energy storage facility. We model the problem as a Markov decision process under uncertainty in energy sources and price, and characterize the optimal policy structure.

3 - 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.

4 - 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.

■ VSB36

Virtual Room 36

Data-Driven Optimization and Control for Power Systems

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Yujie Tang, Harvard University, Cambridge, MA, 02138-2933, United States

Co-Chair: Xin Chen, Harvard University, Cambridge, MA, United States

1 - Model-free Optimal Voltage Control in Distribution Systems Via Continuous-time Zeroth-order Methods

Xin Chen, Harvard University, Cambridge, MA, United States, Jorge I. Poveda, Na Li

In this work, we develop a model-free optimal voltage control algorithm based on projected primal-dual gradient dynamics and continuous-time zeroth-order method (extreme seeking control). This proposed algorithm i) operates purely based on voltage measurements and does not require any other model information, ii) can drive the voltage magnitudes back to the acceptable range, iii) satisfies the power capacity constraints all the time, iv) minimizes the total operating cost, and v) is implemented in a decentralized fashion where the privacy of controllable devices is preserved and plug-and-play operation is enabled. We prove that the proposed algorithm is semi-globally practically asymptotically stable and is structurally robust to measurement noises. Lastly, the performance of the proposed algorithm is further demonstrated via numerical simulations.

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 - Grid-interactive Building Control Using Reinforcement Learning With Global-local Policy Search

Andrey Bernstein, NREL, Golden, CO, 80401, United States

We develop a grid-interactive building controller based on a deep reinforcement learning (RL) approach. The controller is designed to facilitate building operation during normal conditions and demand response events, while ensuring occupants comfort and energy efficiency. We leverage a continuous action space formulation, and devise a two-stage global-local RL training framework. In the first stage, a global fast policy search is performed using a gradient-free RL algorithm. In the second stage, a local fine-tuning is conducted using a policy gradient method. In contrast to the state-of-the-art model predictive control (MPC) approach, the proposed RL controller does not require complex computation during real-time operation and can adapt to non-linear building models. We illustrate the controller performance numerically using a five-zone commercial building.

4 - 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.

■ VSB37

Virtual Room 37

Risk Measures in Power Systems

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Richard Paul O'Neill, ARPA-E, Silver Spring, MD, 20904-2924, United States

Co-Chair: Ashley Arigoni, QS-2 (subcontractor to ARPA-E), QS-2 (subcontractor to ARPA-E), Denver, CO, 80209-4510, United States

Co-Chair: Joseph King, DOE, Washington, DC, United States

Co-Chair: Richard Wilson, ARPA-E, Silver Spring, MD, United States

1 - Risk Dashboard for Power Systems

Daniel Bienstock, Columbia University, New York, NY, United States

Our work focuses on modeling of stochastic risk in day ahead power markets and on development of appropriate financial instruments to help power system stakeholders manage such risk. Both elements are put together in a 'risk dashboard,' a software package designed for effective visualization of risk and opportunities.

2 - An Integrated Framework for Effective Management of Delivery Risk in Electricity Markets

Evangelia Spyrou, National Renewable Energy Laboratory, Golden, CO, United States, Robin Broder Hytowitz, Benjamin Field Hobbs, Helyette Geman, Yuanye Ma, Mengmeng Cai, Yajing Liu, Mohamed Al Ashery, Mads Almassalkhi, Paul Hines, Yingchen Zhang

Under a three-year project funded by the ARPA-E PERFORM program, our team is working towards developing an integrated risk management framework that will leverage flexibility from distributed and bulk resources to cost-effectively and reliably manage delivery risk of intermittent resources. Two novel concepts are at the core of the proposed integrated risk management framework: (a) flexibility options, which are a novel type of options and enable wholesale electricity market participants to hedge uncertainty by buying flexibility; (b) DER flexibility scores, which provide a way for utilities or aggregators to classify assets in groups with different likelihood of delivering contracted flexibility. This presentation will provide an overview of the two novel concepts and summarize key simulation results that illustrate their value.

3 - Abscores, An Electric Assets Risk Bureau

Alberto J. Lamadrid L., Lehigh University, Bethlehem, PA, United States

In this presentation we will discuss a project funded by the Advanced Research Projects Agency -Energy, ARPA-E, under the PERFORM program. This proposed effort will develop a framework for asset and system risk management that can be incorporated into current electricity system operations to improve economic efficiency. We plan to establish an Electric Assets Risk Bureau.

4 - Risk-segmented Renewable Generation Contracts for Day-ahead Market

Aparna Gupta, Rensselaer Polytechnic Institute, Troy, NY, 12180-3522, United States

Risk segmentation techniques can break a bundle of risk into different grades of risk that are more appropriately priced and managed. We apply these techniques to the stochastic generation of renewable resources to enable their participation in the day-ahead power markets. Additionally, comparison against conventional generators day-ahead contracts allows benchmarking our designed renewable contracts.

■ VSB38

Virtual Room 38

Distributed Energy Gneration

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Alexandra M Newman, 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.

4 - Priority Chronological Time-Period Clustering for Generation and Transmission Expansion Planning Problems With Inter-Day Constraints

Álvaro García-Cerezo, Universidad de Castilla-La Mancha, Ciudad Real, Spain, Raquel García-Bertrand, Luis Baringo

This work proposes a novel clustering method that prioritizes the representation of extreme values of the input data keeping their chronological information through the whole time horizon in generation and transmission expansion planning problems. The proposed clustering technique is used to model the short-term uncertainties associated with the demand level and the renewable production from solar- and wind-power units. Numerical results show that a reduction of the computational burden is attained if the proposed method is applied in comparison with other methods since it leads to investment plans closer to the optimal solution when less representative time periods are considered.

■ VSB39

Virtual Room 39

Topics in Sustainability

Sponsored: ENRE/Environment and Sustainability

Sponsored Session

Chair: Arzum E Akkas, Boston University, Cambridge, MA, 02142-1365, United States

Co-Chair: Dorothee Honhon, University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - Recycling of Post-Disaster Debris: A Game Theoretical Approach

Daniel Kim, ISyE Georgia Tech, Atlanta, GA, United States, Pinar Keskinocak, Beril L. Toktay

Natural disasters can generate a large volume of post-disaster debris. While this debris is typically disposed of, recycling is a sustainable recovery operation that has increasingly gained attention. Stakeholders from multiple government levels and the private sector are involved in policy and operational decisions regarding debris recycling. We analyze the implications of different policy choices and recycling process efficiencies on debris recycling outcomes, accounting for the interests of the misaligned stakeholders.

2 - Cleaning After Solar Panels: A Circular Outlook

Serasu Duran, Assistant Professor, Haskayne School of Business, Calgary, AB, T2N 1N4, Canada, Atalay Atasu, Luk N. Van Wassenhove

The sharp reduction in renewable generation costs, especially solar, in the past decade led to rapid growth in adoption of these technologies. Research and industry circles widely accept that installed technologies will last their entire projected lifetime of about 30 years. We posit that the progress in technology along with shrinking prices imply that replacement will be much more frequent, and customers may find it economical to replace their solar panels as early as after 2 years. Large volumes of waste are expected in the very near future, and it is unclear yet who will be bearing the end-of-life costs and how. Moreover, lack of financially viable recycling technology can easily jeopardize the cost competitiveness of solar technology.

3 - Environmental Violations in China: Evaluation of Long-term Impact and Prediction of Future Violations

Yi Zhou, Monash University, Melbourne, Australia, Chris K. Y. Lo, Christopher S. Tang

Catching unethical firms that have violated environmental regulations is always a challenge to regulators. We aim to address this concern by taking a risk-assessment framework to describe the strategic dynamics between an unethical firm and the government. By considering all 1542 environmental incidents committed by 418 public Chinese manufacturers from 2004 to 2013, we find empirical evidence that firms with exposed environmental incidents have a lower ROA in consecutive years only after they were exposed. We develop a predictive risk scoring system and expose over 71% of the violations in 2013 by inspecting only 21.5% of the firms with risk scores above the top 80 percentile based on training data from 2004-2012. Therefore, our predictive analytical approach can be used as a building block for developing a more effective inspection mechanism.

4 - 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.

5 - Reducing Food Waste: An Operations Management Research Agenda

Arzum E. Akkas, Boston University, Boston, MA, 02142-1365, United States, Vishal Gaur

Food waste is a critical problem with implications for global hunger and the environment. To address this problem, we propose a research agenda in Operations Management that is organized around five themes: supply chain technology, business model innovation, behavioral operations, supply chain logistics, and incentives and coordination.

■ VSB40

Virtual Room 40

Optimization Applied to Power Systems

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Luiz Augusto Barroso, PSR, Rio de Janiero, Brazil

Co-Chair: Joaquim Masset Lacombe Dias Garcia, PSR Inc, Rio de Janeiro, 22250-040, Brazil

1 - An Integrated Benders-decomposition and Progressive-hedging Technique for Nonanticipative Energy Resource Planning

Alessandro Junior, PSR, Rio de Janeiro, Brazil

We propose an integrated Benders Decomposition (BD) and Progressive Hedging (PH) approach (BDPH) for solving a large-scale Generation Expansion Planning (GEP) model. The model is stochastic and multiscale, with a detailed representation of short-term constraints with hourly resolution. Also, a temporal clustering technique is used, clustering the days into typical days.Since GEP involves integer decisions, the PH does not guarantee convergence. In contrast, BD guarantees convergence since the second-stage problem is convex. Yet, it may take many iterations. BDPH integrates both approaches, building a decomposition method that guarantees convergence with an improved convergence rate.

2 - Flow Based Market Coupling in Fundamental Electricity Market Models: Methods and Parametrization for Renewable-dominant Power Systems

Richard Weinhold, Technische Universität Berlin, Berlin, 10623, Germany

Europe's increase in electricity production from renewable energy resources (RES) has spawned political and academic interest in the transmission system's ability to accommodate this transition. Central to this discussion is the efficiency of capacity allocation and congestion management (CACM). To facilitate cross-border electricity trading in the presence of finite physical transmission capacity, European TSOs inaugurated flow-based market coupling (FBMC).

Our work provides a comprehensive overview on existing FBMC approaches and assumptions, and explicitly discusses the impact of high-shares of intermittent generation. Theses discussions are complemented by a case-study on the European electricity system in the intermediate future including a risk- and uncertainty-aware extension of the FBMC framework using chance constraints.

3 - Midterm Hydro-Thermal Generation Planning With PowerSimulation.jl

Sourabh Dalvi, National Renewable Energy Laboratory, Denver, CO, United States

Medium-Term Hydro Generation Scheduling plays an important role in the operation of hydropower systems. We assess the application of the progressive hedging algorithm for solving a large-scale multistage stochastic linear program for which decisions are distributed over an extended planning horizon with weekly time steps. The proposed model is build and solved using the open source power system modeling package PowerSimulations.jl and ProgressiveHedging.jl which is a basic implementation of the Progressive Hedging algorithm.

■ VSB41

Virtual Room 41

Approaches for Efficient Power Systems Operation

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Sebastian Souyris, University of Illinois Urbana-Champaign, Champaign, IL, 61820, United States

1 - Depth-based Outlier Detection for Grouped Smart Meters: A Functional Data Analysis Toolbox

Antonio Elias, Postdoctoral researcher, University of Málaga, Málaga, Spain, Juan Miguel Morales, Salvador Pineda

Smart metering infrastructures collect massive time series that present multiple and complex sources of seasonality and, among them, common daily patterns that are repeated between similar days or seasons and shared between grouped meters. In this work, we exploit this context to propose a new method to highlight individuals with abnormal daily evolution patterns termed dependency outliers. To do that, we approach the problem from a Functional Data Analysis (FDA), focusing on the morphological aspects of the curves, such as daily magnitude, daily shape, derivatives, and intra-day dependency. Our proposal, in conjunction with FDA shape and magnitude outliers detection methods, provides a toolbox for smart meters data that covers a wide palette of functional outliers classes. The toolbox is illustrated with residential and non-residential smart meters data sets.

2 - 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.

■ VSB42

Virtual Room 42

Models and Algorithms for Districting Problems

Sponsored: Computing Society

Sponsored Session

Chair: Zeyad Kassem, Arizona State University, Tempe, AR, United States

1 - Presenter

Huanfa Chen, University College London, London, United Kingdom, Tao Cheng

Street networks play an important role in shaping crime and policing activities, but have been relatively ignored in the design of patrol districts. To fill this gap, we propose a street-network police districting problem (SNPDP) that explicitly uses streets as basic units. This model defines the workload as a combination of workload attributes (i.e. number of streets, crime risks, and district diameter) and seeks balanced workloads of districts. This problem can be solved using a tabu-search method. The SNPDP model is tested in a case study in Greater London (UK), which generates patrol districts that are consistent with the crime risk and land use patterns. This model has the potential to generate street-based districts for other problems (e.g. school or health care zones).

2 - 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.

3 - Algorithms and Analysis for Centered Redistricting Plans

Daryl DeFord, Assistant Professor of Data Analytics, Washington State University, Pullman, WA, United States

Many of the tools developed in the previous census cycle for analyzing political redistricting rely on Markov chains defined on the space of contiguous partitions of a fixed graph and several recent innovations build on this analysis by extending the state space to incorporate additional annotations. These extensions offer algorithmic improvements as well as the ability to answer more detailed questions about the properties of the plans and ensembles. In this talk I will discuss the implications of one such class of models where each district is required to contain one or more marked centers. This is also a natural model for extending these approaches to school districting, where the school buildings serve as natural district centers, and I will also discuss some optimization work in this setting.

4 - A Binary Programming Formulation and Logic-based Cuts for Edge-based Districting Without Predetermined Centers

Zeyad Kassem, Arizona State University, Tempe, AR, United States, Adolfo Raphael Escobedo

We introduce an edge-based districting optimization model with no predetermined centers to partition a road network into a given number of contiguous and balanced districts suited to logistics applications. The underlying dispersion measure aims to reduce the sum of node-to-edge distances, specifically from every edge to its assigned center, implicitly reducing the total distance traveled within each district. Since the optimization problem is computationally challenging, we derive logic-based cuts that enable a reduction of the solution space. The technique is tested on planar graphs with up to 500 nodes, leading to speed up in computational time up to 6x. Furthermore, we develop a bounding scheme that can provide the approximate solution to the problem.

■ VSB43

Virtual Room 43

Marketplaces: Empirics and Theory

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Mohammad Rasouli, Stanford University, Stanford University, Palo Alto, CA, 94306-2455, United States

1 - Platform Competition in Two-sided Networks
John R. Birge, University of Chicago, Chicago, IL, 60637-1656, United States

Abstract not available at this time.

2 - Informational Inequality in Online Education
Luis Armona, Stanford University, Palo Alto, CA, United States, Mohammad Rasouli

Using novel search and enrollment data from the largest online education platform in Iran, we estimate a structural model of course search and enrollment for paid courses, allowing us to recover learner belief's about courses and the latent characteristic space of courses. We document significant heterogeneity in how learners perceive course value, due to biased beliefs. Counterfactual policy exercises suggest that the platform can increase revenue, improve consumer surplus, and increase overall achievement in courses by reducing the information inequality via a redesign of search and recommendation engine. Finally, we map the optimal search engine problem of a platform, subject to public non-discriminatory signals, into an information design problem, and characterize the optimal public signal the platform can send to learners with heterogeneous priors.

3 - Scale vs Quality of Service: The Impact of Market Growth on Delivery Times
Vadim Glinsky, Kellogg School of Management, Evanston, IL, 60201-4428, United States, Tarek Abdallah, Robert Louis Bray

Supply chains typically benefit from economies of scale due to market growth but are there any tradeoffs? Our empirical results suggest that there is a tradeoff between scale and quality of service for new customers. We use data from the e-commerce platform JD describing customer transactions and deliveries. We find that newer customers suffer from slower shipping compared to customers who have been using JD's platform longer. As the historical centers of demand exhaust their growth, new customers come from progressively more distant areas with smaller warehouses, and the existing supply chain cannot keep up with such geographically dispersed market growth.

4 - Contracts With Aftermarket Substitution: Case of Electricity Batteries for PG&E
Mohammad Rasouli, Stanford University, Palo Alto, CA, 94306-2455, United States, Tao Sun, Paulo Somaini, Ram Rajagopal

We study electricity retailer's contract design problem when an electricity battery provider enters the market for providing storage service to end users. We model a screening problem in a principal-agent setting in which the monopolist offers a menu of consumption bundles and transfers. In the absence of both arbitrage opportunities and dis-economies of scale, agents do not rely on the battery technology in either the first-best or the second-best allocations. While the substitution technology reduces retailer's surplus under the second best, aggregate agents' surplus and social welfare may be lower or higher. We empirically assess these changes using data from California PG\&E household hourly electricity consumption and a structural model of household utility. We use unsupervised machine learning to cluster consumers according to their consumption patterns.

■ VSB44

Virtual Room 44

Economics and Computation II

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Ignacio Rios, University of Texas at Dallas, 632 Northill Dr, Richardson, TX, 75080, United States

1 - Indivisible Mixed Manna: On the Computability of MMS+PO Allocations
Setareh Taki, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Rucha Kulkarni, Ruta Mehta

We initiate the study of finding fair and efficient allocations of an indivisible mixed manna: Divide m indivisible items among n agents under the popular fairness notion of maximin share (MMS) and the efficiency notion of Pareto optimality (PO). A mixed manna allows an item to be a good for some agents and a chore for others. First, we show that for any >0, MMS allocations may not always exist. Second, we derive two conditions and show that dropping either renders the problem intractable. Third, for instances satisfying the two conditions, we design a to find an (–)-MMS and -PO allocation, given , >0, for the highest possible (0,1].

2 - 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.

3 - Regret-Minimizing Bayesian Persuasion
Konstantin Zabarnyi, Technion - Israel Institute of Technology, Haifa, Israel, Yakov Babichenko, Inbal Talgam-Cohen, Haifeng Xu

We study a Bayesian persuasion setting with a binary-action Receiver. We examine Sender's performance when she is ignorant of Receiver's utility, measuring signaling schemes via regret: the difference between Sender's optimal utility had she known Receiver's utility and her actual utility. We show that if Sender is totally ignorant of Receiver's utility, then no signaling scheme can perform robustly well. However, if Sender only knows Receiver's ordinal state preferences, then she can guarantee a surprisingly low regret even when the number of states tends to infinity. We further show that such positive results are impossible for the adversarial approximation ratio performance measure.

4 - 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.

5 - 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.

■ VSB45

Virtual Room 45

Improving Rail Share of Intermodal Freight: Roundtable Presentations

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
Nikola Besinovic, Delft University of Technology, 2628 CN, Netherlands

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 railThe 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 - Moderator
Bruce W. Patty, Veritec Solutions, Mill Valley, CA, 94941-3032, United States
3 - Presenter
Adriene Bailey, Oliver Wyman, Dallas, TX, United States
4 - Presenter
Michael Leue, Alameda Corridor Transportation Authority, Long Beach, CA, United States

■ VSB46

Virtual Room 46

Application of AI on Digital Platforms

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Keran Zhao, University of Illinois at Chicago, Chicago, IL, 60613, United States

1 - Raid the Chat Room: The Effects of Group Size and Moderation on User Engagement in Online Synchronized Communication
Keran Zhao, University of Illinois-Chicago, Chicago, IL, 60613, United States
Keran Zhao, University of Houston, Houston, TX, United States, Yili Kevin Hong, Tengteng Ma, Yingda Lu, Yuheng Hu

Online synchronous platforms, such as live streaming, spend tremendous effort engaging users in a real-time setting. While the existing literature finds that the group size of peers has a positive effect on user engagement on asynchronous platforms, the effect of group size remains unexplored in the context of synchronous interactions. In this work, we leverage the raid functionality, an exogenous increase in live viewers, and empirically examine how group size affects users' real-time commenting engagement. Collecting and analyzing chat history in 13,382 playbacks on Twitch, our result suggests that existing viewers tend to engage less after the raid. The findings in this paper indicate a negative effect of group size on viewer engagement in the synchronous communication setting, which theoretically extends the prior literature in user engagement and crowd effects.

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 - That Sounds Familiar! Dynamic Voice Clones Elicit Greater Trust
Scott Schanke, University of Wisconsin Milwaukee, Milwaukee, WI, 55104-5838, United States, Gordon Burtch, Gautam Ray

In this work we explore the interactions between two key design choices for voice-based AI agents: i) disclosure of an agent's autonomous nature, and ii) aesthetic personalization (implemented via voice cloning). Through use of a Behavioral Economics game, we evaluate these features impact on trust. Overall, we find that people prefer a cloned version of an A.I. voice compared to a default male voice and no message control. Disclosure, on its own, does not significantly impact trust. When examining the interaction of message medium and agent disclosure, we find that dynamic voice cloning, in tandem with disclosure, achieves the highest user trust levels.

4 - 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.

5 - Effects of Analytics Academic Programs on Local Analytics Job Market
Wei Zheng, University of Tennessee, Farragut, TN, United States, Yuanyang Liu, Melissa Bowers

We estimate the effect of a new academic Data Analytics program on its local economy by evaluating the changes in the number of local Data Analytics job postings and employers after the program establishment. We apply two different estimation strategies and find consistent evidence to support an overall positive impact of an ADS academic program on local ADS job opportunities. To the best of our knowledge, we are the first to present quantified evidence on an ADS academic program's effects on local labor markets in terms of job creation. More broadly, these findings add evidence for the positive impact of an academic institution on its local economy in addition to traditional measures such as unemployment and wage rate.

■ VSB47

Virtual Room 47

INFORMS Finance Student Best Paper Award

Sponsored: Finance

Sponsored Session

Chair: Wendy Swenson Roth, Georgia State University, Atlanta, GA, 30303-2376, United States

1 - The Adoption of Blockchain-Based Decentralized Exchanges
Ruizhe Jia, Columbia University, New York, NY, 10019, United States

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 highly correlated, or of high personal use for investors. The adoption of AMMs leads to a surge of transaction fees on the underlying blockchain if exchange rates fluctuate. A pricing curve with higher curvature makes the arbitrage problem less severe but also decreases 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 - Blockchain-Enabled Deep-Tier Supply Chain Finance
Yunzhe Qiu, Washington University in St. Louis, St. Louis, MO, 63130, United States

For many supply chains, deep-tier suppliers, due to their small sizes and lack of access to capital, are most vulnerable to disruptions. In this paper, we study the use of advance payment (AP) as a financing instrument in a multitier supply chain to mitigate the supply disruption risk and compare the traditional system (deep-tier financing with limited visibility) with the blockchain-enabled system (financing with perfect visibility). The main goal of this paper is to shed light on how blockchain adoption impacts agents' operational and financial decisions as well as profit levels in a multitier supply chain. Traditionally, because of the limited visibility in the deep-tiers, powerful downstream manufacturers' financing schemes offered to their immediate upstream suppliers are not effective in instilling capital into the deep-tiers. Advancements in blockchain technology improve the supply chain visibility and enable the manufacturer to better devise deep-tier financing to improve supply chain resilience. We develop a three-tier supply chain model and take a game-theoretic approach to understand a financially constrained supply chain's optimal operational and financial strategies. We find that the improved supply chain visibility (by blockchain adoption) always benefits the manufacturer by enabling her to induce the desired operational risk-mitigation investment from the tier-1 and tier-2 suppliers. However, depending on the directional change in the operational risk- mitigation investment, which depends on the suppliers' initial wealth levels, the tier-1 and tier-2 suppliers can be worse-off. The "win-win-win" outcome takes place only when all operational risk-mitigation measures increase, that is, when the tier-1 supplier is severely capital constrained but the tier-2 supplier is moderately capital constrained. Comparing the two types of blockchain-enabled deep-tier financing schemes, adjacent- tier delegated financing versus cross-tier direct financing, the manufacturer strictly prefers the latter. In contrast, the tier-1 supplier strictly prefers the former because the former endows the tier-1 with financial leverage over the manufacturer. The tier-2 supplier prefers the latter only when the emergency source is expensive. Our insights help firms assess opportunities and challenges associated with enhancing supply chain visibility via blockchain adoption.

3 - Risk-Sensitive Optimal Execution via a Conditional Value-at-Risk Objective

Seungki Min, Columbia Business School, New York, NY, 44920, United States

We consider an optimal execution problem in a continuous-time setting under which a trader wants to liquidate an asset while minimizing the conditional value-at-risk (CVaR) of implementation shortfall given a target quantile. The trader must determine the trading rate so as to balance transaction costs with risk. We interpret this optimization problem as a continuous-time stochastic game against an adversary who controls a martingale process to distort the likelihood of each sample path. As a result, we obtain a closed-form expression for the optimal policy, which is price-adaptive and demonstrates "aggressive-in-the-money". Our analysis also shows that the optimal adaptive policy can reduce costs by 5%-15% compared to the best static schedule.

4 - Award Presenter

Ariah Klages-Mundt, Cornell University, Winona, MN, 55987, United States

■ VSB48

Virtual Room 48

Digital Platforms and E-Business

Sponsored: eBusiness

Sponsored Session

Chair: Yanzhen Chen, HKUST, Austin, TX, 78712, United States

1 - A Text-analysis Based Framework for Assessing the Effectiveness of Customer Service Chatbots

Agrim Sachdeva, Indiana University, Bloomington, IN, United States, Alan R. Dennis, Antino Kim

Chatbots are increasingly deployed to provide customer support. There are several issue that initial rollouts face that might lead to lower satisfaction amongst users, such as comparisons with human agents, experimentation with the chatbot, etc. These lead to lower user ratings from surveys, especially in the early stages of deployment. Thus, it becomes difficult for organizations to ascertain the value of chatbot to the organization. In this paper, we leverage the text modality and create a framework analyze the transcripts to determine chatbot effectiveness.

2 - Mobile Advertising for Customer Retention? Evidence From a Randomized Field Experiment

Aaron Cheng, London School of Economics, The Aldwych Connaught House Houghton Street Hought, London, WC2A 2AE, United Kingdom, Ting Li

More than three-quarters of users delete an app after the first use, making retention the leading challenge for app business. We study mobile advertising as a retention strategy: launching cross-app ad campaigns to re-engage existing users. Using a large-scale field experiment, we test the impact of ad exposure elsewhere on the focal app usage. We find a disproportionate decrease in the number of logins and in-app purchases for users exposed to the mobile ads. This decrease carries over to future app use occasions. In addition, ad content does not bring much heterogeneity, but timing is a dominant changer. The ad effect is negative if the app has recently been used before the ad—particularly when the gap is smaller than the user's average inter-purchase time; positive otherwise. This study calls to personalize ad timing as a priority for proactive customer retention management.

3 - The Value of Privacy in Online Advertising

Yufei Shen, HEC Paris, Jouy en Josas, 78350, France, Xitong Li

Internet platforms rely on the collection of consumer personal data for ad targeting, which has raised widespread concern about privacy intrusion. Understanding the value of privacy is the key for data regulators to balance personalized recommendation and privacy protection. Using a panel data collected from a leading publisher in China, covering more than 100 million users and over 2 months, we find that after users opt out of allowing the platform to use their personal data for ad targeting, they would be delivered ad impressions that generate 22.64% less revenue for the publisher. More importantly, ads from small and medium-sized advertisers, rather than large advertisers, would be significantly less likely to display to opt-out users. The results indicate that privacy protection can have a price of market inefficiency and increases ad market concentration.

■ VSB49

Virtual Room 49

2021 MCDM Junior Researcher Best Paper Award

Informs Special Session: Multi Criteria Decision Making

Informs Special Session Session

Chair: Serpil Sayin, Koc University, Koc University, Istanbul, 34450, Turkey

1 - Robust Stochastic Sorting With Interacting Criteria Hierarchically Structured

Sally Giuseppe Arcidiacono, University of Catania, Catania, 95129, Italy, Salvatore Greco, Salvatore Corrente

We propose a multiple criteria decision aiding method to deal with sorting problems in which alternatives are evaluated on interacting criteria structured in a hierarchical way. The underlying preference model is the Choquet integral, while the hierarchy of criteria is dealt by the Multiple Criteria Hierarchy Process. Considering the 2-additive Choquet integral, we present a procedure to find all minimal sets of pairs of interacting criteria compatible with the preferences given by the Decision Maker. Robust results are provided using the Robust Ordinal Regression and the Stochastic Multicriteria Acceptability Analysis. The applicability of the method is demonstrated by a financial example.

2 - A Benefit-to-cost Ratio Based Approach for Portfolio Selection Under Multiple Criteria With Incomplete Preference Information

Eduarda Asfora Frej, Universidade Federal de Pernambuco, Recife, Brazil, Petr Ekel, Adiel de Almeida

This work aims to present a new model for solving portfolio selection problems under multiple and conflicting criteria, considering partial information from the Decision Maker (DM). A benefit-to-cost ratio (BCR) based model is introduced to evaluate candidate projects. Linear programming models are applied to compute dominance relations between candidate projects based on incomplete information obtained from the DM. The elicitation process is carried out based on a structured elicitation protocol. An R&D portfolio selection problem of a Brazilian electric energy facility is presented to illustrate the applicability of the proposed methodology.

3 - Multi-dimensional Stability Analysis for Analytic Network Process Models

M Gabriela Sava, Clemson University, Clemson, SC, 29634, United States, Luis G. Vargas, Jerrold H. May, James Dolan

The decision-making process involves, most of the time, working with limited and/or incomplete information to obtain a one-time synthesis of one's preferences. However, additional information might be acquired by the decision-maker at a later time. We developed a new multi-dimensional stability analysis that provides a comprehensive image of how preferences change or evolve, as perturbations are applied to the criteria weights, without reiterating the preference elicitation process. The insights provided by the new method helped define a set of stability measures useful in a practical setting. We applied the method developed to a randomly generated ANP model.

■ VSB50

Virtual Room 50

Simulation-Optimization Applications

Sponsored: Simulation Society

Sponsored Session

Chair: Canan Gunes Corlu, Boston University, Boston, MA, 02215-1201, United States

1 - Simheuristics in Logistics, Transportation & Supply Chain Management

Juan Francisco Gómez González, Oklahoma Christian University, Oklahoma, OK, United States, Angel A. A. Juan, Jon Raleigh, Javier Panadero, Javier Faulin

In many real-life combinatorial optimization problems, there are large-scale challenges and stochasticity in the variables. Metaheuristics can solve large-scale challenges with good results in a reasonable amount of time. However, dealing with uncertain conditions (travel times, demands, among others) is more complex. In such non-deterministic environments, we employ simulation for the analysis of complex systems. Nonetheless, simulation is not an optimization tool, so we need to combine it with metaheuristics. Simheuristics allow us to consider stochastic variables in the objective function and analyze the reliability level, i.e., the probability that the solution is still feasible once executed.

2 - A Constraint-based Simheuristic Approach for Robust Planning and Scheduling of Airport Apron Operations
Yagmur S. Gök, University of Edinburgh, Edinburgh, EH8 9JS, United Kingdom, Silvia Padrón, Maurizio Tomasella, Daniel Guimarans, Cemalettin Ozturk

It is no secret that aircraft operations are prone to delays, many of which generate within airport ground handling services. Conflicting interests in the way these operations are managed concurrently by the airlines, the airport operator and particularly ground service providers have been pointed at as the major underlying issue. We propose a simheuristic approach for robust scheduling of ground handling operations and the construction of route plans for the teams of multiple service providers. Outputs coming from simulations are automatically transformed into a feedback mechanism that leads to stronger robustness owing to the more constrained search space which the feedback imposes. Our methodology improves airport on-time departure punctuality when compared to the current state-of-the-art approach.

3 - Enhancing AGV Dispatching Rules Using Deep Reinforcement Learning
Nitish Singh, Eindhoven University of Technology, Eindhoven, Netherlands, Tugce Martagan, Alp Akcay, Ivo Adan

AGV manufacturers provide simple dispatching rules for controlling AGV movements since they are scalable, and easy to implement. However, simple rules are less efficient in terms of costs since they do not make use of spatial and temporal data to better position AGVs. Artificial Intelligence techniques have been shown to extract temporal and spatial patterns for decision making. Their ease of use and their robustness to changes (in fleet size, order arrival patterns, etc.) make them an attractive alternative. Thus, we develop an AI-based AGV fleet management algorithm which is compared against a simple dispatching rule to prove its superiority.

4 - Encouraging Modal Shift Through Green Technologies: A Multiobjective Simulation Optimization Approach
Sebastian Rojas Gonzalez, Postdoctoral Research Fellow, Hasselt University, Hasselt, Belgium
Sebastian Rojas Gonzalez, 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.

■ VSB51

Virtual Room 51

Service Science Best Cluster Paper Competition (I)

Sponsored: Service Science

Sponsored Session

Chair: Weiwei Chen, Rutgers University, Piscataway, NJ, 08854-8081, United States

Co-Chair: Robin Qiu, The Pennsylvania State University, Malvern, PA, 19355-1488, United States

1 - Off-Grid Lighting Business Models to Serve the Poor: Evidence From a Structural Model and Field Experiments in Rwanda
Bhavani Shanker Uppari, Singapore Management University, Singapore, 178899, Singapore

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 - Who is Next: Patient Prioritization Under Emergency Department Blocking
Wenhao Li, City University of Hong Kong, Hong Kong, 999077, Hong Kong

Inspired by an intriguing observation, we investigate how emergency department (ED) decision makers select the next patient to treat. Using data from a large Canadian hospital, we investigate how patient dispositions impact the prioritization of patients across different acuity levels. We find that when the ED blocking level becomes sufficiently high, decision makers start to prioritize discharged patients to avoid further blocking the ED. We analyze a stylized model to explain the rationale behind decision makers' prioritization behavior. Using a simulation study, we show how policies inspired by our findings improve ED operations.

3 - To What Extent Do Workers' Preferences Matter?
Zhenzhen Jia, Fudan University, Shanghai, 200433, China

Our research investigates how preference satisfaction, particularly intrinsic values, can improve a worker's service efficiency and quality. Examining a comprehensive dataset linking surgeons' performances to their preferences for operating rooms, we confirm and quantify the significant role of intrinsic values in driving workers' service efficiency and quality. Moreover, we find that these preference effects are more pronounced when workers are under heavy workloads or performing complex tasks. Finally, our counterfactual analysis demonstrates that preference satisfaction can greatly benefit operation cost-saving and patient welfare improvement at little expense.

4 - Trade-In or Sell in My P2P Marketplace: A Game Theoretic Analysis of Profit and Environmental Impact
Aditya Vedantam, State University of New York at Buffalo, Williamsville, NY, 14221, United States

Firms are increasingly adopting resale-based business models such as trade-in and resale programs, where firms offer a trade-in discount and resell the traded-in product, or P2P resale marketplaces in which customers buy and sell used products to each other. We investigate the profitability and environmental impacts of both models. We identify when each resale model is better for profitability and environment concurrently and when there is misalignment. The insights we present are useful for firms, non-governmental organizations, and environmental advocacy groups.

■ VSB52

Virtual Room 52

Service Science IBM Best Student Paper Competition (I)

Sponsored: Service Science

Sponsored Session

Chair: Guiping Hu, Iowa State University, Ames, IA, 50011, United States

Co-Chair: Meng Li, University of Houston, Houston, TX, 77204, 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.

4 - A Boon or a Bane? A Game-Theoretic Analysis of Online Subsidiary Healthcare Service

Zhe Wang, Tsinghua University, Beijing, 100084, China

In recent years, many hospitals have started to build their online subsidiary healthcare systems. Such healthcare systems can bring hospitals an additional traffic source but, in the meantime, potentially cannibalize their traditional offline traffic. As a result, hospitals need to balance their offline and online traffic when designing their online subsidiary healthcare systems. Using a game-theoretic model, we study the optimal design of such an online healthcare system and investigate its impact on the outcomes of the traditional healthcare system (e.g., the hospital's offline throughput).

5 - Fulfillment by Platform: Antitrust and Upstream Market Power

Amandeep Singh, Wharton Business School, Philadelphia, PA, 19104, United States

Fulfillment by Platform (FBP) has been widely adopted by many e-commerce sellers. Despite providing better service to customers, recently platforms have come under antitrust scrutiny. We use data from a leading online retailing marketplace to empirically evaluate the validity of such concerns. We find that the adoption of fulfillment by the platform can hurt upstream market competition, measured by the Herfindahl-Hirschman Index. In particular, smaller merchants, with lower margins, are forced to increase prices more to remain profitable with FBP

■ VSB53

Virtual Room 53

Emerging Topics in Social Media Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Rui Zhang, Leeds School of Business University of Colorado Boulder, Boulder, CO, 80309, United States

1 - Two-level Influence Maximization Problem under Deterministic Linear Threshold Model

Dilek Gunnec, Ozyegin University, Alemdag, 34794, Turkey

Data-driven decision-making strategies can make online marketing more efficient and help companies reach a larger number of customers using limited resources. In this respect, the Influence Maximization Problem searches for a certain number of influential individuals on a social network so that the information/product spread initiated from such individuals is maximized. We introduce a novel problem, the Two-Level Influence Maximization Problem, which allows influencing neighbors without eventually adopting the product. To solve this problem, we develop a greedy algorithm where node gains are limited to a specific number of neighbor parameters and a simulated annealing-based metaheuristic with a tabu strategy that exploits the problem-specific neighborhood moves. The computational results show that our heuristics can provide high-quality solutions.

2 - 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.

3 - Fake Review Detection on Online E-commerce Platforms: A Systematic Literature Review

Himangshu Kumar Paul, PhD Candidate, University at Buffalo, Buffalo, NY, United States, Alexander Nikolaev

The increasing popularity of online review systems motivates malevolent intent in competing sellers and service providers to manipulate consumers by fabricating product/service reviews. Immoral actors use Sybil accounts, bot farms, and purchase authentic accounts to promote products and vilify competitors. Facing the continuous advancement of review spamming techniques, the research community should step back, assess the approaches explored to date to combat fake reviews, and regroup to define new ones. This paper reviews the literature on Fake Review Detection (FRD) on online platforms. It covers both basic research and commercial solutions, and discusses the reasons behind the limited level of success that the current approaches and regulations have had in preventing damage due to deceptive reviews.

4 - 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.

■ VSB54

Virtual Room 54

Healthcare resource management during COVID-19

Sponsored: Public Sector OR

Sponsored Session

Chair: Hamid Reza Zarei, United States

1 - Matching Medical Staff to Long Term Care Facilities to Respond to Covid-19 Outbreak and Analyzing Data

Hamid Reza Zarei, PhD Candidate, Northeastern University, Boston, MA, United States, Mahsa Ghanbarpour Mamaghani, Ozlem Ergun

Since the COVID-19 outbreak, resources and medical staff shortages occurred in healthcare centers. The shortage issue has been more vivid in Long Term Care Facilities (LTCFs), where the most vulnerable population segment resides. To assist LTCFs in Massachusetts, the Commonwealth's Executive Office of Elder Affairs put together a team to collect demand and supply data for medical staff and allocate the supply to LTCFs' demand. In this work, we developed a matching framework to match medical workers, centrally and continuously, to an ever-changing list of facility staffing needs and analyzed the data to find the most salient features of successful matches that resulted in the matched staff being hired by the facility.

2 - 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.

3 - A Time-varying Approach to COVID-19 Vaccine Strategies Based on Contact Networks

Dionne Aleman, University of Toronto, Toronto, ON, M5S 3G8, Canada, Mario Ventresca, Randy Giffen, Proton Rahman, Proton Rahman

We investigate the use of social contact networks to prioritize COVID vaccination rollout strategies, particularly recognizing that priority rules can and should change throughout the rollout as vaccine supply and dissemination capacity change. We specifically focus on Newfoundland & Labrador, Canada, and contact networks are derived from a granular agent-based simulation incorporating census, demographic, and COVID data. For each priority epoch, we extract decision trees representing the targeted population segments for clear, implementable public policy rules. Probabilistic vaccine compliance and vaccine efficacy are considered. We find that metrics based on graph-based properties of each person (node) result in more effective use of limited vaccines, compared to age-based rules.

4 - Facility And Operations Design for A COVID-19 Community Vaccination Clinic

Jacqueline Griffin, Northeastern University, Boston, MA, 02115, United States, Ann Suhaimi

The COVID-19 pandemic onset in 2020 required quick changes by communities and organizations, particularly as it related to creating new testing and vaccination clinics. In this presentation we present simulation models, developed to inform decision making for the design of a community vaccination clinic - spanning decisions about scheduling, facility design, and operations. Finally, we discuss how the results of the analysis informed real world decision making.

■ VSB55

Virtual Room 55

Human Trafficking

Sponsored: Public Sector OR

Sponsored Session

Chair: Arezoo Jafari, Northeastern University, Boston, MA, United States

Co-Chair: Shawn Bhimani, Northeastern University, Northeastern University, Boston, MA, 02115-5005, United States

1 - Detection of Labor Trafficking Using Natural Language Processing: Improving the Investigation of Labor Violations Among Employers of Migrant Workers

Arezoo Jafari, PhD Student, Northeastern University, Boston, MA, 02114, United States, Elaine Klatt, Margaret Clark, Renuka Kannan, Shawn Bhimani, Amy Farrell, Kayse Lee Maass

Labor trafficking has been documented within agricultural supply chains with migrant workers on H-2A visas being particularly vulnerable to exploitation in the United States. Given the limited resources available to inspect worksites, this study helps labor inspectors prioritize which worksites to inspect based on merging publicly available data regarding employer wage and hour violations and H-2A certification applications. This merging uses a natural language preprocessing technique to match employer's names which are recorded with various spellings. This ongoing research helps to identify unsafe working conditions by identifying worksites with H2A employees and workplace violations

2 - Dynamics of Human Trafficking Networks in the Agricultural Sector

Shawn Bhimani, Northeastern University, Hayden Hall, Northeastern Univ 360 Huntington Ave, Boston, MA, 02115-5005, United States, Amy Fearrell, Aubrey Sneesby, Leke de Vries, Kayse Maass

This presentation discusses the varying structures of labor trafficking networks in the United States agricultural sector as identified through our review of 12 federally prosecuted cases. In particular, we analyze the impact of socio-technic connections in the operation and eventual disruption of such illicit supply networks. This includes relationships within the workplace, as well as with family members, communities, and external agents such as law enforcement.

3 - The Visualization of Labor Trafficking Within Supply Chains

Emma Toole, Boston, MA, United States, Amy Farrell, Kayse Maass

Using 12 federally prosecuted human trafficking cases in the United States, we identify the actual and potential mechanisms that could have disrupted labor trafficking in the U.S. agricultural sector. By analyzing labor trafficking processes and creating network diagrams, we offer visual insights and recommendations to more effectively enact disruptions.

4 - Human Trafficking And Modern Slavery Allegations In Global Supply Chains And Response Analysis

Kezban Yagci Sokat, San Jose State University, Evanston, IL, 60208-0834, United States, Ayca Erdogan, Nezih Altay

Globalization of technology use has increased the awareness regarding human trafficking and modern slavery allegations by both connecting customers and investors to news and enabling them to share their reactions. In this paper, we analyze consumer response to labor trafficking and modern slavery allegations both qualitatively and quantitatively.

5 - A Game Theoretic Model of Forced Labor Reduction in Supply Chains

Katherine Ashley, Northeastern University, Boston, MA, 02115, United States, Shawn Bhimani

Using a game theoretic model, we show the conditions under which a firm will take action to reduce the risk of forced labor in their supply chain. By doing so, a company can increase its expected profit while avoiding potential brand damage, penalties, and supply chain disruption from randomized inspections by external auditors.

6 - Time-Series Anomaly Detection Comparison with Application to Sex Trafficking Advertising

Seth Guikema, University of Michigan, Ann Arbor, MI, 48105, United States, Julia Coxen

We characterize the effectiveness of univariate time-series anomaly detection techniques to evaluate their effectiveness for online commercial sex advertisements. We draw from concrete examples of biosurveillance, manufacturing, and quality control to generalize their detection power and robustness for the detection of anomalies in online commercial sex advertising. We compare their associated machine learning, statistical process control, and change point detection techniques and provide a reliable comparison using a synthetic data set that contains point, collective, and contextual anomalies. We contextualize these techniques for risk-informed decision-makers and demonstrate their effectiveness with a sex trafficking case study.

■ VSB56

Virtual Room 56

OR/MS Applications at General Electric

Informs Special Session: Informs Section on Practice

Informs Special Session Session

Chair: Nitish Umang, GE Global Research, Schenectady, NY, 12308, United States

1 - Multi-laser Load Balancing in Additive Manufacturing

Nitish Umang, GE Global Research, Niskayuna, NY, 12308, United States

In a particular type of additive manufacturing called powder-based melting, multiple laser systems work in parallel to build 3D parts by melting powdered grains at targeted locations in consecutive material layers. We present an optimization based approach to balance workload between the lasers systems to increase machine throughput and minimize build time while ensuring that the lasers are not occluded by the smoke generated during the build process and the build quality is preserved.

2 - Improving Aircraft Engine On-time Delivery at GE Aviation

Karolina Glowacka, GE Aviation, Warsaw, Poland, Witold Chmielowiec, Krzysztof Wesek, Michal Skowron

Aircraft engines consist of thousands of parts. To deliver them to customers efficiently and on-time, we need to have a thorough understanding of their supply chains. At GE Aviation, we performed a large-scale project aimed at improving engine on-time delivery, which included the analysis of various interconnected systems. Using techniques from OR and data science, we proposed a method for part importance ranking, which helps to focus improvement efforts where they provide the most benefit.

3 - Optimizing Locations of Stations in a Shop Floor

Karthik Senthil, GE Aviation, Bangalore, India

A shop floor typically contains stations like machines, workbenches, storage areas etc. The locations of these stations can be optimized to minimize total movement between stations.

■ VSB57

Virtual Room 57

AAS Best Student Presentation Competition (2)

Sponsored: Aviation Applications

Sponsored Session

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

1 - Identification and Prediction of Disruptions in Airline Networks

Xiyitao Zhu, University of Illinois at Urbana-Champaign, Champaign, IL, 61820-4903, United States

Air transportation disruptions can lead to demand-capacity imbalances, resulting in flight delays and cancellations due to traffic management actions. To facilitate system recovery and enable decision support for management actions, it is crucial to understand system disruptions and predict their evolution. Based on the framework of disruption-recovery trajectories which represents key network delay performance metrics as transitions between discrete states, we develop two prediction models: The first identifies whether or not the system will recover in the next hour; the second seeks to predict the trend of key performance metrics. We report prediction results for four major US airlines.

2 - Adaptive Condition-Based Maintenance Under Uncertainty: A POMDP Framework

Iordanis Tseremoglou, PhD Candidate, Delft University of Technology, Delft, 2514JB, Netherlands, Bruno F. Santos

With the increased number of sensors installed in modern aircraft, Condition-Based Maintenance (CBM) has attracted much attention during recent years. However, translating the CBM data to an efficient maintenance schedule remains a challenging problem, due to the uncertainty in the output of the prognostics. We formulate the aircraft maintenance scheduling problem in a CBM context as a Partially Observable Markov Decision Process (POMDP). A novel scheduling model based on Partially Observable Monte Carlo Planning (POMCP) algorithm is developed, that integrates frequently updated inputs from prediction-based maintenance tasks to establish and continuously adjust the maintenance plan.

3 - A Data-Driven Network Delay Modeling Approach Considering En-route Congestion

Yu Lin, City University of Hong Kong, Hong Kong

En-route congestion has become prominent as air traffic demand continues to increase yet airspace volume cannot grow. However, existing studies on flight delay modeling do not consider en-route congestion. We propose a flight delay model, Multi-layer Air Traffic Network Delay (MATND) model, which takes flight operational data as input to construct a national air traffic network, and then models the delay process based on queueing theory. MATND is tested using historical data of an air traffic network, and scenario analyses are conducted to evaluate improvement strategies. Results show that MATND is good for evaluating the impact of policy alternatives on systematic delay at a macroscopic level.

4 - 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.

■ VSB58

Virtual Room 58

Data-driven Logistics

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Debjit Roy, Indian Institute of Management, Ahmedabad, 380015, India

1 - A Data-driven Optimization Approach To Enhance Worker Productivity In A Production Plant

Seyyed Mahdi Ghorashi Khalilabadi, Ph.D. Candidate, Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands ", Debjit Roy, René B.M. De Koster

Worker productivity in facilities is largely governed by the arrangement of the workstations. Traditional facility layout methods that use pairwise interactions between departments may underestimate travel distances under certain conditions. Using IoT-based worker movement data collected from a production plant, we determine the real worker sequence and develop a data-driven optimization model to optimize layouts. Using optimized layouts, we show the value of leveraging worker movement data in improving worker productivity.

2 - Dynamic Order Assignment In E-commerce Order Fulfillment

Govind Kumawat, Indian Institute of Management Udaipur, Udaipur, 380015, India

We study the order assignment problem that arises in e-commerce order fulfillment operations. We derive structure of the optimal policy and present several managerial insights using real data obtained from a large e-commerce company.

3 - Neural Policy Search For Determining The Optimal Packaging Box Sizes For E-commerce Order Fulfilment

Shanthan Kandula, Doctoral Student, Indian Institute of Management Ahmedabad, Ahmedabad, India, Srikumar Krishnamoorthy, Debjit Roy

Determining optimal packaging box sizes is of crucial importance to e-commerce platforms that handle millions of SKUs. The use of sub-optimal box sizes leads to a significant impact on material and transportation costs. This paper presents a reinforcement learning approach to determine the optimal packaging box sizes. In particular, we formulate the problem as an unsupervised machine learning task and solve it to generate an initial solution. The initial solution is improved using a heuristic policy that is learned employing reinforcement learning. The approach is validated on a large e-commerce platform dataset. Results show a significant improvement when compared to the current industrial solution and other conventional methods.

■ VSB59

Virtual Room 59

Freight Transportation II

Sponsored: TSL/Freight Transportation

Sponsored Session

Chair: Sarah Hernandez,

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, 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 Hybrid Agent-based Simulation And Optimization Approach For Statewide Truck Parking Capacity Expansion

Taslima Akter

Truck parking shortages are a critical concern for both the trucking industry and truck drivers in the USA. To tackle growing shortages, this study presents a hybrid agent-based simulation and optimization approach that determines feasible locations for truck parking facility capacity expansions. The simulation model estimates parking facility utilization over time considering the driving limit and rest requirements. The estimated parking usage data is then fed into an optimization model to deduce capacity expansion locations given budgetary restrictions. Ultimately the model recommends where and how many parking spaces to add to accomplish a certain level of parking overcrowding.

■ VSB60

Virtual Room 60

Integrated Trade-Off Analytics

Sponsored: Military and Security

Sponsored Session

Chair: Shaun Doheney, Amazon Web Services (AWS), Stafford, VA, 22554-6548, United States

Co-Chair: Gregory S Parnell, University of Arkansas, Fayetteville, AR, 72701, United States

1 - AI for Smart Base Weather and Transportation

Randy K. Buchanan, USACE - ERDC, Vicksburg, MS, 39180-6133, United States

The DOD has an interest in understanding Artificial Intelligence (AI) and Automated Vehicle (AV) systems in order to plan for modernization, readiness, and quality of life that include infrastructure, security, economic impacts, cyber, and communications. This presentation covers the development of a data integration and decision dashboard that collects data from multiple sources to inform the weather and operations decision-making process at Fort Carson, CO.

2 - Early Life Cycle Prediction Of Reliability

Tevari Barker, University of Arkansas, Fayetteville, AR, 72701, United States, Gregory S. Parnell, Edward A. Pohl, Randy K. Buchanan

The critical role of reliability in acquisition program performance, cost, and schedule motivates the need for improved system reliability models in early design. The U.S. Army Engineer Research and Development Center seeks to integrate reliability, performance, and cost models in a trade-off analysis framework in the early acquisition stages. We are developing models to estimate reliability Pre-Milestone A and assess the impact on performance and cost. The integrated model will inform decision-makers on the impact of reliability before choosing a system concept for further development.

3 - Assessment of Structures and Systems for Enterprise Tradeoffs (asset)

William Brandon Fangio, University of Arkansas, Fayetteville, AR, 72701, United States, Gregory S. Parnell, Edward A. Pohl, Kayla Cotterman, Christina Rinaudo, Cody Salter, William Leonard, Eddie Gallarno, Kathleen Staebell

The project uses decision analysis to inform infrastructure asset management decision making within the United States Army Corps of Engineers Civil Works. USACE-CW has eight business lines, each have a process for asset management work package funding decisions. There is a need to analyze existing and new business line metrics. Our proposed value models build on each other. We begin by evaluating work packages, then we evaluate each business line, finally we use this to evaluate the whole program. The goal is to improve the availability of information for asset management decisions.

4 - Feasibility of Lighter Than Air Cargo Airships

Bruce Cox, Assistant Professor of Operations Research, Air Force Institute of Technology, Oakwood, OH, 45419, United States, Collin Weidner, Noel Dupont, Larry Nance, Bryan Harris

In the modern era Lighter than Air (LTA) airships have been limited to aerial photography/advertising. This study examined the utility of LTA cargo airships. VFT ID'd key parameters driving the utility of cargo assets. 40 LTA variants & 4 conventional assets were modeled in Simio, and multiple scenarios varying the ID'd mission factors were created. These sims were used within a surrogate modeling loop via OptQuest. Each output optimal fleet mixtures for that instantiation, postprocessing produced efficient solutions balancing cost & speed. MBA & ANOVA associated LTA assets to mission types/vice-verse. LTA cargo assets were found to be cheaper than traditional cargo assets for medium/heavy loads, and only marginally slower. As end point trucking was reduced (e.g., natural disasters) the LTA asset's point of need delivery ability overcame that marginal speed advantage.

5 - Using Value of Information in Quantitative Set-based Design

Nicholas Shallcross, PhD, DoD/University of Arkansas, Fayetteville, AR, 72701, United States, Gregory S. Parnell

Increasing system complexity requires that engineers, systems analysts, and program managers use comprehensive design methodologies to deliver affordable and resilient designs. One method is set-based design (SBD), a product development and managerial process distinctly suited for developing complex systems under uncertainty. This research integrates design maturation and multiobjective value of information analysis into a comprehensive quantitative SBD process, guiding system development from initial design concepts to the pre-production design decision. Our research specifically enables complex design maturation and uncertainty reduction decisions in system design.

■ VSB61

Virtual Room 61

Data-driven Disruption Management in Air Transportation/Air Cargo Networks

Sponsored: Aviation Applications

Sponsored Session

Chair: Max Zhaoyu Li, Massachusetts Institute of Technology, Cambridge, MA, 02139-4309, United States

1 - 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.

2 - Managing Regional Air Traffic Management Initiatives

James Calvin Jones, MIT Lincoln Laboratory, Lexington, MA, 02140-2336, United States, Zach Ellenbogen, Yan Glina

In this talk we discuss the use of a set of reinforcement learning algorithms for controlling the planned rates on a set of Traffic Management Initiatives across the Northeast United States. The work is validated through the use of a fast-time air traffic management simulation.

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3 - Identification And Prediction Of Disruptions In Airline Networks

Xiyitao Zhu, University of Illinois at Urbana-Champaign, Champaign, IL, United States

Air transportation disruptions can lead to demand-capacity imbalances, resulting in flight delays and cancellations due to traffic management actions. To facilitate better system recovery and enable near-real time decision support for prescriptive management actions, it is crucial to better understand system disruptions as well as predict their evolution. We first formalize the notion of disruption-recovery trajectories (DRTs) by representing key network delay and cancellation performance metrics as transitions between discrete states. Based on the DRT framework, we then develop two distinct one-step prediction models: The first model identifies whether or not the system will recover in the next hour; the second seeks to predict the trend of key performance metrics. We report prediction results for four major US airlines, and elaborate on next steps.

4 - Airport Ground Holding With Hierarchical Control Objectives

Max Zhaoyu Li, Massachusetts Institute of Technology, Cambridge, MA, 02139-4309, United States, Christopher Chin, Karthik Gopalakrishnan, Hamsa Balakrishnan

A resilient air traffic management system seeks to restore airport delays to their nominal values quickly after such disruptions. Two challenges complicate this goal: The lack of a high-fidelity model for airport delay dynamics, and poor computational tractability of large-scale flight rescheduling optimization problems. We propose a two-stage hierarchical control strategy for rescheduling aircraft after network disruptions. Our high-level planner leverages a low-fidelity approximation of airport delay dynamics to propose a reference plan based on user preferences. The low-level controller then solves the multi-airport ground holding problem (MAGHP), augmented to track the reference plan. We illustrate the benefits of our proposed methodology using six disruption case studies of the National Airspace System (NAS)

■ VSB62

Virtual Room 62

INFORMS Optimization Society Prize Talk Session

Sponsored: OPT/Global Optimization

Sponsored Session

Chair: Alper Atamturk, University of California-Berkeley, Berkeley, CA, 94720-1731, United States

1 - Heuristics for Mixed-Integer Optimization though a Machine Learning Lens

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

In this talk, we discuss how a careful use of Machine Learning concepts can have an impact in primal heuristics for Mixed-Integer Programming (MIP). More precisely, we consider two applications. First, we design a data-driven scheduler for running both diving and large-neighborhood search heuristics in SCIP, one of the most effective open-source MIP solvers. Second, we incorporate a major learning component into Local Branching, one of the most well-known primal heuristic paradigms. In both cases, computational results show solid improvements over the state of the art.

2 - Award Presenter

Wotao Yin, Ali Baba, United States

3 - An $O(s^r)$-Resolution ODE Framework for Understanding Discrete-Time Algorithms

Haihao Lu, University of Chicago Booth School of Business, Chicago, IL, 60605, United States

There has been a long history of using ordinary differential equations (ODEs) to understand the dynamics of discrete-time algorithms (DTAs). Surprisingly, there are still two fundamental and unanswered questions: (i) it is unclear how to obtain a suitable ODE from a given DTA, and (ii) it is unclear the connection between the convergence of a DTA and its corresponding ODEs. In this paper, we propose a new machinery — an $O(s^r)$-resolution ODE framework — for analyzing the behavior of a generic DTA, which (partially) answers the above two questions. The framework contains three steps: 1. To obtain a suitable ODE from a given DTA, we define a hierarchy of $O(s^r)$-resolution ODEs of a DTA parameterized by the degree r, where s is the step-size of the DTA. We present a principal approach to construct the unique $O(s^r)$-resolution ODEs from a DTA; 2. To analyze the resulting ODE, we propose the $O(s^r)$-linear-convergence condition of a DTA with respect to an energy function, under which the $O(s^r)$-resolution ODE converges linearly to an optimal solution; 3. To bridge the convergence properties of a DTA and its corresponding ODEs, we define the properness of an energy function and show that the linear convergence of the $O(s^r)$-resolution ODE with respect to a proper energy function can automatically guarantee the linear convergence of the DTA.

4 - Sufficient Conditions for Exact SDP Reformulations of QCQPs

Alex Wang, Carnegie Mellon University, Pittsburgh, PA, 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.

5 - Algorithmic Complexity for Multistage Stochastic Optimization

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

In this talk, we discuss the iteration complexity of a class of stochastic dual dynamic programming (SDDP) algorithms for general multistage stochastic mixed-integer nonlinear programs (MS-MINLP). Our SDDP algorithmic class encompasses, as important special cases, the traditional SDDP algorithm on multistage stochastic convex optimization and stochastic dual dynamic integer programming (SDDiP). We then characterize the iteration complexity of the proposed algorithms. In particular, for a $(T+1)$-stage stochastic MINLP with d-dimensional state spaces, to obtain an ϵ-optimal root node solution, we prove that the number of iterations of the proposed deterministic sampling algorithm is upper bounded by $\mathcal{O}((\frac{2T}{\epsilon})^d)$, and is lower bounded by $\Omega((\frac{T}{4\epsilon})^d)$ for the general case or by $\Omega((\frac{T}{8\epsilon})^{d/2-1})$ for the convex case. This shows that the obtained complexity bounds are rather sharp. It also reveals that the iteration complexity depends exponentially on the state space dimension. We further show that the iteration complexity depends linearly on T, if all the state spaces have a bounded number of points, or if we seek a $(T\epsilon)$-optimal solution, i.e.\ allowing the optimality gap to scale with T.

6 - The Unreasonable Effectiveness of Optimization in Applications: Personal Experience

Boris Polyak, Institute for Control Science, Russian Academy of Sciences, Moscow, Russian Federation

This is an attempt to mimic the famous paper by E.Wigner «The unreasonable effectivenes of mathematics in the natural sciences». It is my strong belief that any smart method of optimization invented purely theoretically, subsequently finds the field of applications where it happens to be highly effective and well fitted. This simple thought will be illustrated with few examples of my personal experience.

■ VSB63

Virtual Room 63

Recent Advances in Optimization Software I

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Hans Mittelmann, Arizona State University, Tempe, AZ, 85287-1804, United States

Co-Chair: Gregor Hendel, FICO, Germany

1 - Recent Developments In The Gurobi Optimizer

Edward Rothberg, Gurobi Optimization, LLC, Beaverton, OR, 97008, United States

This presentation will focus on the latest version of the Gurobi Optimizer. We'll talk about new heuristics for both linear and quadratic MIP models, as well as a number of other new capabilities.

2 - New Progress On Copt Solver

Dongdong Ge, Cardinal Operations, Shanghai, China

Since last October we have made the new progresses on cardinal optimizer(COPT)'s development. In this talk, I will mainly present some new progress in its linear programming and MILP development, present a few recently developed techniques to solve large scaled math programs and report some successful real world examples using COPT.

3 - Recent Progress In The Global Optimization Of Nonlinear And Mixed-integer Nonlinear Programs With Baron

Nick Sahinidis, Georgia Institute of Technology, Pittsburgh, PA, United States

We review recent developments toward the global optimization of nonlinear and mixed-integer nonlinear programming problems with BARON. We discuss relaxation construction and preprocessing techniques. Finally, we present computational results on a large test set.

4 - Latest Benchmark Results

Hans Mittelmann

Selected results from our optimization software benchmarks will be reported.

4 - New Developments In The Fico Xpress Solver

Michael Perregaard, FICO, Birmingham, B37 7GN, United Kingdom

We will present on the latest developments in the FICO Xpress Solver for mixed integer linear and convex quadratic optimization.

■ VSB64

Virtual Room 64

Combinatorial Optimization I

Contributed Session

Chair: Ignacio Rozada, 1Qbit, Vanccouver, BC, Canada

1 - Learning to Enumerate Shifts for Large-scale Personnel Scheduling Problems

Farin Rastgar Amini, Polytechnique Montreal, Montréal, QC, Canada, Claudio Contardo, Guy Desaulniers, Maxime Gasse

Our work studies the problem of personnel scheduling (PSP). A popular approach for modeling PSP is the explicit set-covering formulation, which assigns a single variable to each working shift. Having too many variables makes solving these problems challenging. We propose to use machine learning methods to accelerate the solution of PSP. Based on the information collected from previously solved instances, we can predict a subset of time points that are likely to be the start or end of optimal shifts for a new problem. The computational results on realistic instances show that PSP can be solved 2.5 times faster with an optimality gap of 0.55% if shifts are enumerated according to predicted time points.

2 - 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.

3 - 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.

■ VSB65

Virtual Room 65

Applications and Algorithms for Copositive Programming

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Arvind Raghunathan, Mitsubishi Electric Research Laboratories, Cambridge, MA, 02139-1955, United States

1 - Stabilization Of Complementarity Systems With Contact-aware Controllers

Alp Aydinoglu, University of Pennsylvania, PA, United States

Many robotic tasks, like manipulation and locomotion, fundamentally include making and breaking contact with the environment. However, state-of-the-art control policies struggle to deal with the hybrid nature of multi-contact motion. Such controllers often rely heavily upon heuristics or, due to the combinatorial structure in the dynamics, are unsuitable for real-time control.

In this talk, I will present techniques for overcoming these challenges and propose a framework for provably stable local control of multi-contact systems. The framework relies on linear complementarity system models and exploits the complementarity structure for efficient stability analysis and controller design.

2 - Copositive Duality For Discrete Markets And Games

Cheng Guo, University of Toronto, Toronto, ON, M5T 1K5, Canada, Merve Bodur, Joshua Taylor

Optimization problems with discrete decisions are nonconvex, which limits the usefulness of tools such as shadow prices and KKT conditions. Burer (2009) shows that mixed-binary quadratic programs can be written as convex completely positive programs (CPPs). CPP reformulations of discrete optimization problems therefore have strong duality. We apply this perspective in two ways. First, we write unit commitment in power systems as a CPP, and use the dual copositive program to design pricing mechanisms. Second, we reformulate integer programming games as CPPs, and use KKT conditions to obtain Nash equilibria. We also design a cutting plane algorithm for copositive programs.

3 - Stability Analysis Of Discrete-time Linear Complementarity Systems

Jeff T. Linderoth, University of Wisconsin-Madison, Madison, WI, 53706-1539, United States, Arvind Raghunathan

A Discrete-Time Linear Complementarity System (DLCS) is a dynamical system in discrete time whose state evolution is governed by linear dynamics in states and algebraic variables that solve a Linear Complementarity Problem (LCP). We derive sufficient conditions for Lyapunov stability of a DLCS, both when using a quadratic Lyapunov function that depends only on the state variables and a quadratic Lyapunov function that depends on the state and the algebraic variables. The sufficient conditions require checking copositivity over nonconvex cones. We devise a novel, exact cutting plane algorithm for the verification of stability and the computation of the Lyapunov functions. To the best of our knowledge, our algorithm is the first exact approach for stability verification of DLCS.

4 - Reduced Space Completely Positive Representation Of Binary And Continuous Nonconvex Quadratic Programs

Arvind Raghunathan, Mitsubishi Electric Research Laboratories, Cambridge, MA, 02139-1955, United States, Jeff T. Linderoth

Burer (Math. Prog. 120, 479-495 (2009)) showed that every binary and continuous nonconvex Quadratic Program can be represented as a linear program over the Completely Positive (CP) cone of dimension $(n+1)$ where n is the number of variables in the QP. In this work, we show that in the presence of m equality constraints the QP can be equivalently represented as a linear program over a CP cone of dimension $(n+1-m)$. The proposed CP cone is a completely positive representation of points that are in the intersection of the nonnegative cone and a homogenized formulation of the equality constraints. We also provide conditions under which proposed formulation has a strict interior while it is known that formulation of Burer typically does not possess one. We also present a necessary and sufficient condition for membership in the dual of the proposed CP cone.

■ VSB66

Virtual Room 66

Recent developments in Semidefinite Programming

Sponsored: OPT/Linear and Conic Optimization

Sponsored Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, Pittsburgh, PA, 15217-1420, United States

Co-Chair: Alex Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Homogeneous Chordal Cone Programming

Levent Tuncel, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, Lieven Vandenberghe

We identify a class of conic optimization problems called homogeneous chordal cones. These are regular convex cones whose automorphism groups act transitively in the interior of the cone and at the same time the members of the cone can be expressed as the nonzero elements of a cone of symmetric positive semidefinite matrices with chordal sparsity pattern. This class of convex cones lie strictly between SDPs and Homogeneous Cone Programming problems. We illustrate how convex optimization problems based on homogeneous chordal cones provide a better generalization of Second Order Cone Programming problems compared with SDPs and better ways of exploiting the related special structures in many special cases as well as in some more general settings of nonlinear optimization problems.

2 - How Do Exponential Size Solutions Arise In Semidefinite Programming?

Aleksandr Igorevich Touzov, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27519-7705, United States, Gabor Pataki

As a classic example of Khachiyan shows, some semidefinite programs (SDPs) have solutions whose size — the number of bits necessary to describe it — is exponential in the size of the input. Exponential size solutions are the main obstacle to solve a long standing open problem: can we decide feasibility of SDPs in polynomial time? The consensus seems to be that large size solutions in SDPs are rare. Here we prove that they are actually quite common: a linear change of variables transforms every strictly feasible SDP into a Khachiyan type SDP, in which the leading variables are large. As to ``how large", that depends on the singularity degree of a dual problem. Further, we present some SDPs in which large solutions appear naturally, without any change of variables. We also partially answer the question: how do we represent such large solutions in polynomial space?

3 - 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.

4 - Restricted Simultaneous Diagonalizability with Applications to Quadratic Programming

Alex Wang, Carnegie Mellon University, Pittsburgh, PA, 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

5 - 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.

■ VSB67

Virtual Room 67

Optimization in Quantum Computing and Vice Versa I

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Anastasios Kyrillidis, Rice University, Houston, TX, 77005-1827, United States

Co-Chair: Leonardo Duenas-Osorio, Rice University, Houston, TX, 77005, United States

Co-Chair: Guido Pagano, Rice University, Houston, TX, United States

Co-Chair: Amir Kalev, Information Sciences Institute-USC, Los Angeles, CA, United States

Co-Chair: Kaden Hazzard, Rice University, Houston, TX, United States

Co-Chair: Kaden Hazzard, Rice University, Houston, TX, 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 - From Quantum Algorithms to Out-of-Equilibrium Phenomena in Interacting Spin Chains

Guido Pagano, Rice University, Houston, TX, United States

Laser cooled trapped ions offer unprecedented control over both internal and external degrees of freedom at the single-particle level. They are considered among the foremost candidates for realizing quantum simulation and computation platforms that can outperform classical computers at specific tasks. In this talk I will show how linear arrays of trapped 171Yb+ ions can be used as a versatile platform for studying out-of-equilibrium many-body quantum systems and to implement quantum variational algorithms. In particular I will show how a cryogenic trapped-ion quantum simulator [1] allowed the implementation of a Quantum Approximate Optimization algorithm (QAOA) used to approximate the ground state energy of a long-range transverse field Ising model of up to 40 qubits [2]. The reliable production and lifetime of large linear ion chains also enabled us to investigate how confinement can suppress information propagation and thermalization of meson-like quasi-particles in a many-body system [3,4]. Finally, I will report on the observation of a time crystalline behaviour in a disorder-free system, where high frequency drive suppresses Floquet heating, allowing the realization of a prethermal discrete time crystal [5]. [1] G. Pagano et al., Quantum Sci. Technol., 4, 014004 (2019)[2] G. Pagano, et al., PNAS 117, 41, 25396 (2020)[3] F. Liu, et al., Phys. Rev. Lett. 122, 150601 (2018)[4] W. L. Tan, P. Becker, et al., Nature Phys. (2021)[5] A. Kyprianidis et al., Science 372, 1192 (2021)

4 - Quantum-based and Inspired Methods to Compute Network Systems Reliability

Roger Paredes, Rice University, Houston, TX, United States

Counting ground states of spin systems is a computationally difficult problem with relevant applications in science and engineering, including probabilistic inference in graphical models, functional verification in digital systems, and network reliability evaluation in complex systems. Focusing on the latter, we represent the operation of networks as a locally interacting classical Hamiltonian, where the ground states represent operative network configurations. Then, we use quantum-based or inspired methods to exploit and cope with large-scale combinatorial properties of man-made networks. For example, we empirically verify that reliability computations in acyclic networks of small treewidth can be efficiently realized via tensor network contraction algorithms, which are typically used in the simulation of large-scale quantum circuits. Also, for more general networks, we employ a modified quantum approximate optimization algorithm (QAOA) to sample operative network configurations or ground states. This enables us to rigorously approximate the reliability of network systems, while numerically verifying a quadratic speedup with respect to classical techniques. Our work offers a new approach to treat complex network systems as locally interacting Hamiltonians, letting physical and algorithmic advances in quantum computing to work in the service of critical socio-technical systems, including network reliability computations and other measures of resilience.

5 - Presenter

Michael L. Wall, Johns Hopkins University, Baltimore, MD, United States

■ VSB68

Virtual Room 68

Social Media Analytics and Nonlinear Optimization in Cyber Security

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Abdullah AlOmair, Ohio State University, Athens, OH, 45701-9291, United States

Co-Chair: Theodore T Allen, Ohio State University, Columbus, OH, 43210-1271, United States

1 - Optimal Experimentation On Games: Threatgen

Theodore T. Allen, Ohio State University, Columbus, OH, 43210-1271, United States

In game experimentation, we can control key aspects of strategy of all sides. Single period game models can give insights into sequential games by mimicking a players' meeting. We show that small numbers of runs and effect heredity assumptions can generate equilibria estimates and insights. Future topics of research are also discussed.

2 - Cybersecurity Analytics In Iiot Dashboards

Tu Feng, The Ohio State University, Columbus, OH, United States

Smart manufacturing and IIOT dashboard are important research topics in the ongoing Industry 4.0 transformation of manufacturing and are driving a variety of positive business outcomes. The nature that the "Things" must be connected into a network and that data must be shared with diverse users and tools unavoidably result in significant reliability issues to the systems. In this talk, we explore ways to visualize and monitor cybersecurity analytics in IIOT dashboards based on ThingWorx.

3 - Design of Experiments, Games, with Applications to Cybersecurity

Matthew Booth, Ohio State University, Columbus, OH, United States, Theodore T. Allen

Design of Experiments and GameTheory currently stand far apart from another in the literature. However, by combining the two and using them to predict the payoff matrices for two players, one can come to useful conclusion about the nature of the game.This method is particularly relevant where the cost of playing the game may be fairly high and therefore there is a constraint on the number of runs possible.After performing the regression on the payoff matrices, one can also estimate the Nash equilibria of the games (including cybersecurity games).

4 - Non-linear Optimization Two-stage Stochastic For Resilience Engineering Framework

Abdullah AlOmair, Ohio State University, Athens, OH, 45701-9291, United States

We proposed a system for resilience framework and analysis using Taguchi's system for robust engineering and simulation. While our examples have focused on resilience recovery from cyber attacks, the system may be helpful in the supply chain for protecting critical infrastructure and social media reputation recovery context. We used nonlinear optimization to solve the two-stage stochastic problem.

5 - Fast Approximation For Power System State Estimation Under Cyber Attacks

Kamal Basulaiman, University of Pittsburgh, Pittsburgh, PA, 55414-3265, 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.

■ VSB69

Virtual Room 69

Data Science and Stochastic Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Suvrajeet Sen, Univ. of Southern California, Santa Monica, CA, 90403, United States

1 - 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.

2 - 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.

3 - Primal-dual Incremental Gradient Method Fornonsmooth And Convex Optimization Problems

Afrooz Jalilzadeh, The University of Arizona, Phoenix, AZ, 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.

4 - Joint Online Learning And Decision-making Via Dual Mirror Descent

Alfonso Lobos Ruiz, UC Berkeley, Berkeley, CA, 94720, United States, Paul Grigas, Zheng Wen

We consider an online revenue maximization problem over a finite time horizon subject to lower and upper bounds on cost. At each period, an agent receives a context vector sampled i.i.d. from an unknown distribution and needs to make a decision adaptively. The revenue and cost functions depend on the context vector as well as some fixed but possibly unknown parameter vector to be learned. We propose a novel offline benchmark and a new algorithm that mixes an online dual mirror descent scheme with a generic parameter learning process. When the parameter vector is known, we demonstrate an $O(\sqrt{T})$ regret result and possible worst-constraint bound violation. When the parameter is not known and must be learned, we demonstrate that the regret and constraint violations are the sums of the previous $O(\sqrt{T})$ terms plus terms that directly depend on the convergence of the learning process.

■ VSB70

Virtual Room 70

MIF Paper Competition

Sponsored: Minority Issues Forum

Sponsored Session

Chair: Michelle M. Alvarado, University of Florida, Gainesville, FL, 32611-6595, United States

Presentations can be seen in the online search

■ VSB71

Virtual Room 71

Scheduling Problems

Contributed Session

Chair: Chandrasekharan Rajendran, IIT Madras, India, Chennai, 600036, India

1 - Cross-regions Collaborative Scheduling Problem For Scarce Equipment Of Hhc

Gang Du, East China Normal University, Shanghai, China

This paper initially considers the cross-regions collaborative scheduling of scarce medical equipment in HHC, and take stochastic factors into account. To deal with uncertain issues, this paper puts forward a Stochastic Programming model with Recourse (SPR model) with the objection of minimizing the total dispatching cost considering the cross-regions profits. Furthermore, the improved Tabu Search Algorithm is proposed to solve the model. A series of numerical experiments demonstrate the effectiveness of the proposed model and algorithm. This research will provide reference for the improvement of equipment collaborative scheduling scheme, and be applied in the actual HHC to promote community support.

2 - Tighter Formulations for Scheduling Problems with Makespan and Lateness Objectives

Nitin Srinath, United States

Scheduling literature in the recent past has moved away from the development of exact methods due to their inability to solve large sized NP-hard problems in a reasonable timeframe, even though they provide optimal solutions. We aim to improve the general scheduling MILPs by adding valid constraints and cuts so that these methods can be used to solve practical problems.

3 - A Mathematical Model and a Heuristic for the Shift Scheduling and Rostering Problem: The Case of Call Centers in India

Chandrasekharan Rajendran, IIT Madras, India, Chennai, 600036, India, Sweety Hansuwa

The problem of shift scheduling and rostering for workforce planning is challenging in view of various constraints and real-life considerations present in different contexts. In this work, we consider such a problem in the context of call centers with real-life considerations present in India, and present a mathematical model and a heuristic. Computational results are presented.

■ VSB72

Virtual Room 72

Rail Transportation

Contributed Session

Chair: Si Chen, Southwest Jiaotong University, ChengDu, 610031, China

1 - Africa Transcontinental Railway Routes Planning By Using Statistical Analytics Tool In Phase NA To WA

Chi-Feng Ho, Henry M. Gunn High School, Palo Alto, CA, United States, Chi-hong Ho

The overall economy in Africa was in a downward trend since 2016, which had been affected by the oil price reductions. Because of increasing the amount of exploited Shale Oil, the oil price decreased which affected African countries' economy hugely. The authors proposed that building railways could increase employment opportunities and improve the economic condition of crossing areas. The authors used multivariate statistical models to analyze 23 countries' economic, natural resources, and further sketch up transcontinental railway routes across the North Africa and West Africa section.

2 - Towards A Unifying Framework For Modelling And Solving Large Scale Slot Allocation Problems

David Torres Sanchez, Lancaster University, Lancaster, United Kingdom, Konstantinos G. Zografos

In this work we present a unified framework to solve large scale slot allocation problems with pre-defined priorities and capacity constraints. The problem consists of satisfying several operator requests for the use of the network capacity for some specified periods of time. Subject to capacity and priorities for different services, we provide a network-wide schedule. Such problems can be found, for example, in the railway and airline scheduling process. We provide a solution procedure to effectively schedule slots on a network and present results from our case studies.

3 - Performance Factors Influencing The Service Reliability And Service Interruption In Train Operations Under PTC

Yalda Khashe, University of Southern California, Los Angeles, CA, United States

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.

4 - Imperfect Rail Track Inspection Scheduling With Zero-inflated Miss Rates

Ayca Altay, Rutgers University, Piscataway, NJ, United States, Melike Baykal-Gursoy

Despite the technological advances in maintenance, railway companies continue to conduct walking inspections on tracks. Due to human errors, these manual inspections may miss existing defects leading to further degradation even derailments. In order to reflect the impact of missed defects on the inspection schedule, we propose a zero-inflated Poisson process model for the number of defects detected at each inspection. Furthermore, we provide an approach to find an optimal inspection schedule given the inspection history. Results indicate considerable savings in maintenance costs.

5 - Research On The Impact Of China Railway Express On International Logistics Routes Of Inland Cities In China

Si Chen, Southwest Jiaotong University, ChengDu, China, Juan Zhong, Yinying Tang, Yue Liang

Since the launch of the China Railway Express, the number of international logistics routes in cities in China has increased to varying degrees. This difference reflects the differences in the level of development of international logistics in different inland cities. It is of great significance to identify the factors that cause such differences for cities' and China's international logistics. Analyse the diversity in the number of international logistics routes of cities,which have steadily launched the China Railway Express and classify the above cities by cluster analysis method. Identify the factors by structural equation model, and put forward policy recommendations.

■ VSB73

Virtual Room 73

COVID-19 Applications

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Wendy Nilsen, National Science Foundation, Alexandria, VA, United States

1 - Opportunities And Challenges Of Covid-19

Wendy Nilsen, Acting Deputy Division Director, National Science Foundation, Alexandria, VA, United States

Medicine and public health have unknowingly become a digital industries. Data from patient records, lab tests, images, apps and the Internet of Things, have changed the interface for health. COVID-19 has escalated a shift in care from providers to patients and from clinics to the home. With the proper safeguards, these technologies can now safely move health diagnosis, treatment, prevention, and surveillance into the home and community. These changes provide many opportunities and challenges to transform health now and in the future and require the technological and biomedical communities to partner in new ways for the development, dissemination and adoption of safe and trustworthy technologies.

2 - 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.

■ VSB74

Virtual Room 74

Multi-objective optimization

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Tim Marler, PhD, RAND Corporation, RAND Corporation, Santa Monica, CA, United States

1 - 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.

■ VSB75

Virtual Room 75

Enterprise Revenue Management at 84.51

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Yifan Liu, 8451, 8451

1 - An Overview Of The Science Team At 84.51°
Paul Helman, Chief Science Officer, 84.51°, Cincinnati, OH, United States

The Science team at 84.51° conducts long-term R&D in a variety of scientific fields, including Optimization, Forecasting, and Machine Learning. We will give a brief overview of the work of the team, describe the business domains to which our work is applicable, and provide context for the other presentations in this session.

2 - Massive, Robust, And Consistent Multiscale Forecasting In Enterprise Applications
Kiran Ravulapati, 84.51, Cincinnati, OH, United States, Joe Puchala, Andrew Cron

Deploying an enterprise scale forecasting solution induces many technical and methodological constraints often overlooked in academic forecasting literature. We discuss the intersection of scalable - hundreds of millions of forecasts daily - forecasts in the cloud while quantifying uncertainty for rational supply chain optimization, maintaining consistency through multiple client use cases to drive coherent decision making, and automated error analysis applied to retail forecasts throughout Kroger.

3 - Recurrent Neural Networks-based Forecast Models
Tao Hu, 84.51° LLC., Chicago, IL, United States

We present a neural-network-based model for Kroger store traffic forecast with multi-timescale seasonality. Store traffic characterizes the total number of product types sold and is crucial for downstream SKU level forecast tasks. We develop a dilated seq2seq architecture to capture the seasonality and generative model + contrastive learning-based distribution regularization. The model achieved 20%+ improvement against traditional methodologies and a significant boost on SKU level prediction accuracy.

4 - Product Embedding For Parity Constraints Construction In Price And Promotion Optimization
Shaojun Zhang, 84.51°, Cincinnati, OH, United States, Yi Liu, Ritesh Khire, Yifan Liu

One challenge in price optimization is systematic construction of parity constraints, the first step of which is to find similar products of different package sizes. By applying word embedding techniques to transactional basket and attribute data, we derive a product representation such that meaningful relationship among products are preserved and similar products can be efficiently extracted, which makes the parity construction customer-centric and easy to automate.

5 - 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.

■ VSB76

Virtual Room 76

Applied Machine Learning for a Two-Sided Marketplace

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Margaret Pierson, Wayfair, Boston, MA, United States

Co-Chair: Tulia Plumettaz, Wayfair, Boston, MA, United States

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, 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, 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.

5 - Optimally Delisting Products that Are Likely to Arrive Damaged
Nathaniel Burbank, Wayfair, Boston, MA, United States, Tim Scully

Orders that arrive damaged can create unhappy customers and increase Wayfair's shipping costs. Identifying which products are likely to break during shipment, however, is challenging because of the difficulty in distinguishing between differences in latent damage rates and sampling variation, especially in the long tail of our large catalog. To compensate, we apply a combination of probabilistic modeling and gradient boosted trees to predict future damage rates. We combine these predictions with cost and customer experience assumptions to decide which products to delist (if any), while balancing the benefits of diverse selection with the negative outcomes of damages.

■ VSB77

Virtual Room 77

Integrating OR/MS/Analytics Teaching and Scholarship IV

Informs Special Session: INFORMS Committee on Teaching and Learning

Informs Special Session Session

Chair: Neil Desnoyers, Saint Joseph's University, Upper Darby, PA, 19082-1307, United States

1 - Publishing Educational Research on Teaching and Learning in OR/MS/Analytics
Susan Wright Palocsay, James Madison University, MSC 0202, Computer Info Sys & Bus Analytics Dept, Harrisonburg, VA, 22807, United States

This presentation will provide an overview of scholarship of teaching and learning (SOTL) in OR/MS/analytics, with an emphasis on its development over time. The increase in popularity and recognition of SOTL makes it important for educators in our discipline to learn how to conduct pedagogical research. Guidelines for planning, doing, and writing up instructional research projects will be discussed.

2 - Instructional Scaffolding for an Online Operations Research Course
Natarajan Gautam, Texas A&M University, College Station, TX,

77845-7718, United States

Teaching an operations research course online is daunting but many of us had to do it during the pandemic. The major concerns are students not learning the material adequately, and the effectiveness of online exams. We present an instructional scaffolding approach to provide support and guidance to the students, thereby addressing the aforementioned concerns. In the talk, we will describe the approach in detail, give examples, and illustrate its impact on the students.

3 - Pedagogical Video Creation and Use: What Does the Data Say?

Wendy Swenson Roth, Georgia State University, Atlanta, GA, 30303-2376, United States

Students interacting with videos as part of the learning process is commonplace. Videos are replacing some face-to-face lectures, specifically in hybrid and flipped formats. Review videos are added to standard lecture format courses. Massive open online courses (MOOC) require videos to make the format possible. These are just a few examples of how universities and course content have adapted to technology advances. What guidelines does research provide about the creation of videos? Then, once videos are incorporated into a course, how is student engagement with this content measured and what does this reveal that can be used to continue to improve learning. Results from data collect from an undergraduate hybrid business analysis course will be discussed.

4 - Enhancing Student Buy-in For A Management Science Course

Julie Ann Stuart Williams, Professor, University of West Florida, Pensacola, FL, 32514-5732, United States, Randall Reid, Philip Billings, Yun Chi Chiang, Natalie Belford

Addressing the question, How could a management science course enhance my career?, early in the term can improve the student's engagement with the subsequent material. To establish the relevance of management science, we assigned a series of practitioner video clips and a group discussion exercise. Upon listening to management scientists in the field, students interacted with group members via a series of asynchronous posts. We share our experiences with this approach.

5 - OR/MS/Analytics K-12 Education Outreach

Sara Manago, Junior League of Boston, Boston, MA, 01845-2122, United States

As OR/MS/Analytics has become increasingly ubiquitous across modern industries and disciplines, it is more important than ever to ensure that members of the next generation have the tools they need to succeed in OR/MS/Analytics programs before they enter college. In order to improve exposure to OR/MS/Analytics in primary and secondary education, it is necessary for academic institutions, government agencies, and industries in OR/MS to engage in education outreach to K-12 administrators, teachers, STEM program leads, and students. Strategies to engage in education outreach and to advocate for improvement in OR/MS/Analytics and OR/MS/Analytics-supportive education will be discussed.

■ VSB78

Virtual Room 78

Undergraduate Operations Research Prize 2

Informs Special Session: Undergraduate Operations Research Prize

Informs Special Session Session

Chair: Kayse Lee Maass, Northeastern University, Boston, MA, 02115-5005, United States

Co-Chair: Camilo H Gomez, Univ de Los Andes-Bogota, Bogota, Colombia

1 - Learning Prescriptive Trees from Observational Data

Nathanael Jo, University of Southern California, Los Angeles, CA, United States

2 - Optimization of Sliding Windows IMRT Treatment Planning

Rafiq Habib, University of Waterloo, Waterloo, ON, Canada

3 - Scheduling Appointments Online: The Power of Deferred Decision-Making

Devin Smedira, Cornell University, Ithaca, NY, United States

4 - Smart Surgical Scheduling Tool: An Optimization Model with Integrated Perioperative Information Input

Shengwei Zhang, Johns Hopkins University, Baltimore, MD, United States

Operating room is one of the main resources in a hospital, and any disruption in its workflow can have a cascade effect on the rest of hospital operations. We approach OR scheduling problem by developing a surgical scheduling tool that takes integrated perioperative input and outputs an optimized OR schedule. This tool consists of five modules: three modules provide preoperative and postoperative input; one module takes input and output an OR schedule; one module evaluates output performance. By deploying this tool, hospitals can reach multiple objectives in improving OR operational efficiency.

■ VSB79

Virtual Room 79

Data Driven Decision Making for Agriculture

Informs Special Session: Agriculture

Informs Special Session Session

Chair: Guiping Hu, Iowa State University, Ames, IA, 50011, United States

Co-Chair: Lizhi Wang, Iowa State University, Ames, IA, 50011, 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 - Combining Multi-type Data To Improve Multi-category Trait Prediction

Vamsi Manthena, PhD Student, University of Nebraska-Lincoln, Lincoln, NE, United States, Diego Jarquin, Reka Howard

Modern plant breeding programs collect several data types such as weather, images, and secondary or associated traits besides the main trait (e.g. grain yield). Genomic data is high-dimensional and often over-crowds smaller data types when naively combined to explain the response variable. There is a need to develop methods that are able to effectively combine different data types of differing sizes to significantly improve predictions. In this work, we develop a new three-step statistical method to predict multi-category traits by combining three data types — genomic, weather, and secondary trait and address the various challenges associated with this problem. We compare our method with several standard classifiers using simulation study and real data.

4 - Optimizing Crop Planting Schedule Considering Weather Conditions and Storage Capacity

Saiara Samira Sajid, Iowa State University, Ames, IA, United States, Guiping Hu

Implementation of the emerging technologies in the agricultural sector has contributed to productivity improvement. However, the challenges in resource utilization and field operation impede the gain from this improvement. One such challenge for crops is designing an optimal planting strategy, as weather conditions and storage capacity have to be taken into account while deciding planting dates. In this research, we propose a two-stage model to assist the decision-making during the planting phase. This model considers weather uncertainties as well as resource constraints while suggesting the optimal planting schedule. In the first stage, the weather conditions are addressed by a weather prediction model for Growing Degree Units (GDUs). Our research observed that for GDUs prediction 1D-CNN model outperformed other prediction models with an RRMSE of 7% to 8% for two different locations. While in the second stage, these predictions are incorporated into the model formulation for the planting schedule. The objective of the optimization model is to complete the harvesting within the storage capacity and utilizing a minimum number of harvesting weeks. The results demonstrate the efficacy of our proposed model to provide an optimal planting schedule considering planting window and storage capacity.

1 - 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.

■ VSB80

Virtual Room 80

INFORMS TutORials - Learning and Information in Stochastic Networks and Queues

Tutorial Session

Chair: Douglas R. Shier, Clemson University, Pittsboro, NC, 27312-8612, United States

1 - Learning And Information In Stochastic Networks And Queues

Neil Walton, University of Manchester, Manchester, M13 9PY, United Kingdom, Kuang Xu

We review the role of information and learning in the stability and optimization of queueing systems. In recent years, techniques from supervised learning, online learning and reinforcement learning have been applied to queueing systems supported by the increasing role of information in decision making. We present observations and new results that help rationalize the application of these areas to queueing systems. We prove that the MaxWeight policy is an application of Blackwell's Approachability Theorem. This connects queueing theoretic results with adversarial learning. We then discuss the requirements of statistical learning for service parameter estimation. As an example, we show how queue size regret can be bounded when applying a perceptron algorithm to classify service. Next, we discuss the role of state information in improved decision making. Here we contrast the roles of epistemic information (information on uncertain parameters) and aleatoric information (information on an uncertain state). Finally, we review recent advances in the theory of reinforcement learning and queueing, as well as provide discussion of current research challenges.

■ VSB81

Virtual Room 81

Emerging Themes in Urban Transportation Planning

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Yifei Sun, Dartmouth College, Lebanon, NH, 03766, United States

1 - Transit Network Design and Frequency Setting With Ridesharing Services: A Case Study of the Greater Boston Area

Yifei Sun, Dartmouth College, Lebanon, NH, 03766, United States

This study focuses on developing the optimal transit network and frequency strategies for transit operators considering the competition and collaboration with ride-sharing services and compare different feasible government policies to increase social welfare. A Second-order Cone Programming model is formulated to optimize the transit network and optimal on-demand vehicle fleet size. Social welfare which includes passenger utilities and operating costs is maximized. The optimization model is applied to a case study in Greater Boston Area. The results showed that social welfare increased by 23% compared to the current transit network. Several relevant government policies will be evaluated like subsidizing ridesharing services if multi-model services are provided; banning on-demand services from entering the city center.

2 - Control Of A Mixed Autonomy Signalized Urban Intersection: An Action-delayed Reinforcement Learning Approach

Arnob Ghosh, Imperial College of London, London, 110016, United Kingdom

We consider a mixed autonomy scenario where the traffic intersection controller decides whether the traffic light will be green or red at each lane for multiple traffic-light blocks. The objective of the traffic intersection controller is to minimize the queue length at each lane and maximize the outflow of vehicles over each block. We consider that the traffic intersection controller informs the autonomous vehicle (AV) whether the traffic light will be green or red for the future traffic-light block. Thus, the AV can adapt its dynamics by solving an optimal control problem. We model the decision process of the traffic intersection controller as a deterministic delay Markov decision process owing to the delayed action by the traffic controller. We propose Reinforcement-learning based algorithm to obtain the optimal policy.

3 - Ridesharing Morning Commute In Monocentric City Networks - An Equilibrium Model And The Analytical Solutions

Rui Ma, University of Alabama in Hunstville, Huntsville, 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.

4 - 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.

■ VSB82

Virtual Room 82

Dynamic Decisions in Autonomous Vehicles

Sponsored: TSL/Facility Logistics

Sponsored Session

Chair: Seyma Gunes, University of Washington, Turkey

1 - 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.

2 - Managing Autonomous Vehicle Technology And Service Level For Ride Sharing

Fei Qin, Shippensburg University, Shippensburg, PA, United States, Saravanan Kuppusamy

We study Ride-Sharing (RS) Business that offers both Autonomous Vehicle (AV) and Conventional Vehicle (CV) services to consumers. We find that the incentive of RS to improve the AV's availability and affordability is greater under a more favorable market environment with higher consumer AV evaluations.

3 - Analyzing Traffic Impacts Of Different Curbspace Management Strategies Through Simulation

Seyma Gunes, Research Assistant, University of Washington, Seattle, WA, United States, Andisheh Ranjbari, Chase Patrick Dowling

As the demand for curb space is increasing and cities are revising their curb management plans, it is important to be able to understand traffic impacts of different curb management strategies. Using a microsimulation platform, we have developed a framework for evaluating the impacts of different curb allocations and vehicle behaviors. For each simulated scenario, speed-flow diagrams are created to understand the traffic impacts in the study blocks. Curb performance is also studied in terms of occupancy, turnover and productivity. The findings help cities implement curb management strategies that improve curb performance and alleviate traffic disruptions.

■ VSB83

Virtual Room 83

INFORMS Case Competition

Award Session

Chair: Jeroen Belien, KU Leuven, Brussel, 1000, Belgium

1 - A Perfect Storm: Examining the Supply Chain for N95 Masks during COVID-19

Tim Kraft, NC State - Poole College of Management, Raleigh, NC, 27695, United States, Jimit Shah

This case introduces students to critical issues that occurred in the supply chain for N95 masks during the global pandemic. While many students will be familiar with the fact that supply chain disruptions occurred during the crisis, many will not know the specific details or why these disruptions occurred. The case can be used to illustrate the fundamental operational issues that occurred throughout the N95 masks' supply chain, discuss the root causes of the supply chain disruptions that occurred during the pandemic, and introduce the concept of the Triple-A supply chain.

2 - Integration Planning at SFB

Georgina Hall, INSEAD, Fontainebleau, France, Piyush Gulati, Anton Ovchinnikov

This three-part case considers an analytics value chain, from data to prediction to prescription, wrapped around a "people analytics" problem. Following an acquisition, the acquirer (BAP) and the target (SFB) need to reduce headcount at the merged company. This must be done within the confines of the Rupture Conventionnelle Collective (RCC), a legal framework in France that gives employees in pre-defined categories the option to leave voluntarily with extra pay. The goal of the case is to design these categories using classification techniques and optimization.

3 - Pennsylvania Dominion

Lauren Cipriano, Ivey Business School, London, ON, N6G 0N1, Canada, Oladapo Folami, Melanie-Anne Atkins

This case presents the opportunity to investigate systemic racial bias in mortgage approval decisions using regularized logistic regression and other classification techniques in the presence of numerous correlated predictors. The case setting requires a challenging discussion of managerial issues in analytics including discrimination embedded in 'objective' predictor variables and algorithmic bias. Student-use datasets and, for instructors, solution R code are provided. The case is appropriate for machine learning or data science courses at the senior undergraduate, MBA, and Master's levels.

■ VSB84

Virtual Room 84

Doing Good with Good OR: II

Award Session

Chair: Renata Alexandra Konrad, Worcester Polytechnic Institute, Worcester, MA, 01609, United States

Co-Chair: Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States

1 - EMS Hospital Load Balancing in New York City

Elioth Sanabria, Columbia Unviersity, New York, NY, United States, Enrique Lelo de Larrea

Unusual spatial shifts in 911 incidents, such as during the COVID-19 pandemic, can lead to hospital overload that degrades patient outcomes. Collaborating with the New York City (NYC) Fire Department, we design a hospital load-balancing rule for EMS ambulance crews that accounts for both patient transport time and hospital capacity at the city level, by integrating optimization with simulation tests and data analytics. The rule has been implemented in NYC's EMS system since January 2021, serving as a safeguard against a future surge in NYC and a road map for other urban EMS systems.

2 - Shield-Net: Matching Supply with Demand for Face Shields During the COVID-19 Pandemic

Rebecca Alcock, University of Wisconsin–Madison, Madison, WI, 53711, United States

The early months of the COVID-19 pandemic were marked by shortages of personal protective equipment (PPE). In response, domestic suppliers pivoted to PPE production, but the lack of an established marketplace left new suppliers and healthcare facilities disconnected. Therefore, we developed Shield-Net, an online matching platform based on an optimization model, to connect face shield requesters with suppliers. During March-September 2020, Shield-Net curated 390 matches, resulting in the shipment of over 50,000 face shields to 68 organizations.

3 - The Power of Analytics in Epidemiology for COVID-19: Prediction, Prevalence, and Vaccine Allocation

Omar Skali Lami, MIT, Cambridge, MA, 2139, United States

This paper is our contribution to the global efforts to mitigate the COVID-19 pandemic; we predict new cases and deaths, study the true prevalence of the disease, and prescribe an optimal vaccine allocation plan. We present a novel predictive ML aggregation method, which is used by the CDC and is consistently among the top 10 models in accuracy. We use these predictions to model the true prevalence of COVID-19 and incorporate this into an optimization model for fair vaccine allocation. Our work has been used in a collaboration with MIT's Quest for Intelligence and as part of MIT's reopening.

Sunday, 7:45AM - 8:30AM

■ VSB86

Virtual Room 86

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.

Sunday, 8:00AM - 8:30AM

■ VS85-2

Virtual Room 85

Technology Showcase: Using Arena Simulation to Have Confidence in your Business Decisions

Technology Showcase

1 - Using Arena Simulation to Have Confidence in Your Business Decisions

Nancy Zupick, Rockwell Automation, Wexford, PA, 15090, United States

The session will begin with what you need to know before starting a simulation project and some advice on how to keep your project on track and focused on your objectives. This presentation will include how Arena simulation is applied within business settings to assist in making decisions about labor management, process changes, capital improvements and various other situations that require a more thorough analysis before committing time and money to an effort.

Sunday, 8:30AM - 9:15AM

■ VSB86-2

Virtual Room 86

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.

Sunday, 9:00AM - 9:30AM

■ VS85-3

Virtual Room 85

Technology Showcase: This IS IT! Interactive Smart Textbooks for the Modern Program!

Technology Showcase

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. During this 30 minute presentation we'll share how each smart learning resource, hosted on our intuitive platform, is filled with auto-graded assessments, ample instructor material, and robust analytics all with a seamless single sign-on LMS integration. Additionally, all our learning resources provide students an affordable price with lifetime access and best-in-class service.

Full access will be given to any book on our platform to attendees.

Sunday, 9:45AM - 10:45AM

■ SP01

CC - Ballroom E /Virtual Theater 5

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, 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

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

Co-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

■ VSC01

Virtual Room 01

Energy Systems Integration: Linking Platforms and Stakeholders across Systems, Scales, and Vectors

Sponsored: Data Mining

Sponsored Session

Chair: Madeleine McPherson, University of Victoria, Victoria, BC, V8S 3X5, Canada

1 - Interfacing the CODERS Database with Energy System Models Using the SPINE Platform

Jacob Garner Monroe, North Carolina State University, 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 - An Open-access Integrated Platform For Visualizing Transition To A Low-carbon Energy System

Mohammad Miri, University of Victoria (UVic), Vancouver, BC, Canada

Efforts to develop and apply modeling tools that explore energy systems' transition towards decarbonization have grown in recent years. Such analysis deal with topics ranging from technical to economic, resource and environmental issues, and social and behavioral topics. But the diversity of insights derived from models makes it challenging to have that conversation in a coherent and cohesive manner. Visualization dashboards can play an important role in presenting insights in a coherent way to facilitate the constructive dialogue that is necessary for navigating complex choices. The IDEA platform represents the output from multiple model types that span sectors (power, transport, buildings), as well as scales (provincial, national, international) in an interactive platform and open-source and transparent way.

3 - City Scale Electricity Supply And Demand Modelling To Investigate Renewable Energy Pathways

Madeleine Seatle, University of Victoria, Victoria, BC, Canada, Robert Xu, Lauren Stanislaw, Madeleine McPherson

As populations move out of rural areas and into urban ones, possibilities for cross-sector decarbonization become more feasible. On the demand side, electrification can contribute to decarbonization, though only with a low-carbon electricity supply; integrating variable renewable energy (VRE) is one solution. VRE integration and electrification can work together, with electrified loads providing the flexibility required to integrate variable sources of generation. Using the city of Regina, SK as a case study, an integrated model platform, consisting of sector-specific models focused on transportation, buildings, and the power system, was developed. By linking the outputs of the supply and demand sectors, the integrated model platform can be used to explore the effects that demand side electrification and management can have on system cost and GHG emissions.

4 - Canadian Energy Investment Needs For Mid-century Energy System Transformation And Decarbonisation Pathways

Muhammad Awais, University of Victoria (UVic), Vancouver, BC, Canada

Muhammad Awais, International Institute of Applied Systems Analysis (IIASA), Laxenburg, Austria

Developed countries like Canada need to ramp up ambitions on climate targets to avoid falling behind. Regional planners are therefore keen to understand the types of technologies and size of investments needed to support decarbonization pathways. This study plans to support regional planners by developing and analyzing a set of long-term energy scenarios that not only achieve the NDC commitments by Canada but also mid-century emissions targets aligned with the Paris Agreement. It utilizes the open-source MESSAGEix modeling platform for integrated and scenario analysis and its implementation as the global integrated assessment model MESSAGEix-GLOBIOM. The study demonstrates how these tools can be leveraged to rapidly prototype technology-rich sustainable energy futures at a national scale consistent with policy objectives.

5 - A Proposed Workflow and Strategy to Bridge the Modeller-Decision-Maker Divide

Madeleine McPherson, University of Victoria, Victoria, BC, V8S 3X5, Canada

How can improve the effectiveness of models for use in evidence-based decision making in our transition to a sustainable energy future? Part, but by no means all, of the answer to that question lies in putting together software capacity that: (1) can be leveraged in a timely way to respond to policy windows, (2) is transparent and credible, and (3) can be used by multiple stakeholders for a range of questions. Doing so relies on three key pillars: the data to populate models, the individual models and the linkages between them, and effective visualizations to communicate the results. This presentation will discuss the framework that we have developed to pull these pieces together into a cohesive workflow that can facilitate bridging the gap between modellers and decision makers.

■ VSC02

Virtual Room 02

Big Data in Business Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Tawei Wang, DePaul University, DePaul, IL, United States

1 - The Dynamic Effects of News and User-Generated Content on a Firm's Product Recalls

Yen-Yao Wang, Auburn University, Auburn, AL, 36849, United States, Vivek Astvansh

OM researchers have long investigated the variety of factors that may determine a firm's product recalls. We study how the level of negativity and the level of positivity in news and in user-generated content on social media platforms (UGC) about a firm's product defects would influence its recalls.

2 - 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, 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.

3 - A Text Mining Approach To Assessing Company Ratings Via User-generated And Company-generated Content

Shih-Hui Hsiao, Rowan University, Glassboro, NJ, United States

Retail and third-party websites are online platforms where customers collect information and interact with other users and companies. User-generated content is available through different online platforms, and online reviews are one of the most common types of user-generated content used for product or company evaluation. Previous research has mainly focused on the characteristics of online reviews. Current research has expanded to discuss the impact of the company's interaction with customers on online reviews. The current survey results provide further insights into how companies use public manager responses as a business strategy to improve companies' online ratings.

4 - An Evaluation of Twitter Customer Service Chatbots

Tawei (David) Wang, DePaul University, Chicago, IL, 60604-2201, United States, Chi-Heng Yang, Ju-Chun Yen, Fujiao Xie

Conversational AI has been shown to provide immediate responses and reduce human efforts. However, how effective it remains an open question. Using a sample of customer service chatbot interactions on Twitter, we investigate and show how effective chatbots are when addressing different types of questions.

■ VSC03

Virtual Room 03

Statistical Learning and Decision Making

Sponsored: Data Mining

Sponsored Session

Chair: Yunzong Xu, Massachusetts Institute of Technology, Cambridge, MA, 02139-4204, United States

Co-Chair: Yunbei Xu, 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.

3 - Distributionally Robust Prescriptive Analytics With Wasserstein Distance

Tianyu Wang, Columbia University, New York, NY, United States

In prescriptive analytics, the decision-maker observes historical samples of (X, Y), where Y is the uncertain problem parameter and X is the concurrent covariate, without knowing the joint distribution. Given an additional covariate observation x, the goal is to choose a decision z conditional on this observation to minimize the cost $\mathbb{E}[c(z,Y)|X=x]$. This paper proposes a new distributionally robust approach under Wasserstein ambiguity sets, in which the nominal distribution of $Y|X=x$ is constructed based on the Nadaraya-Watson kernel estimator concerning the historical data. We show that the nominal distribution converges to the actual conditional distribution and establish the out-of-sample guarantees as well as the computational tractability. Through experiments, we demonstrate the strong performance of the proposed framework.

4 - Yield Modeling For Multi-layer Products

Emmanuel Yashchin, IBM TJ Watson Research Center, Yorktown Heights, NY, United States

We discuss statistical modeling of yields for products that are built layer-by-layer; typical examples include three-dimensional printing and semiconductor manufacturing. We focus on problems where product failure is primarily related to defects in various layers. Information available about the defects is typically incomplete, and there is a possibility of a product failing due to other causes. We describe a probabilistic approach to yield modeling, and discuss problems related to estimation, forecasting and yield management. This is joint work with Michael Baron and Asya Takken.

■ VSC04

Virtual Room 04

Optimization Modelling in Structural Econometrics

Sponsored: Data Mining

Sponsored Session

Chair: Stefano Nasini, IESEG School of Management, Lille, 59800, France

1 - Endogenous Technology Sharing In Decentralized Production

Marijn Verschelde, Associate Professor, IÉSEG School of Management, Lille, France, Stefano Nasini, Bruno Merlevede

We study the endogenous choice of intangible assets by the parent firm, organizing decentralized multi-plant production. A distinguishing feature of our framework is that we allow for anticipation by the parent of the affiliates' best response to the technology transfer and transfer price, set by the parent. Our approach is general in the sense that we cover both horizontal and vertical production and allow for dynamic optimization by the follower. We implement the leader-follower structure by the use of a bi-level optimization framework wherein the parent acts as a newsvendor. For horizontally organized firm structures, we recover the optimal solution and for vertically organized firm structures we recover tight lower and upper bounds. We show the empirical applicability by simulation and application.

2 - Estimating Nonconvex Cost Metafrontiers Correctly: The Price Of A Convexification Strategy

Kristiaan Kerstens, CNRS-LEM, IESEG School of Management, Lille, France, Christopher O'Donnell, Ignace Van de Woestyne

Metafrontier analysis is popular to account for technological heterogeneity in production. The approach involves combining a number of group-specific production possibilities sets to form a production possibilities metaset. Even though the union of the group sets normally results in a nonconvex metaset, most authors proceed as if the metaset is convex. Kerstens, O'Donnell and Van de Woestyne (2019) obtain new results on the union operator on sets under various assumptions. Here, we transpose their results on the union operator from a production to a cost context: this is new. We then explore the extent to which a convexification strategy is tenable when estimating a cost metafrontier. Using a secondary data set, we establish that the convexification strategy leads to potentially-biased estimates of the cost metafrontier and associated measures of efficiency.

3 - Socially Optimal Ridesharing With Fixed (Static) and Endogenous (Dynamic) Congestion

Andre de Palma, ENS-Cachan, Cachan, 94230, France

Ridesharing is formulated as a matching model in general networks with fixed congestion. The social planner matches drivers and passengers to minimize travel time, environmental and perceived users' costs. Incentives are designed to compensate losses for drivers and passengers. This matching scheme is formulated as a Linear Programming problem. Existence, integrality and stability are investigated. An application to Sioux Falls network illustrates benefits (fuel consumption, CO2 savings) and costs (detours) of ridesharing. Ridesharing with endogenous dynamic congestion is shortly presented.

4 - Nash Bargaining Partitioning For Decentralized Portfolio Optimization

Stefano Nasini, IESEG School of Management, Lille, France, Francisco Benita, Rabia Nessah

Understanding how to distribute a budget among decentralized intermediaries is a relevant question for financial investors. We consider the Nash bargaining partitioning for a class of decentralized investment problems, where risk minimizer intermediaries are in charge of the portfolio construction in heterogeneous markets. We propose a reformulation that is valid within a class of risk measures (that we call quasi-homogeneous risk functions) and allows the reduction of a complex bilevel optimization model to a convex separable knapsack problem. As numerically shown using stock returns from U.S. listed enterprises, this allows solving large-scale investment instances in less than a minute.

■ VSC05

Virtual Room 05

Data Curation and Feature Engineering in Data Mining Applications

Sponsored: Data Mining

Sponsored Session

Chair: Suhao Chen, Oklahoma State University, Norman, OK, 73071, United States

1 - Cross Validation For Multiple Methods Of Synthetic Data Generation

Lin Guo, University of Oklahoma, Norman, OK, 73071-4109, United States

For a complex system, such as a hospital, we do not always have sufficient authentic data. When the authentic data is missing, we need to generate synthetic data to learn patterns of the system, capture emergent properties, and predict future patterns. Synthetic data generation can roughly be categorized into two classes: process-driven methods and data-driven methods. Process-driven methods derive synthetic data from computational or mathematical models of an underlying physical process, for example, numerical simulations, Monte Carlo simulations, and Agent-based Modeling. Data-driven methods, on the other hand, derive synthetic data from generative models that have been trained on observed data. In this presentation, a framework for cross-validation of the synthetic data generated using multiple methods is proposed.

2 - 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.

3 - DialogueGAT: A Graph Attention Network For Financial Risk Prediction By Modeling The Dialogues In Earnings Conference Calls

Yunxin Sang, Shanghai Jiao Tong University, Shanghai, China, Yang Bao

Financial risk prediction is an essential task for risk management in capital markets. Recent studies have shown that the soft information of verbal cues in earnings conference calls is significant for predicting market risk due to its less constrained fashion and direct interaction between managers and analysts. However, most existing models ignore the subtle yet important information of dialogue structures and speakers from the textual conference call transcripts. To bridge this gap, we develop a graph attention network called DialogueGAT for financial risk prediction by simultaneously modeling the speakers and their utterances in dialogues in conference calls. We propose a new method for constructing the graph of speakers and utterances in a dialogue, and design contextual attention at both speaker and utterance level for disentangling their effects.

4 - A Predictive Analytics And Explainable AI Methodology To Identifying Injury Severity Risk Factors In Car Crashes

Ali Bagheri, Oklahoma State University, Stillwater, OK, 74075, United States, Mostafa Amini, Dursun Delen

Millions of car crashes occur annually in the US, leaving tens of thousands of deaths and many more severely injured or debilitated. In this research, we design and develop a hybrid methodology involving predictive analytics, explainable AI, and heuristic optimization techniques to investigate the injury severity risk factors in automobile crashes. First, we examine a wide variety of machine learning models to identify the most predictive ones, and then, we utilize the post-hoc variable explanation methods to discover the most predictive features. We also propose an explanation method based on a heuristic optimization technique and compare it with the existing methods.

■ VSC06

Virtual Room 06

Data Analytics in Developing Quality Management Theory

Sponsored: Data Mining

Sponsored 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, 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 - Healthcare Quality Management: An Exploration Of The Use Of Text-mining In Customer Satisfaction

Heng (John) Xie, The University of Texas Permian Basin, Odessa, TX, 79762-8122, United States

One of the main goals of healthcare quality management is to help healthcare organizations improve customer satisfaction. This study discusses the efficiency of using text mining techniques in customer satisfaction in healthcare organizations. Compared with survey data, customer reviews include unique information. Researchers used text mining techniques to analyze the feedback and compared previous studies. The results show that text mining technology can help quality management researchers further understand the relationship between healthcare quality management and customer satisfaction.

3 - The Intersection Of Artificial Intelligence And Quality Management Theory: A Proposed Framework For The Utilization Of Advanced Analytical Techniques In Quality Management

Benjamin T. George, University of Toledo, Toledo, OH, 57106-0444, United States, Bartlomiej Hanus, Rebecca Scott

Artificial Intelligence and Machine Learning are often depicted as the new transformative technologies for the coming age. These powerful tools can provide a variety of flexible applications and approaches that can deliver significant changes in how we view the Quality Management paradigm. Historical context shows that transformative technologies necessitate a re-imaging in how quality management is implemented. This new leap in technology will therefore necessitate a greater forward-looking approach in the way we view problems, information, and data as well as how we resolve the conflict between artificial intelligence and quality management. This conflict will be the focal point for both institutional gains and organizational conflict. A novel framework will be proposed to explore this phenomenon, and future research and implications will be discussed.

4 - 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.

5 - Internal Control and Cybersecurity Breaches: The Moderating Effect of Operational Efficiency

Anh Ta, University of North Texas, Omaha, NE, 68105, 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.

■ VSC07

Virtual Room 07

Risk Management & Industrial AI

Sponsored: Data Mining

Sponsored Session

Chair: Mehdi Dadfarnia, National Institute of Standards & Technology, National Institute of Standards & Technology, Chevy Chase, MD, 20815, United States

1 - Panel on Risk & Industrial AI

Michael Sharp, National Institute of Standards & Technology, Gaithersburg, MD, United States, Mehdi Dadfarnia

Risk management is an important topic in any domain. With the growing acceptance and adoption of Industrial Artificial Intelligence (IAI), both the academic and industrial communities are beginning to take a more serious look at the risks and rewards of using IAI. This panel addresses the risk-based evaluation of AI use from both a performance and business impacts perspective. What are the economic and performance impacts when an IAI tool operates correctly? And when it fails? The panel also touches on the use of IAI software for the risk-based evaluation of broader systems

2 - Enhancing Risk Assessment With Greater Situational Awareness

Jamie Coble, PhD, The University of Tennessee, Nashville, TN, United States

Formal logic-based approaches to risk analysis, so-called probabilistic risk assessment, are ubiquitous in the nuclear power industry. Risk assessment results used to support licensing and license amendments rightfully rely on the expected gross behavior over long periods of time. Risk monitors used for short-term decision making at plants, however, should consider the current and near-term conditions at the specific facility. Industrial AI provides the opportunity to integrate greater situational awareness into these risk monitors, giving a more complete view of the risk of performing (or not performing) actions.

3 - Fail-safes And Risk Mitigation Strategies For Mission Critical IAI Systems - Lessons Learned From The Nuclear Power Industry

Sola Talabi, PhD, Pittsburgh Technical, Pittsburgh, PA, United States

Nuclear risk and safety management uses the Probabilistic Risk Analysis (PRA) framework to assess and mitigate risk of core damage (Level 1), radioactivity release (Level 2) and consequences (Level 3). PRA may be applied in other industries that require a robust framework to characterize nascent issues and uncertainties. Mission Critical Industrial Artificial Intelligence Systems may benefit from a PRA framework. Fail-safe design is required for safety-related nuclear components, which based on a PRA approach, implies a probability of failure at an acceptably low frequency. Nuclear passive safety systems that reduce the probability of core damage and radioactivity release will be explained.

4 - Intelligent Risk Management by Artificial Intelligence

Enrico Zio, PhD, Politecnico di Milano, Milano, Italy

In this talk, I will dare to state how artificial intelligence can help risk assessment and management, and underline the main characteristics that artificial intelligence solutions must have to make risk management intelligent. I will, then, address some research and development directions that are emerging in the area of risk assessment and management supported by artificial intelligence.

5 - Artificial Intelligence for Risk Assessment of Complex Engineering Systems: Nuclear Industry Applications

Askin Guler Yigitoglu, PhD, Oak Ridge National Laboratory, Oak Ridge, TN, United States

This talk will focus on state-of-art the AI applications for risk assessment in nuclear industry. Integrating AI methods and tools to risk assessment for advanced reactors designs at different stages of the analysis from pre-assessment (e.g., component health assessment, data analysis) to post-processing (e.g., generating surrogate models of high-fidelity simulations, uncertainty assessment) will be discussed.

6 - Exploring The Connection Between IAI And PRA

Katrina Groth, PhD, University of Maryland, College Park, MD, United States

Ensuring the safety of complex engineering systems ranging from power plants and pipelines is a challenging problem rife with uncertainties. Probabilistic risk assessment (PRA) plays an important role in because of its ability to handle uncertainty and complexity. Advances in data analytics have positioned IAI as important tool for component failure monitoring. However, single point hardware failures rarely lead to catastrophic failure; instead, complex systems fail due to the interplay between hardware, software, humans, the environment, and the physical constraints. Is there a solution at the intersection of these two approaches?

■ VSC08

Virtual Room 08

Analytical Models and Methods in Management Innovations

Sponsored: Data Mining

Sponsored Session

Chair: Luning Shao, PhD, Tongji University, Shanghai, China

1 - Big Data Application and Challenge in Smart Airport Operation

Xiaojun Wu, Tongi University, Shanghai, China

The operations and management of large airports around the world are facing significant opportunities and challenges in the context of big data and artificial intelligence. We will present concerns and expectations in the digital transformation process of large hub airports, especially how to deal with the challenges in the process of various new technologies empowering airport services and operations.

2 - Data Life Cycle Management in Retail Industry

Yanshan Zhou, Sunrise Technologies Co., Ltd, Shanghai, China

Our AI-driven data middle office intelligent data governance, data asset privatization to agile data application. intelligent data governance, data asset privatization to agile data application. With in-depth knowledge on industries and business challenges, we cooperate with enterprises to apply data intelligence to several aspects of business operations to reduce cost and improve effection.

■ VSC09

Virtual Room 09

Sanjay and Panna Mehrotra Research Excellence Award Session

Sponsored: Health Applications Society

Sponsored Session

Chair: Julia L Higle, University of Southern California, Los Angeles, CA, 90089-0193, United States

1 - Optimization and Delivery of Radiotherapy Treatments with Non-uniform Fractions

David Papp, North Carolina State University, Raleigh, NC, 27695, United States

Radiotherapy treatments are fractionated, meaning that the treatment is delivered in several daily sessions, to facilitate the recovery of impacted healthy tissue. Conventional treatments are always uniformly fractionated: the same treatment is delivered each day. We examine how much patients could benefit from receiving treatments with different doses delivered in each fraction, where the benefit could come from, and can such treatments be safe, in the context of proton as well as photon therapy, or the combination of both. We will touch upon both the modeling and computational challenges.

2 - An Operational Approach for Improving Outcomes of High-risk Patients

Vishal Ahuja, Southern Methodist University, Dallas, TX, 75240-3623, United States

Patients with multiple chronic health conditions are at high risk for hospitalization and poor health outcomes over time. Such patients require complex management and health care coordination. In this talk, I explore how continuity of care (CoC) - an operational lever - can be used to improve outcomes of such patients. I also investigate factors that moderate or mediate the relationship between continuity and outcomes. I also shed light on implementation strategies.

3 - Redesigning Sample Transportation in Malawi Through Improved Data Sharing and Daily Route Optimization

Jonas Oddur Jonasson, MIT Sloan School of Management, Somerville, MA, 02143, United States, Sarang Deo, Emma Gibson, Mphatso Kachule, Kara Palamountain

Sample transportation (ST) systems move medical samples (e.g. blood, sputum) between health centers and laboratories in many developing countries. In partnership with Riders for Health Malawi, we implemented an optimized ST algorithm to deploy motorcycle couriers on a daily basis and maximize the efficiency of the Malawian ST system.

■ VSC10

Virtual Room 10

Data-driven Modeling for Disease Management

Sponsored: Health Applications Society

Sponsored Session

Chair: Jagpreet Chhatwal, Harvard Medical School, Mass General Hospital, Boston, MA, United States

Co-Chair: Gizem Nemutlu, Brandeis University, Brandeis University, Burlington, MA, 01803-3872, United States

1 - A Model-Based Study Of Eliminating Circulating Vaccine-Derived Poliovirus Type 2 (cVDPV2)

Yuming Sun, ISyE Georgia Tech, Atlanta, GA, United States, Pinar Keskinocak, Stephanie Kovacs, Lauren N Steimle

The Global Polio Eradication Initiative coordinated global cessation of type 2 containing oral poliovirus vaccine (OPV) in 2016, following the eradication of wild poliovirus type 2. The polio program continues to respond to circulating vaccine-derived poliovirus type 2 (cVDPV2) outbreaks through supplementary immunization activities using monovalent OPV type 2 (mOPV2). However, the attenuated live virus in mOPV2 can, in rare occurrence, mutate to regain neurovirulence and cause cVDVP2 outbreaks in areas with low population immunity. In our study, we build a differential equation-based poliovirus transmission model with OPV evolution process to capture dynamics of transmission and evaluate and compare different preventions and outbreak response options to achieve a polio free world. We focus on Northern Nigeria in our study given its ongoing cVDPV2 transmission.

2 - Data and Decision Sciences: Supporting Patient Care at Ontario Health

Saba Vahid, Ontario Health, Toronto, ON, Canada

Ontario Health is a government agency created to ensure integrated, patient-centred healthcare delivery across the province. Data and Decision Sciences team is an enterprise resource that enables the agency to design and deploy health system interventions and predict their outcome. This talk will include an overview of sample projects where a variety of modelling approaches were used to inform planning and policy within Ontario's health system. Examples will be provided on planning models for a variety of services such as dialysis, diagnostic imaging and cognitive behavioral therapy in Ontario.

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.

4 - 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.

■ VSC11

Virtual Room 11

OR Applications for Medical Decision-making

Sponsored: Health Applications Society

Sponsored Session

Chair: Daniel Felipe Otero-Leon, University of Michigan, Ann Arbor, MI, 48109, United States

1 - Multi-session Appointment Scheduling With Heterogeneous Clients

Reut Noham, Northwestern University, Evanston, IL, 60208-0884, United States, Karen Smilowitz

Clients seeking paramedical therapies attend frequent appointments over an extended period. We study scheduling policies that are designed to meet the needs of heterogeneous clients and the operational considerations of the providers. The problem of assigning clients to available time slots is described as a Markov Decision Process. We characterize the structural properties of optimal scheduling decisions under idealized conditions and develop a heuristic for general cases. We evaluate the performance of this heuristic relative to intuitive rule-of-thumb heuristics. Ultimately, we show that designing dynamic scheduling policies balances the many considerations involved in these scheduling decisions, specifically decreasing the number of rejected requests and improving health outcomes while maintaining high service providers' utilization.

2 - 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.

3 - Unsupervised Clustering Analysis Using Orthopedic Care Features For Hospitals In An Inclusive Trauma System

Xiaonan Sun, University of Washington, Seattle, WA, 98195, United States, Rebecca Maine, Shan Liu

Orthopedic care is vital in treating injuries, but real-life variability in orthopedic care by different level trauma centers (TCs) is unknown. We carried out a clustering analysis with state hospital discharge data from 2016 to see if the hospital cluster aligned with TC level. We included all major orthopedic procedures (MOPs) and conducted a PCA to reduce 2,770 patient and hospital features to 16 components that accounted for 90% of the variation. Results showed that the clusters only partially aligned with TC designations. Of all MOPs, humeral, radial, and tibial fixations in the trauma patients, and knee replacements in non-trauma patients, had the greatest contribution to cluster assignments.

4 - 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.

5 - Patient Prioritization Model With Limited Resources And Stochastic Compliance

Daniel Felipe Otero-Leon, PhD Student, University of Michigan, 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.

■ VSC12

Virtual Room 12

OR for Improving Acute Elderly Care

Sponsored: Health Applications Society

Sponsored Session

Chair: Robert van der Mei, CWI & Vu University, CWI & Vu University, Amsterdam, 1098XG, Netherlands

Co-Chair: Bianca Buurman, PhD, Amsterdam University Medical Center, Amsterdam University Medical Center, Amsterdam, Netherlands

Co-Chair: Sandjai Bhulai, Vrije Universiteit Amsterdam, Vrije Universiteit Amsterdam, Amsterdam, 1081 HV, Netherlands

1 - Influenceable Societal Factors to Lower the Need for Acute Elderly Care: a Practical Perspective

Hanna C. Willems, PhD, Amsterdam University Medical Center, Amsterdam, Netherlands

This presentation gives an overview of the challenges in acute elderly care in the Netherlands. To follow a patient on a journey through a year of medical care gives insight in the challenges a head. What problems are we facing in a ageing society with less informal caregivers and more and more elderly living alone at home? The usual elderly patient has multiple problems and several chronic illnesses. On the other hand, in healthcare there is a trend for more specific care units for one organ, one condition or illness. Therefore there is a lack of fit between elderly with multimorbidity and the care options. Which influenceable factors do we have? How can we change prospects of increasing elderly at the ED? If all factors are known and it is known how and in what matter we can influence, choices can be made on which factors stakeholders can interfere.

2 - Unraveling Acute Care Demands Leading to Emergency Department Visits of Elderly in the Amsterdam Region

Oscar Smeekes, PhD, Amsterdam University Medical Center, Amsterdam, Netherlands

Increasing acute care demands of the elderly give an increasing burden at patient, caregiver and societal level in the Netherlands. Little is understood yet about its genesis. Aim To identify major risk factors and understand their interconnectedness. Method A qualitive study approach, using focus groups with experts following group model building (GMB) scripts leading to the design of a causal loop diagram. Results A causal loop diagram of main contributing factors and possible points of healthcare system improvement Conclusion The model makes the user understand elderly acute care demands on a high over level and shows options for optimalization of the health care system

3 - Understanding the Dynamics of Elderly Care in Practice: Data Analysis and Lessons Learned

Bart Baselmans, PhD, Amsterdam Health and Technology Institute, Amsterdam, Netherlands, Rosan van Zoest

In DOLCE VITA (data-driven optimization for a vital elderly care system in the Netherlands) we develop a data model for acute elderly care in Amsterdam, the Netherlands, with the ultimate aim to improve the elderly care system. To feed the model we predominantly use data from Statistics Netherlands (CBS). These include amongst others data on demographics, socio-economic characteristics and health care use of virtually all citizens in the Netherlands. Data-analysis will enable to populate the model, track movements through the elderly care system and eventually carry out model validation. Lessons learned from the data-analysis will be shared in this session.

4 - Optimal Assignment of Elderly Patients to Nursing Homes

Rebekka Arntzen, MSc, Centre for Mathematics and Computer Science (CWI), Amsterdam, Netherlands

In many countries, the rapid aging of the population leads to an additional burden on already-stretched long-term care systems. Motivated by this, we propose a new, easy-to-implement and scalable method for the optimal allocation of patients-in-need to nursing homes, balancing the trade-off between the waiting time performance and the individual patients' preferences. The results show that if more patients replacements are approved, the allocation model can reduce the abandonment fraction in Amsterdam from 32.6% to 8.1%. We also show that the simple regulation to allow patients to choose two nursing homes instead of one is also very effective, and leads to a reduction of the abandonment fraction to 14.6%.

5 - A Macro-Level Systems Dynamics Approach to Model Complex Acute Elderly Care Systems

Rene Bekker, VU University Amsterdam, Amsterdam, 1081 HV, Netherlands, Tim de Boer, Rebekka Arntzen, Robert van der Mei

The pressure on our elderly health system is expected to increase substantially over the next decade. To support strategical decision making about a sustainable organization of elderly care, it is essential to have insight in the impact of policy changes and capacity decisions. During this presentation, we present macro-level models of the acute elderly system. Specifically, the system is modeled as a network of nodes with corresponding flows of patients and is analyzed using system dynamics. The aim is to provide insight in bottle necks and required capacities to avoid dead lock situations. We supplement the analysis by modeling the system as a network of queues.

■ VSC13

Virtual Room 13

Pharmaceutical Supply Chains

Sponsored: Health Applications Society

Sponsored Session

Chair: Anita L Tucker, Boston University, Boston, MA, 02215-1704, United States

Co-Chair: Minje Park, Boston University, Boston, MA, 02215-1704, United States

1 - The Effect Of Drug Reimbursement Policy On Drug Shortages: Theoretical And Data Analyses

Justin Jia, University of Tennessee, Knoxville, TN, United States, Xuejun Zhao, Hui Zhao

In 2005, Medicare changed its drug reimbursement policy from an Average Wholesale Price (AWP) regime to an Average Sales Price (ASP) regime. The years following the reform witnessed severe drug shortages. We employ drug supply chain modeling and data analysis to address the continued arguments on whether the policy reform aggravated the drug shortages. We find that the ASP policy actually possesses some resilience to drug shortages and consequently, is not more likely than the AWP policy to cause drug shortages.

2 - The Unintended Consequences of Quality Failure: Evidence From the US Pharmaceutical Industry

Rachna Shah, University of Minnesota, Carlson School of Management, Minneapolis, MN, 55455, United States, Hanu Tyagi, Junghee Lee

The impact of quality failures has been well studied on various measures of firm performance such as market share and stock market performance. However, quality failures may also have other unexpected consequences that have not been studied previously. In this study, we explore the unintended consequences of quality failure. We focus on external quality failure and operationalize it as product recalls. We examine our questions in the context of the US pharmaceutical industry by compiling a unique dataset from several available public sources over a long duration of time.

3 - Human Decision-making In Pharmaceutical Supply Chains: Studying The Effect Of Information Sharing By Leveraging Serious Games

Omid Mohaddesi, Ph.D. Candidate, Northeastern University, Boston, MA, United States, Min Gong, Noah Chicoine, Ozlem Ergun, Jacqueline Griffin, David Kaeli, Stacy Marsella, Casper Harteveld

The decision-making behavior of stakeholders in pharmaceutical supply chains is hypothesized to have an important role in changing the dynamics of the supply chain and aggravating drug shortages. Prior research attempted to mitigate drug shortages by focusing on the source of disruptions and recommended information sharing as a mitigation strategy. However, there is little knowledge on how sharing information affects decision-making from a behavioral perspective, or how human behavior drives disruptions. We use a game-based methodology called Gamettes to immerse human participants into decision-making scenarios to get a better understanding of such behavioral aspects. In this talk, we present results from our empirical study on human decision-making in a pharmaceutical supply chain and show how disruptions and information sharing drive supply chain behaviors.

4 - Changing Standards And Drug Shortages In the Pharmaceutical Industry

Ivan Lugovoi, 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.

5 - 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.

■ VSC14

Virtual Room 14

Best student Paper Award I

Sponsored: Revenue Management and Pricing

Sponsored Session

■ VSC15

Virtual Room 15

Topics in RM

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Joline Uichanco, University of Michigan, Ross School of Business, Ann Arbor, MI, 48109-1234, United States

Co-Chair: Mengzhenyu Zhang, University of Michigan, Ann Arbor, MI, 48105-1847, 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.

3 - Presenter

Zeyu Zheng, University of California-Berkeley, Berkeley, CA, 94720-1731, United States

4 - Multi-product Dynamic Pricing (and Ranking) With Limited Inventories Under Cascade Click Model

Sajjad Najafi, HEC Paris, Paris, France, Izak Duenyas, Stefanus Jasin, Joline Uichanco

We consider a multi-product dynamic pricing (and ranking) problem with limited inventories under the so-called Cascade Click model. First, we derive a sufficiently general characterization of the optimal pricing policy. Second, we show that the optimal expected total revenues under the Cascade Click model can be upper-bounded by the objective value of an approximate deterministic pricing problem, and that this deterministic problem can be efficiently solved. This result is reminiscent of the classic upper-bound result in the standard RM setting, whose importance and impact on RM research in the past two decades cannot be overstated. Third, we show that two heuristic policies that are known to have strong performance guarantees in the standard RM setting can be properly adapted to the setting with Cascade Click model and retain their strong performance guarantees.

■ VSC16

Virtual Room 16

Modern Approaches to Pricing

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Michael L Hamilton, University of Pittsburgh, Pittsburgh, PA 07960-5148, United States

1 - 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.

2 - 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.

3 - Selling Enhanced Attempts

Xuying Zhao, University of Notre Dame, Notre Dame, IN, 46556-5646, United States, Lifei Sheng, Christopher Ryan

Achieving a milestone often requires numerous attempts: a student takes and retakes an exam or a video-game player takes numerous attempts to complete a challenging puzzle. Attempters may be willing to pay for enhancements that increase their chances. This work asks the question of how to optimally deploy and price enhancements. We show how the agents' inherent ability to pass the milestone, and the inherent randomness of the milestone, influence enhancement selling strategies. For instance, we show that if the proportion of highly skilled agents is either sufficiently large or sufficiently small, firms should adopt pure advance selling strategies with no "spot" market. Our results also yield implications for games companies, including the suggestion that they should only offer advance purchases of enhancements in games with a sufficiently high level of randomness.

4 - Data-driven Assortment Pricing

Ningyuan Chen, University of Toronto, Mississauga, ON, L5L 1C6, Canada, Andre Augusto Cire, Ming Hu, Saman Lagzi

We study a firm setting prices for products based on the transaction data. Our approach does not impose a model on the distribution of the customers' valuations and only assumes, instead, that purchase choices satisfy incentive-compatible constraints. The individual valuation of each past customer can then be encoded as a polyhedral set, and our approach maximizes the worst-case revenue assuming that new customers' valuations are drawn from the empirical distribution implied by the collection of such polyhedra. We study special practical cases where the program can be solved efficiently, and design three approximation strategies that are of low computational complexity.

5 - 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.

■ VSC17

Virtual Room 17

Algorithmic Competition and Collusion in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ali Aouad, London Business School, London, NW6 4TG, United Kingdom

Co-Chair: Arnoud Victor den Boer, University of Amsterdam, University of Amsterdam, Amsterdam, 1090 GE, Netherlands

1 - Learning To Collude In A Pricing Duopoly

Arnoud Victor den Boer, University of Amsterdam, Amsterdam, 1090 GE, Netherlands, Janusz Meylahn

We construct a price algorithm based on simultaneous-perturbation stochastic-approximation and show that, if implemented collaboratively by two price-setting firms in a duopoly, their prices will converge to those that maximize the firms' joint profit in case this is profitable for both firms, and to a Nash equilibrium otherwise. In addition, if the competitor is not willing to collaborate but behaves according to a reaction function, we show that the prices generated by our algorithm converge to a best-response to the competitor's price. This is done without illicit communication or signaling, so that implementation of the algorithm would be legal under current competition law, showing that collusion by self-learning price algorithms is in theory possible.

2 - Algorithmic Collusion In Assortment Games

Ali Aouad, London Business School, London, NW6 4TG, United Kingdom

This paper contributes to the ongoing debate on the plausibility of a tacit collusion between sellers in algorithmic marketplaces. We study a broad class of assortment decisions routinely made by retailers, including which set of products is offered to the customers, at what price, and under which display configuration. Our main contribution is to show that there exists low-regret computationally efficient algorithms that reach collusive outcomes tacitly, without any form of explicit communication between sellers.

3 - No-regret Learning In Price Competitions Under Consumer Reference Effects

Negin Golrezaei, Massachusetts Institute of Technology, Lexington, MA, 02421-5830, United States, Patrick Jaillet, Jason Cheuk Nam Liang

We study long-run market stability for repeated price competitions between multiple firms, where consumer demand depends on firms' posted prices and consumers' price expectations called reference prices. Consumers' reference prices vary over time according to a memory-based dynamic, which is a weighted average of all historical prices. We focus on the setting where firms are not aware of demand functions and how reference prices are formed but have access to an oracle that provides a measure of consumers' responsiveness to the current posted prices. We show that if the firms run no-regret algorithms, in particular, online mirror descent (OMD), with decreasing step sizes, the market stabilizes in the sense that firms' prices and reference prices converge to a stable Nash Equilibrium (SNE).

4 - 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.

5 - 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.

■ VSC18

Virtual Room 18

Online Platforms and Digital Economics

Sponsored: Information Systems

Sponsored Session

Chair: Zixuan Meng, The University of Texas at Dallas, Seattle, WA, 98105, United States

1 - 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.

2 - Market Segmentation, Cannibalization, And Competing Retailers' Online And Physical Channel Choices

Ping Tang, University of Texas at Dallas, Richardson, TX, 75080-2265, United States, Jianqing Chen, Srinivasan Raghunathan

Motivated by the emerging practice of "new retail," this paper aims to examine the channel structures in a competitive market. We develop a game-theoretic model in which two retailers sell in the same category of products and choose their channel structures. We capture the unique feature of new retail by modeling online shopping cost to be dependent on offline stores' locations. Our findings reveal that the main forces that drive the equilibrium outcomes are channel competition, channel cannibalization and consumer segmentation effects. In addition, we find that in some cases, introducing new channel will change the competition nature and the pricing strategies of both firms.

3 - Product Giveaways: Influence On Perceived Helpfulness And Cross Platform Reviews

Zehan Zhao, The University of Texas at Dallas, Richardson, TX, United States, Zixuan Meng

In this research, we empirically study how reviewer's voluntary disclosure of receiving free products affects the review helpfulness, and how free product giveaways on another platform would impact user's rating behavior on the focal platform. By using data from Steam.com, we found that free samplers receive lower helpfulness scores. Furthermore, we also identified other contingent factors such as reviewer's play history, gaming owning history, and review history. We also utilized Epic Game Store's weekly game giveaway as a quasi-experiment to investigate its impact on review ratings on Steam.com. Our empirical findings provide contributions to the literature on free product sampling, online reviews, and managerial implications to practitioners such as online platforms, game developers, and consumers.

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.

■ VSC19

Virtual Room 19

Trending topics in applied probability

Sponsored: Applied Probability Society

Sponsored 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 - Group Testing And The Power Of Local Search Methods

Ilias Zadik, New York University (NYU), New York, NY, 02141-1001, United States

Group testing is a fundamental statistical problem with many real-world applications, including the need for massive testing during the COVID-19 pandemic. The goal is to detect a set of infected individuals out of a large population using as few (group) tests as possible. One of the most simple and optimal testing procedures is the Bernoulli group testing (BGT), where each individual participates in any given test independently with some fixed probability. A crucial unknown in the extensive study of the BGT model is identifying the most time-efficient algorithm which can recover the infected individuals, given the test results. In this talk, I will present to you both computational and theoretical evidence that a family of simple local algorithms can outperform the current state-of-the-art algorithms in this task. This is joint work with Fotis Iliopoulos (Princeton/IAS).

3 - Admission Control To A Single-class Queue With Arrival Forecast Information

Xiaoshan Peng, Indiana University, Kelley School, Bloomington, IN, 47405, United States

With the availability of the data collecting technology, the system can collect real-time information to update the arrival forecast dynamically. We study the admission control to a single-class queue with real-time arrival forecast updates. The arrival process is a general stochastic process. The system incurs a waiting cost of h per unit time for each customer, whereas it incurs a one-time penalty of p if the customer is not admitted to the system. We formulate the problem as a finite-horizon stochastic control problem and solve the problem by deriving its dual problem and the complementary slackness conditions. We show that the optimal admission policy admits new incoming customers to the system if the expected congestion time of the system exceeds the threshold p/h given all the forecast information under the optimal policy.

4 - 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.

5 - Distributionally Robust Batch Contextual Bandits

Nian Si, Stanford, 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.

■ VSC20

Virtual Room 20

Learning for queueing and beyond

Sponsored: Applied Probability Society

Sponsored Session

Chair: Weina Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - An Efficient Pessimistic-optmisitc Algorithm For Sotchastic Linear Bandits With General Constraints

Xin Liu, University of Michigan, Ann Arbor, MI, 85281, United States, Bin Li, Pengyi Shi, Lei Ying

In this work, we studied stochastic linear bandits with general nonlinear constraints. The objective is to maximize the expected cumulative reward subject to a set of constraints in each round. We proposed a pessimistic-optimistic algorithm for this problem, which is efficient in two aspects. First, the algorithm yields sharp upper bounds on regret and constraint violations. Second, the algorithm is computationally efficient. Our algorithm is based on the primal-dual approach in optimization, where the primal component is similar to unconstrained stochastic linear bandits, so optimistically learning the reward and the dual component is updated with a tightened version of dual subgradient, so pessimistically tracking the constraint violations.

2 - Learning While Playing In Mean-field Games: Convergence And Optimality

Qiaomin Xie, UWisconsin-Madison, Madison, 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.

3 - 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.

■ VSC21

Virtual Room 21

APS Special Session on 'Stochastic Optimization'

Sponsored: Applied Probability Society

Sponsored Session

Chair: Siva Theja Maguluri, ISyE Georgia Tech, Atlanta, GA, 30339, United States

3 - Complexity Analysis Of Stochastic Gradient Descent

Guanghui Lan, ISyE Ga Tech, Atlanta, GA, 30332, United States

During the past 10 years or so, significant progress has been made for the development of Stochastic gradient descent (SGD) methods. These methods are attractive to process online streaming data as they scan through the dataset only once but still generate solutions with acceptable accuracy. As a result, they have found wide applications for large-scale data analysis, especially machine learning. In this talk, we first review some basic SGD type algorithms and discuss their rates of convergence to the global minimum for convex stochastic optimization. We then establish the convergence of SGD to a stationary point for solving general nonconvex problems, motivated by some important applications, e.g., in deep learning. Finally, we show how fast SGD can converge to the global solutions for some structured nonconvex problems arising from reinforcement learning.

■ VSC22

Virtual Room 22

Fundamentals of Start-Ups

Sponsored: Quality, Statistics and Reliability

Sponsored 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

3 - Panelist

Nagi Gebraeel, ISyE Georgia Tech, School Of Industrial Systems Engineering, Atlanta, GA, 30318, United States

■ VSC23

Virtual Room 23

Active Learning in Quality and Reliability Applications

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ashif S Iquebal, Arizona State University, College Station, TX, 77845-5050, United States

1 - Adjacency-adaptive Gaussian Process For Active Learning And Response-surface Modeling Of Black-box Functions

Stanford Martinez, University of Texas at San Antonio, San Antonio, TX, 78750-1413, United States, Adel Alaeddini

Many sequential strategies can be used to reduce the number of experiments required in Response Surface Methodology (RSM). To our knowledge, many existing methods do not incorporate response-based feature extraction within their infrastructures. While methods such as Laplacian regularization are both popular and effective, such frameworks may not introduce features unique to experiments to the learning agent. We propose a Gaussian Process (GP) framework that incorporates response-based geometry and adjacency between measured and unmeasured points. These adjacencies are then combined with the measured data to create a GP model used for predictive RSM. To evaluate effectiveness, we compare the prediction accuracy of the proposed methodology across several simulation studies with popular established models.

2 - Partitioned Active Learning for Heterogeneous Systems

Cheol Hei Lee, Virginia Tech, Kaiwen Wang, Jianguo Wu, Wenjun Cai, Xiaowei Yue

Active learning coupled with Gaussian process (GP)surrogate modeling is an indispensable tool for demanding and complex systems, while the existence of heterogeneity in underlying systems may adversely affect the modeling process. We propose the partitioned active learning strategy that seeks the most informative design point in twosteps. The global searching scheme accelerates the exploration aspect of active learning by investigating the most uncertain design space, and the local searching exploits the active learning criterion induced by the local GP model. The proposed method shows promising performance in real world cases outperforming benchmark methods

3 - Design Of Experiments In Autonomous Materials Discovery

Shilan Jin, Texas A&M University, College Station, TX, 77845-1929, United States, Yu Ding

Methods in design of experiments have been extensively studied for and broadly applied to industrial applications. From model-free design of experiments to uncertainty-quantification based methods, either in a frequentist perspective or a Bayesian perspective, they all accelerate the engineering processes to achieve their goal. However, most of the material discovery systems are complicated with a large number of adjustable parameters and non-differentiable design space. Within the conventional exploration and exploitation framework, no matter how hard the design tries to maximize the gains or maximize the information, it may remain in the loop defined by the probabilistic assumption. We will review some works that devote to designing experiments, beyond using the conventional exploration and exploitation based methods, to explore the underexplored space.

4 - Dynamical Exploration-exploitation Trade-off In Active Learning Regression

Upala Junaida Islam, Arizona State University, AZ, United States

We present an active learning approach for regression problems via a dynamic trade-off between exploration and exploitation. We perform exploration via an improved greedy sampling and exploitation via query by committee and subsequently estimate the trade-off parameter via maximum marginal likelihood estimation approach. Simulation and real-world case studies are presented to show the efficacy of the proposed approach.

■ VSC24

Virtual Room 24

Modeling and Analytics for Heterogeneity in System Informatics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Minhee Kim, University of Wisconsin-Madison, Madison, WI, 53706-1539, United States

Co-Chair: Kaibo Liu, UW-Madison, Madison, WI, 5J78

3706-1539, United States

1 - Gpsrl: Learning Semi-Parametric Survival Rule Lists From Heterogeneous Patient Data

Ameer Hamza Shakur, University of Washington, Seattle, WA, 98105, United States

Survival data is often collected from a heterogeneous population of patients. While popular survival models focused on modeling the average effect of the covariates in survival outcomes, rapidly advancing sensing and information technologies have provided opportunities to further model both heterogeneity of the population and non-linearity of the survival risk. Here we present GPSRL, a semi-parametric Bayesian survival rule list model which derives a rule-based decision-making approach, while within the regime defined by each rule, survival risk is modelled via Gaussian process latent variable model. The use of ordered rule lists enables us to model heterogeneity while keeping model complexity in check. Performance evaluations on a simulated heterogeneous survival dataset and a real world sepsis dataset demonstrate the effectiveness of our model.

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.

3 - Anomaly Detection Based On Generative Adversarial Network With Application To Additive Manufacturing Process

Andrew Chung Chee Law, Virginia Tech, Blacksburg, VA, 24060-3191, United States ", jihoon Chung, Zhenyu James Kong

The objective of this work is to address the anomaly detection problem in Additive Manufacturing (AM) Process. Many previous works dealt with this problem. However, existing works need a lot of in-control data to train their model. As AM produces small number of customized product, it is hard to collect a lot of data in AM process. To overcome this challenge, we proposed framework that uses Generative Adversarial Network (GAN) to generate in-control data. The framework shows the effectiveness in anomaly detection when there exists small number of in-control data from AM process.

4 - Clustering And Classification-based Review Of Post-emergency Use Authorization Covid-19 Vaccines' Safety From The Vaccine Adverse Reporting System (VAERS)

Meng Liu, Pennsylvania State University, State College, PA, 16801, United States, Chen Zhou, Kartik Ramakrishna, Swaminathan P. Iyer, Soundar Kumara

In this work, we discuss the data structures associated with VAERS, extracting relevant information and analysis. In specific, we discuss how we can use the extracted data to develop a VAERS visualization dashboard and how to machine learning based prediction of vaccine adverse events (AE) risk.

■ VSC26

Virtual Room 26

Analytical and Empirical Approaches to Healthcare Operations

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Jayashankar M Swaminathan, University of North Carolina Chapel Hill, Chapel Hill, NC, 27599-3490, United States

1 - Collaborative Care For Diabetes And Depression

Jayashankar M. Swaminathan, University of North Carolina Chapel Hill, Kenan-Flagler Business School, 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.

2 - The Effect Of Standardization On Hospital Performance

Anand Bhatia, University of North Carolina-Chapel Hill, 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.

3 - 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.

4 - 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.

■ VSC27

Virtual Room 27

Behavioral Operations I

Contributed Session

Chair: Aykut Turkoglu, Boston University, Boston, MA, 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 - Desperateness In Contract Bargaining Under Supply Chain Networks

Lei Hua, University of Texas at Arlington, Arlington, TX, United States, Alper Nakkas, Kay0Yut Chen, Xianghua Wu

This paper theoretically and behaviorally studies contract bargaining in two-sided supply chain networks where retailers on the demand side purchase products from suppliers on the supply side. We reveal behavioral regularities on contracting behaviors and develop a behavioral theory, named desperateness theory, which explains and predicts the contract bargaining behaviors.

3 - 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.

■ VSC28

Virtual Room 28

Empirical Healthcare Operations Management

Sponsored: MSOM/Healthcare

Sponsored 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 - Do Physicians Influence Each Other's Performance? Evidence From The Emergency Department

Raha Imanirad, Schulich School of Business, Toronto, ON, M2K 0G1, Canada, Soroush Saghafian, Stephen Traub

In this study, we examine whether and how physicians' relative performance affect their peers' speed and quality in the context of an Emergency Department (ED) setting. Our results show that, on average, a faster peer has a negative effect, and a slower peer has a positive effect on a focal physician's speed. In addition, a higher-quality peer is shown to negatively impact a focal physician's average quality, and a lower-quality peer is found to positively affect a focal physician's average quality. We explore potential channels through which these effects occur and discuss how our results can be utilized by hospital administrators to improve the overall performance of physicians.

3 - How And In What Ways Does Colocation Of Services Matter? Empirical Evidence From A Large Healthcare

Vishal Ahuja, SMU Cox School of Business, Dallas, TX, United States, Carlos Alvarez, Bradley R. Staats

We examine how colocation of mental and behavioral health services with primary and specialty care services impacts patient outcomes: MBH hospitalizations; average length of stay; total number of 30-day readmissions; and suicidal ideations/attempts by a patient. We hypothesize that colocation improves outcomes. In addition, we study the impact of two moderators on the relationship between colocation and outcomes: continuity of care, known to be linked with improved outcomes and variability and patient's severity of mental illness, as measured by past hospitalizations. We also investigate two mechanisms through which colocation impacts outcomes. Specifically, we study the mediating role of a patient's no-show rate to their primary care appointment; and their adherence to MBH medications.

4 - The Impact Of Covid-19 Crisis On Travel Behavior

Jiaqi Zhao, Beijing University, Beijing, China, Susan F. Lu

The COVID-19 crisis seemingly provides a sudden glimpse into the future world. In reaction to the infection transmission, people were forced to reduce their mobility and might continue their newly adapted behavior even after reopening. In this study, we examine the impact of COVID-19 pandemic on human mobility. Compared to the same periods in the past years, both the phone-detected within-city travel intensity and the pollutant generated by automobile emissions decrease significantly by an average of 42.1% and 11.2% respectively during the break, and 59.6% and 32.1% after reopening. The reduction effects are more pronounced in first and second tier cities which are populated with considerable white-collar jobs. Our results suggest that the COVID-19 crisis may fundamentally change human travel behavior in both daily life and working models in the near future.

■ VSC29

Virtual Room 29

Operational Issues in Agribusiness

Sponsored: MSOM/iForm

Sponsored Session

Chair: Kwan Wee, Singapore Management University, Singapore

1 - Optimal Procurement from Multiple Contracts in Agricultural Processing

Bin Li, Wuhan University, Wuhan, China, Onur Boyabatli, Rowan Wang

This paper examines the procurement decision of an agri-processor that sources a commodity input from multiple quantity flexibility contracts to produce and sell a commodity output under input and output spot price uncertainties. We characterize how the spot price correlation affects the processor's procurement decision, profitability and the value of contracts. We also study the optimal procurement in the presence of a non-commodity by-product and investigate its impacts. Our results have important implications about the procurement strategy and by-product management in agricultural processing industries.

2 - Presenter

Saurabh Bansal, Penn State University, State College, PA, 16802-3603, United States

3 - Food Safety Audits In Developing Economies: Centralization Vs. Decentralization

Duo Shi, The Chinese University of Hong Kong, Shenzhen, 518116, China, Lingxiu Dong, Iva Rashkova

This paper investigates and compares two types of food safety auditing structures: decentralized audits and centralized audits.

4 - Farmland Leasing In Agricultural Processing When Processing Rate Is Yield Associated

Kwan Wee, Singapore Management University, Singapore

This paper considers an agri-processor that sources an agricultural input from the farmland, processes the input into an output and sells the output under fixed-price sales contract in the presence of yield uncertainty. We investigate the impact of yield-associated processing rate and the changing yield variability on the farmland leasing decision and the profitability of the processor. We also investigate the cost of ignoring the yield-associated nature of processing rate. Our results have important implications about the procurement strategy for practical planning purposes in agricultural processing industries.

■ VSC30

Virtual Room 30

Service and Quality Operations Management

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: George Ball, Indiana University, Kelley School of Business, Bloomington, IN, 47405-1701, United States

1 - Drivers Of Engagement On Social Media Platforms During Disasters

Eunae Yoo, Indiana University, Bloomington, IN, United States, Changseung Yoo

When responding to disasters, humanitarian organizations (HOs) engage with beneficiaries and donors by providing information on social media platforms. Our study examines the extent to which content-related factors, such as topic and sentiment, drive engagement of HOs' social media content. We also analyze how these relationships vary across different stages of the disaster management cycle. In partnership with Twitter and the Canadian Red Cross, we compile a unique dataset containing hourly engagement metrics for the Canadian Red Cross' tweets during the 2016 Alberta wildfires. Our results offer valuable implications to HOs about the design of their social media content to improve engagement with key stakeholders during disasters.

2 - 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.

3 - Quality-Speed Trade-off in Pharmaceutical Review

In Joon Noh, Assistant Professor, Penn State University, State College, PA, United States, Hessam Bevafa, Christian Blanco

In this research, we examine the extent to which the faster generic drug application review process, enabled by Generic Drug User Fee Amendments (GDUFA) implemented in October 2012, may have compromised generic drug quality, as measured by drug recalls.

4 - 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.

■ VSC31

Virtual Room 31

MSOM Session

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Nicholas A. Arnosti, Columbia Business School, Saint Paul, MN, 55105, United States

1 - Optimal Matchmaking Strategy In Two-sided Marketplaces

Peng Shi, University of Southern California, Los Angeles, CA, 90064-1961, United States

Online platforms that match customers with service providers utilize a wide variety of matchmaking strategies: some create a searchable directory of one side of the market (i.e., Airbnb, Google Local Services); some allow both sides of the market to search and initiate contact (i.e., Care.com, Upwork); others implement centralized matching (i.e., Amazon Home Services, TaskRabbit). This paper compares the efficiency of these strategies using information theory, by quantifying the amount of communication they need to reach a good market outcome. We find that the relative performance of these strategies is driven by two parameters, which represent the degree that agent preferences are easy to describe or satisfy. For suitable markets, each of the above strategies provides performance guarantees that are close to the best possible using any possible system of matchmaking.

2 - Modern Distribution Systems: Dealing With Multiple Correlated Items With Joint Capacity Constraints

Daniel Guetta, Columbia Business School, New York, NY, 10027, United States, Awi Federgruen, Garud N Iyengar, Xujia Liu

A large part of the complexity in modern distribution systems arises from the fact that they deal with many distinct items, stored in facilities with a shared but limited storage capacity. We analyze a periodic review inventory system with an arbitrary number of items and a limited shared storage capacity. Demands are obtained from a general, possibly time dependent multivariate distribution, allowing for an arbitrary correlation structure between products. We develop lower and upper bounds for the optimal cost value, along with a heuristic policy derived from the policy associated with the lower bound. We use a numerical study to show the heuristic policy is close to optimal for many different model parameters.

3 - Escrow Payment: A Smoother Driver Pay Mechanism

Arash Asadpour, Baruch College - The City University of New York, Stern School of Business, New York, NY, 10012, United States, Daniel Freund

Dynamic pricing is a frequently used tool to match supply and demand in the gig economy. The comparatively fast-paced dynamics of supply and demand have also led to dynamic pricing featuring prominently in the recent operations research literature. In practice, ridesharing platforms like Lyft and Uber no longer employ the strictly proportional commission. Further, beyond the drivers' expected pay, the volatility in prices affects drivers' decision-making. We discuss a mechanism to smooth the drivers' dynamic pay and analyze its properties in a stylized stochastic setting. We demonstrate both numerically and analytically the characteristics of the mechanism and discuss its potential benefits.

■ VSC32

Virtual Room 32

Recent Topics in Operations Management

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Sanjith Gopalakrishnan, McGill University, Burnaby, BC, V5B 3P9, Canada

Co-Chair: Sriram Sankaranarayanan, IIM Ahmedabad, Ahmedabad, 380015, India

1 - Effects Of Usage-based Auto Insurance: A Dynamic Mechanism-design Approach

Mona Imanpoor Yourdshahy, Assistant Professor, Beedie School of Business, Simon Fraser University, Vancouver, BC, Canada, Mahesh Nagarajan, Hao Zhang

Tracking drivers' behavior, Usage Based Insurance (UBI) allows insurance companies to connect insurers' premiums more closely to their type and performance. This paper presents a dynamic principal-agent model with hidden information and hidden action to capture the effects of UBI. We analyze the optimal history-dependent contract, so that the premium rate for customers depend on the whole record of their driving performance. Our study sheds light on how to design the contract to manage a UBI program, to what extent UBI policy can outperform a traditional policy, and how the potential gains depend on the demographics of the target market.

2 - Assortment Planning With Satisficing Customers

Forough Pourhossein, Sauder School of Business, University of British Columbia, Vancouver, BC, V6T 1N4, Canada, Woonghee Tim Huh, Steven Shechter

Limited information, time or capacity may prevent customers to act as utility maximizers when purchasing an item. They rather settle for a good enough option, i.e. they stop searching and make a purchase as soon as they find an acceptable option. We incorporate this behavior in an assortment optimization problem. We first formulate a nonlinear optimization problem and then prove that the problem of finding the optimal assortment is NP-hard. Next we establish certain structural properties of the optimal decision to reformulate the problem as a MIP. We show the size of the optimal assortment cannot exceed the maximum search budget of all customers. We also identify a tight upperbound on the expected profit loss of the firm for small instances when it assumes incorrectly that customers are utility maximizers; we take the MNL model as the representative of a utility maximizing model.

3 - Effect Of Contingent Wholesale Price Contract On Target And Pledge Amount In Crowdfunding

Joyaditya Laik, Bucknell University, Lewisburg, PA, United States, Prakash Mirchandani

We study a wholesale price contract between an entrepreneur and a supplier that is enforceable only if the expected sales quantity is large enough for the supplier to cover a known development cost. The supplier estimates the size of the new product based on a signal received from a crowdfunding campaign. We find that the correlation between the size of the subscribing backers in crowdfunding and a post-campaign affects the optimal target and pledge amount set for the crowdfunding campaign. Comparative statics of the target and pledge amount with other parameters of the model are explored.

4 - 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.

■ VSC33

Virtual Room 33

Emerging Topics In Data-Driven Supply Chain and Revenue Management

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Divya Singhvi, MIT, Cambridge, MA, 02139-4230, United States

1 - A Robust Predict And Optimize Framework

Rares Cristian, Massachusetts Institute of Technology, Cambridge, MA, United States, Georgia Perakis

Many real-world prediction problems are important for optimization. Nevertheless, separating the prediction from the optimization task can produce significantly suboptimal decisions, due to errors in prediction. Recent work has focused on predicting and optimizing jointly. We propose a novel method where in-sample the optimization outcome is not too suboptimal. The proposed approach adds robustness and allows for nonlinear problems. Our method is as difficult to solve as the original problem class.

2 - 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.

3 - 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.

■ VSC34

Virtual Room 34

Operations of Sustainable Micro-mobility Business Models

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Ashish Kabra, University of Maryland-College Park, College Park, MD, 20740-3119, United States

1 - 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.

2 - Crowd-starting Shared (shuttle) Service With Customer Engagement

Long He, National University of Singapore, Singapore, 119245, Singapore, Tu Ni

Motivated by shared shuttle service (e.g., Beeline.sg), we study how to crowd-start a service with customer engagement. The crux of the problem is to understand how the information from customer suggestions so as to provide a customer-centric service design. Thus, we propose a service design optimization model to maximize the expected adoption of a service, together with the modeling of customers' suggestion and adoption behaviors. We then quantify and investigate the value of information from customer suggestions. Moreover, we estimate adoption probabilities using modern data-pooling techniques for implementation. Finally, we conduct a case study for the shared shuttle service and discuss insights from the computational results.

3 - Bike Demand Prediction Under Substitution

Junming Liu, City University of Hong Kong, Kowloon, Hong Kong, Weiwei Chen

Bike-sharing systems have been widely deployed for first- and last-mile transportation in urban cities. We propose a nonlinear autoregressive network with exogenous inputs to predict bike pick-up demand, and a pick-drop bike transition predictor to predict bike drop-off demand. To consider the demand substitution effect and the potential endogeneity issue, a regional inventory status calculated every three minutes is proposed to capture the substitute demand from nearby empty stations. Extensive numerical experiments using real data from Citi Bike, the largest bike-sharing system in the US, demonstrate the accuracy of the proposed bike demand predictors.

4 - Estimating And Increasing The Demand For Corporate Ridesharing In Brazil

Sergey Naumov, Smeal College of Business, The Pennsylvania State University, University Park, PA, 16802-3603, United States, Aydin Alptekinoglu

Achieving sustainability goals set by most countries will require mass decarbonization of the transportation sector. One approach to reduce the carbon footprint of the vehicle fleet is to increase the current low occupancy of automobiles, providing the same amount of economic and social mobility with fewer vehicle-miles. However, a shared ride might be less comfortable and take longer to accommodate the other riders. Corporate ridesharing largely avoids these problems since passengers commuting together are employees who work at the same location, and commute time can be used for relevant social interactions. We partner with a large business park in Brazil to study the evolution of transportation choices of its employees by collecting and analyzing commuting data before and after the implementation of a new corporate ridesharing platform.

■ VSC36

Virtual Room 36

Quantitative Modeling of Non-cost Outcomes in Energy Systems Planning Models

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Neha Patankar, Princeton University, New Jersey, United States

1 - Optimal Tariff-Making via The Lens of Social Justice

Yury Dvorkin, New York University, Tandon School of Engineering, Brooklyn, NY, 11201, United States

This talk presents regulatory frameworks for modeling justice and distributional fairness as operationalized design goals for optimal tariff-making in electric power distribution systems. We formulate a Multi-Objective Problem with Equilibrium Constraints (MOPEC) incorporating economic, health, and environmental considerations in tariff-making to reveal, by comparison, injustices in current, socio-economically blind tariffs. Our case study is based on a test system representing New York, NY and provides insights into existing and arising tariff-making inefficiencies and injustices.

2 - Unequal Regional Benefits And Vulnerabilities In Cost-optimal And Near-optimal Scenarios Of The European Electricity Sector In 2035

Jan-Philipp Sasse, University of Geneva, Renewable Energy Systems, Geneva, Switzerland, Evelina Trutnevyte

Equity has a strengthening role in energy and climate strategies, yet little is known about the inequities these strategies might produce. We investigate 150 cost-optimal and near-optimal scenarios of the European electricity sector in 2035 at a high spatial resolution of 296 regions and measure inequities in terms of regional benefits and vulnerabilities to divestment, job losses, and local increases in electricity prices, land use, and greenhouse gas and particulate matter emissions. We show that even though benefits outweigh adverse impacts on a continental-level, such benefits occur in affluent Western European regions, while adverse impacts occur in deprived regions, thus reinforcing existing inequities.

3 - Broad Ranges Of Investment Configurations For Renewable Power Systems, Robust To Cost Uncertainty And Near-optimality

Fabian Neumann, Karlsruhe Institute of Technology, Karlsruhe, Germany, Tom Brown

In this talk, we will explore trade-offs near the cost-optimum of an investment planning model for a fully renewable European electricity system. Such alternative system configurations, besides least-cost solutions, may be attractive to policymakers because they allow them to navigate around rising public opposition towards onshore wind turbines and overhead transmission lines or balance the regional distribution of capacities more evenly. Here, we offer computational methods that present a wide spectrum of alternatives that are feasible, robust to cost uncertainty, and still within a reasonable system cost range to help society decide how to shape the future of the energy system. As methods we apply multi-objective optimisation and leverage multi-fidelity surrogate modelling techniques using sparse polynomial chaos expansion and low-discrepancy sampling.

4 - Modeling All Alternative Solutions For Highly Renewable Energy Systems

Tim Pedersen, PhD Fellow, Aarhus University, Aarhus, Denmark, Marta Victoria, Gorm Andresen

Energy system design is challenged by real-world objective functions consisting of a blurry mix of technical and socioeconomic agendas, with limitations that cannot always be clearly stated or included in models. As a result, economically suboptimal solutions, possessing other desirable qualities, will likely be preferable over the economically optimal model solution. We present a method capable of determining the continuum containing all economically near-optimal solutions, in energy system optimization models. The method is demonstrated on a model of the European electricity network.

5 - Land Use Trade-offs In Decarbonization Of Electricity Generation In The American West

Neha Patankar, Princeton University, Nashik, 422007, India

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.

■ VSC37

Virtual Room 37

Managing Delivery Risk in Power Systems

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Richard Paul O'Neill, ARPA-E, Silver Spring, MD, 20904-2924, United States

Co-Chair: Ashley Arigoni, QS-2 (subcontractor to ARPA-E), Denver, CO, 80209-4510, United States

Co-Chair: Joseph King, DOE, United States

Co-Chair: Richard Wilson, ARPA-E, United States

1 - Stochastic Market Auction Redesigned Trading System (SMARTS)

Hungpo Chao, Energy Trading Analytics, LLC., Phoenixville, PA, United States

SMARTS allows aggregation of smart devices into self-selected priority service portfolios offered into real-time energy and reserve markets. The goal of the SMARTS project is to expand the reserve market design by integrating flexible demand resources as reserves into the real-time wholesale market and conduct a simulation test at the PJM market. Recognizing challenges caused by unpredictable, intermittent and correlated renewable energy supply sources that make market more difficult to balance and the grid less reliable, the new approach will harness the increased value of demand flexibility in systems suffering physical constraints and ultimately shift the power market and grid management to a price-elastic demand-oriented paradigm. SMARTS is funded by the ARPA-E PERFORM Program.

2 - 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.

3 - Demand Asset-Backed DER Aggregations in Energy Markets and Management of Delivery Risks

Alex Papalexopoulos, ZOME Energy Networks, Inc., San Francisco, CA, United States

In this presentation we present a methodology for creating a Virtual Power Plant (VPP) by aggregating small loads which would otherwise not be deployable as demand side resources for market participation. We aggregate controllable demand of capacity increments of different flexibility levels which are grouped in different priority service levels controlled by a proprietary dispatch algorithm to produce a VPP which can emulate a dispatchable conventional generator. The dispatch algorithm, based on stochastic distributed stochastic control mitigates the delivery risk of the total VPP capacity and calculates the supply energy offer of the VPP. Examples based on actual data will be presented.

4 - Day Ahead Power Market Bids under Uncertainty: Data Based Joint P.d.f. And Uncertainty Budget Estimation

Michael C. Caramanis, Professor, Boston University, Boston, MA, 02215, United States, Panagiotis Andrianesis, Dimitris Bertsimas

Day Ahead Power Markets decide unit commitment (UC) and Security-Constrained-Economic-Dispatch (SCED) of energy and reserves to (i) meet hourly energy balance requirements (ii) observe transmission line congestion constraints and (iii) secure reserve capacity that guarantees system reliability. Minimizing cost in the presence of renewable generation uncertainty this is a formidable task. UC/SCED must schedule jointly distributed stochastic available capacities to form a least cost portfolio that satisfies system reliability with a minimal probabilistic guarantee. To achieve this, we rely on historically observed and stochastically forecasted data to convolve jointly distributed supply minus demand and quantify uncertainty budgets that enable scalable robust optimization methodologies.

■ VSC38

Virtual Room 38

Energy and Climate Analysis: Learning and Markets

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Valerie Thomas, ISyE Georgia Tech, Atlanta, GA, 30332, United States

1 - 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.

2 - Comparative Analysis Of Iterative Approaches For Incorporating Learning-by-doing Into The Energy System Models

Hansung Kim, Pohang University of Science and Technology, Cheongam, Pohang, Korea, Republic of, Dong Gu Choi

Appropriate treatment of technological changes has been an important issue in the field of energy system modeling. Although mixed integer programming-based formulations have been introduced to incorporate learning-by-doing endogenously, they require high computational effort. Recently, some studies have suggested iterative approaches to incorporate learning-by-doing indirectly. This study provides a comparative analysis among mixed integer programming-based formulation and iterative approaches. We also propose a revised iterative approach that can overcome the cons partially. Lastly, we apply the methods to analyze renewable energy policies in the Korean electricity sector.

3 - Green Capital And Green Jobs: A Fast Transition To Green Economy

Soheil Shayegh, RFF-CMCC European Institute on Economy and the Environment, Milano, Italy, 07432, Italy, Elnaz Roshan

Transition to green economy is urgently needed in order to reach the climate targets by the end of this century. In this paper we investigate what it takes for such transition to happen and what is the socially optimal pathway from brown to green economy. We identify endogenous technological change as a central driver of such transition and modify a well-known integrated assessment model (DICE) to include learning-by-doing effect, in parallel with R&D and education investment. Our results indicate that endogenous technological change can rise abatement rate substantially by bringing down the mitigation cost through learning-by-doing. We show that the green transition requires substantial investment in renewable energy infrastructure and human capital development which in turn reduces greenhouse gas emissions and constrains global warming.

4 - The Rise Of Electric Vehicles

Matteo Muratori, National Renewable Energy Laboratory, Golden, CO, 30332, United States

Aspects of EVs are reviewed, including: (a) an overview of the status of the light-duty-EV market and current projections for future adoption; (b) insights on market opportunities beyond light-duty EVs; (c) a review of cost and performance evolution for batteries, power electronics, and electric machines that are key components of EV success; (d) charging-infrastructure status with a focus on modeling and studies that are used to project charging-infrastructure requirements and the economics of public charging; (e) an overview of the impact of EV charging on power systems at multiple scales, ranging from bulk power systems to distribution networks; (f) insights into life-cycle cost and emissions studies focusing on EVs; and (g) future expectations and synergies between EVs and other emerging trends and technologies.

5 - A Multinational Carbon-Credit Market Integrating Distinct National Carbon Allowance Strategies

Miguel F. Anjos, University of Edinburgh, Edinburgh, EH9 3FD, United Kingdom, Felipe A. Feijoo, Sriram Sankaranarayanan

We propose a multinational carbon-credit (CC) market allowing countries to procure CCs and allocate them to their electricity producers via national strategies that may include taxes on emissions or subsidies for fossil fuel-based production. We compare the cases of producers accessing the market directly versus through their government. Rrecent mathematical optimization methods are used to compute the relevant market outcomes. Using historical data and 2050 EIA projections for the USA, we confirm that acting as intermediaries, countries can adjust their production and mitigate the impacts of high CC prices. We evaluate the impact of imposing renewable portfolio standards on the government versus on the producer, and observe that while output remains similar, the cash flows are favorable for producers if they are responsible for meeting the standards.

■ VSC39

Virtual Room 39

Mathematical Optimization for Decarbonizing the Future Energy System

Sponsored: ENRE/Environment and Sustainability

Sponsored Session

Chair: Md. Monirul Islam ", Texas A&M University-Kingsville, Kingsville, TX, United States

1 - Optimally Design an Onsite Microgrid System for Hydroponic Greenhouse Industry

Md. Monirul Islam, Texas A&M University-Kingsville, Kingsville, TX, United States

Due to the advantage of controlling micro-climate environment, hydroponic greenhouse industry is becoming significantly popular to improve the quality and economic performance of organic crop production in modern agriculture. To maintain such a controlled environment (temperature, humidity, ventilation, water level etc.), significant amount of electrical energy is required. To meet this large amount of energy using the renewable sources, a non-linear mixed-integer programming model is proposed to design an onsite microgrid system for developing a carbon-free hydroponic greenhouse industry. Linearization strategy is adopted to determine the optimal size of the microgrid system.

2 - Presenter

Hao Liang

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.

■ VSC40

Virtual Room 40

Issues in Energy Market Design, Regulation, and Evolution

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Joe Duggan, University of Dayton, Dayton, OH, United States

Co-Chair: Ramteen Sioshansi, Ohio State University, Columbus, OH, United States

1 - Incentive And Social Welfare Implications Of Carbon Capture And Storage

Joseph Edward Duggan, University of Dayton, Dayton, OH, 43123-8705, United States, Jonathan Ogland-Hand

Carbon Capture and Storage (CCS) is increasingly being seen as a powerful tool in decarbonizing the power sector and ameliorating the effects of climate change. We examine a stylized model of carbon capture and storage given a different regulatory and market structure regimes to examine the incentive effects and social welfare implications of proposed regulatory frameworks.

2 - 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).

3 - The Impact Of Load Following Contracts

David Brown, University of Alberta, Edmonton, AB, Canada, David Sappington

Load-following forward contracts (LFFCs) require a commodity supplier to deliver a specified fraction of the realized demand at a fixed price. LFFCs are becoming increasingly common in competitive electricity markets where a load-serving entity aims to procure power supply to cover their uncertain retail demand. We show that in contrast to more standard forward contracts, LFFCs can promote higher commodity prices and reduced levels of consumer surplus and welfare.

4 - Crediting Variable Renewable Energy and Energy Storage in Capacity Markets: Effects of Unit Commitment and Storage Operation

Shen Wang, Johns Hopkins University, Baltimore, MD, United States, Ningkun Zheng, Cynthia D. Bothwell, Benjamin Field Hobbs

As more variable renewable energy (VRE) and energy storage (ES) facilities are installed, accurate quantification of their contributions to system adequacy becomes crucial. We propose a definition of capacity credit (CC) for valuing adequacy contributions of these resources based on their marginal capability to reduce expected unserved energy. We show that such marginal credits can incentivize system-optimal investments in markets with installed capacity requirements and energy price caps. We simulated such markets using a LP-based capacity expansion planning model with convexified unit commitment (UC) constraints and ES. The impacts of UC and ES on capacity credits are investigated. Furthermore, we analyze technology and system cost distortions resulting from implementing inaccurate CCs in the capacity market. The results show that ignoring UC constraints can overestimate the CCs for VRE and ES. Building ES increases the CCs of VRE resources with higher capacity factors and a negative correlation with load. Assigning the wrong credit to VRE can significantly distort resource mixes and system costs. Implementing the proposed CCs can, in theory, eliminate those distortions and achieve the same overall optimum as a theoretical market without energy price caps.

■ VSC41

Virtual Room 41

Sustainable Operations and Energy Management

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Ali Fattahi, Johns Hopkins University, Baltimore, MD, 21202, United States

1 - Cost-driven Screening Of Network Constraints For The Unit Commitment Problem

Álvaro Porras, University of Málaga, Málaga, Spain, Salvador Pineda, Juan Miguel Morales Gonzalez, Asuncion Jimenez-Cordero

In an attempt to speed up the solution of the unit commitment (UC) problem, both machine-learning and optimization-based methods have been proposed to lighten the full UC formulation by removing as many superfluous line-flow constraints as possible. While the elimination strategies based on machine learning are fast and typically delete more constraints, they may be over-optimistic and result in infeasible UC solutions. For their part, optimization-based methods seek to identify redundant constraints in the full UC formulation by exploring the feasibility region of an LP-relaxation. In our work, we propose a procedure based on tightening the LP-relaxation which the optimization-based method uses with a valid inequality related to the objective function of the UC problem. As a result, the proposed approach gets rid of redundant and inactive line-flow constraints.

2 - The Benefit Of Transforming Cascade Hydropower Stations Into Pumped Hydro Energy Storage Systems

Parinaz Toufani, Bilkent University, Ankara, Turkey, Emre Nadar, Ayse Selin Kocaman

We evaluate the potential benefits of transforming existing conventional cascade hydropower stations into pumped hydro energy storage (PHES) systems by taking into account uncertainties in the streamflow rate and electricity price. We formulate a Markov decision process and analytically derive an upper bound on the profit improvement that can be obtained from this transformation. We then conduct numerical experiments for various realistic instances of these systems in different seasons of the year. Our results imply that the pumping mode of the PHES system is more beneficial when the negative prices occur more frequently or the streamflow availability is more limited.

3 - A Reduce-to-threshold Approach To Direct Load Control Contracts With Monthly Constraints

Ali Fattahi, Johns Hopkins University, 100 International Dr., 1322, Baltimore, MD, 21202, United States, Foad Iravani, Sriram Dasu, Reza Ahmadi

We formulate an optimization model for executing Direct Load Control Contracts, a class of incentive-based demand response programs that allow utilities to directly reduce consumers' energy consumption. We develop a hierarchical approximation scheme and use real data from the California system operator to show the effectiveness of our approach.

4 - The Impact Of Hourly Commitment Decisions On The Wind Power Producers' Profitability

Ece Cigdem Karakoyun, PhD Candidate, Bilkent University, Ankara, Turkey, Ayse Selin Kocaman, Emre Nadar

We study the energy generation, storage and commitment problem for a wind power plant that is co-located with an industrial battery. Formulating this problem as a Markov decision process, we examine the impact of system components and imbalance pricing parameters on the system operations and profits under uncertainty.

5 - 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.

■ VSC42

Virtual Room 42

VRP/Last Mile Delivery

Sponsored: Computing Society

Sponsored Session

Chair: Ahmed Ghoniem,

1 - The Complexity of Some Branch-and-price Formulations of the Two-stage Vehicle Routing Problem

Ricardo Fukasawa, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

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.

■ VSC43

Virtual Room 43

Matching with Preferences

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Thayer Morrill, NC, United States

1 - The Short-side Advantage In Random Matching Markets

Clayton Thomas, PhD Student, Princeton University, Princeton, NJ, United States

A breakthrough of Ashlagi, Kanoria, and Leshno [AKL17] found that imbalance in the number of agents on either side of a random matching market has a profound effect on the market's expected characteristics. Specifically, across all stable matchings, the "long side" (i.e. the side with a greater number of agents) receives significantly worse matches in expectation than the short side. Intuitively, this occurs because an agent on the long side is essentially unneeded to create a stable matching — a matching could form almost as easily without them. Thus, an agent on the long side has very little market power, and must settle for a match which is not much better than a random assignment. We provide a new and simpler proof for a result of [AKL17] which formalizes this intuition.

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.

■ VSC44

Virtual Room 44

Economics and Computation III

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Young-San Lin,

1 - Fulfillment By Platform: Antitrust And Upstream Marketpower
Amandeep Singh, Wharton Business School, Philadelphia, PA, United States, Jiding Zhang, Senthil Veeraraghavan

Fulfillment by Platform (FBP) has been widely adopted by many e-commerce sellers. We examine whether mere adoption of fulfillment services offered by platforms affects competition in the upstream markets among sellers. We use data from a leading online retailing marketplace to empirically evaluate the validity of such concerns, and estimate its effect on upstream supply echelons. We find that the adoption of fulfillment by platform, can hurt upstream market competition. In particular, smaller merchants, with lower margin, are forced to increase price more to remain profitable with FBP, leading to a price disadvantage compared to bigger merchants.

2 - Robust Repeated First Price Auctions
Eric Balkanski, Columbia University, New York, NY, United States, Shipra Agrawal, Vahab Mirrokni, Balasubramanian Sivan

We study dynamic mechanisms for optimizing revenue in repeated auctions, that are robust to heterogeneous forward-looking and learning behavior of the buyers. Typically it is assumed that the buyers are either all myopic or are all infinite lookahead, and that buyers understand and trust the mechanism. These assumptions raise the following question: is it possible to design approximately revenue optimal mechanisms when the buyer pool is heterogeneous? We consider a heterogeneous population with an unknown mixture of lookahead and no-regret-learners. Facing this population, we design a simple state-based mechanism that achieves a constant fraction of the optimal achievable revenue.

3 - 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.

4 - Learning To Persuade On The Fly: Robustness Against Ignorance
Krishnamurthy Iyer, University of Minnesota, Saint Paul, MN, United States, YOU ZU, Haifeng Xu

We consider a repeated persuasion setting where a sender seeks to persuade a myopic receiver to choose the sender's preferred actions by sharing partial information about payoff-relevant states drawn i.i.d. from an unknown prior distribution. We study the sender's problem of making persuasive recommendations to achieve low regret against an optimal mechanism that knows the prior. We propose an algorithm that, with high probability, is persuasive across all rounds and achieves O(sqrt(T log T)) regret, where T is the horizon length. Finally, we prove a matching lower-bound (up to log T terms) on the regret of any algorithm that holds even if the persuasiveness requirements were significantly relaxed.

5 - 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.

■ VSC45

Virtual Room 45

Behavioral SCM

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Eirini Spiliotopoulou, Tilburg University, GH Amsterdam, 1057, Netherlands

1 - Orchestrating Coordination among Humanitarian Organizations
Lea Ruesch, PhD Candidate, Kuehne Logistics University, Hamburg, Germany, Murat Tarakci, Maria Besiou, Niels Van Quaquebeke

Despite the common aim to assist beneficiaries, coordination among humanitarian organizations remains a challenge. This is why the United Nations has formed clusters to facilitate resource exchange among humanitarian organizations. Yet, coordination failures in disasters raise questions as to the effectiveness of the cluster approach in coordinating relief efforts. To understand barriers to coordination, we developed a grounded theory and augmented it with an agent-based simulation. Our theory discerns a cluster lead's roles of facilitating coordination but also investing in its own ground operations. We find that serving such a dual role impairs trust and consequent coordination among cluster members. The simulation findings generalize the detrimental effect of the cluster lead's dual role versus a pure facilitator role and specify its boundary conditions.

2 - A Behavioral Study Of Nanostores: Cash Constraints And Suppliers' Impact
Sebastian Villa, Indiana University, Bloomington, IN, United States, Rafael Escamilla, Jan C. Fransoo

Nanostores are small and family-owned stores. In these systems, both shopkeepers and suppliers face a tension that makes their job hard. Shopkeepers place orders considering the product profitability, customer demand, and cash flow. Their decisions affects their ability to satisfy their customers and their family needs. Suppliers decide how often to visit the nanostore based on the shopkeeper's preferences. We use empirical and behavioral analyses to study shopkeepers' behavior in a nanostore context. We manipulate product profitability and visit frequency of the supplier. We provide managerial insights at the shopkeeper and supplier level.

3 - Nudging Slow but Green Shipping Choices in Online Retail
Yeonjoo Lee, University of Minnesota, Minneapolis, MN, United States, Karen L. Donohue

While online retail consumers favor shorter delivery times, they may not be aware of the environmental impact of rush shipping. This research provides an intervention strategy to lead customers to choose slower but greener shipping. Using two online experiments, we test the effect of providing different types of information, coupled with or without financial incentives, on customer's choice of no-rush shipping and consolidated shipping. We find that green labeling is more effective at nudging consumers toward no-rush shipping versus toward consolidated shipping. Also, the type of information provided (i.e., outcome or process-based) interacts with financial incentives in interesting ways.

4 - Integrating Machine Learning And Human Judgment
Rebekah Brau, Assistant Professor, Brigham Young University, Provo, UT, United States, John Aloysius, Enno Siemsen

Our research examines how to best integrate human judgement and algorithmic methods in demand planning. Specifically, we use a laboratory experiment and a field study to compare existing methods of integration with two novel machine learning methods. Both novel methods represent supervised machine learning; they allow the algorithm to utilize human judgment to train the model. The laboratory experiment and our field study both demonstrate that human judgment provides a significant benefit to demand planning processes dependent on the method of integration. The two machine learning methods of integration are the most effective methods of integration vis-a-vis the other established methods.

5 - 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.

■ VSC47

Virtual Room 47

Machine Learning Algorithm and Theory in Stochastic Control and Games

Sponsored: Finance

Sponsored Session

Chair: Ruimeng Hu, University of California, Santa Barbara, New York, NY, 10027-3206, United States

1 - Convergence Analysis for Gradient Descent Optimization Methods in the Training of Artificial Neural Networks with ReLU Activation
Arnulf Jentzen, Ph.D., University of Münster, Münster, 48149, Germany

Gradient descent (GD) type optimization methods are the standard instrument to train artificial neural networks (ANNs) with rectified linear unit (ReLU) activation. Despite the great success of GD type optimization methods in numerical simulations for the training of ANNs with ReLU activation, it remains - even in the simplest situation of the plain vanilla GD optimization method with random initializations - an open problem to prove (or disprove) the conjecture that the true risk of the GD optimization method converges in the training of ANNs with ReLU activation to zero as the width/depth of the ANNs, the number of independent random initializations, and the number of GD steps increase to infinity. In this talk we prove this conjecture in the situation where the probability distribution of the input data is equivalent to the continuous uniform distribution on a compact interval, where the probability distributions for the random initializations of the ANN parameters are standard normal distributions, and where the target function under consideration is continuous and piecewise affine linear.

2 - 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.

3 - A Class Of Dimensionality-free Metrics For Convergence Of Empirical Measures
Jihao Long, Ph.D. student, Princeton University, Princeton, NJ, 08544, United States

This talk concerns the convergence of empirical measures in high dimensions. We propose a new class of metrics and show that under such metrics, the convergence is free of the curse of dimensionality, in contrast to Wasserstein distance. Proposed metrics originate from maximum mean discrepancy, which we generalize by proposing criteria for test function spaces. Examples include RKHS, Barron space, and flow-induced function spaces. Three applications are presented: 1. Convergence of empirical measure for random variables; 2. Convergence of n-particle system to McKean-Vlasov SDE; 3. Construct Nash equilibrium for homogeneous n-player game by its mean-field limit. This talk is based on the paper: Jiequn Han, Ruimeng Hu, and Jihao Long. A class of dimensionality-free metrics for the convergence of empirical measures. arXiv preprint arXiv: 2104.12036(2021).

4 - Convergence Of A Deep Learning Algorithm For A Free Boundary Pde:optimal Investment In A Market With Correlated Assets And Transaction Costs
Ke Chen, Ph.D. student, Johns Hopkins University, Baltimore, MD, 21218, United States, Maxim Bichuch

In this paper, we propose a numerical scheme to solve fully nonlinear partial differential equation and free boudnary problem through deep neural network. According to the universal approximation capacity of nerual network, we prove the existence of the numerical scheme and the convergenent of the numerical scheme. Moreover, we verify our approach bu correlated multi-assets optimal investment with transaction cost problem, which is chanenging to be solved with tranditional methods like finite difference method or finite element method because of the special characteristics of viscosity solution.

■ VSC48

Virtual Room 48

Online User Behavior

Sponsored: eBusiness

Sponsored Session

Chair: Zike Cao, Zhejiang University, Hangzhou, China

1 - The Unintended Consequences of Information Feeds Integration on Incentives to Contribute
Yingpeng Zhu, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, China

Online Q&A communities supply both high-effort "long" content (e.g., professional knowledge) and low-effort "short" content (e.g., casual tweets). However, it remains unclear whether these two types of content should be presented to users in two separated information feeds or in one integrated information feed. Leveraging a natural experiment, we empirically assess the impacts of integrating two information feeds for the two types of content on the contributors' incentives to contribute. Overall, our results show that the information feeds integration leads to a substantial decrease in casual content generation. Moreover, although incentives to contribute professional content are not affected on average, more active professional content contributors before integration show significantly lower such contribution incentives after integration.

2 - Price and Assortment Competition under Consideration Set Formation: The Role of Anticipated Regret
Mengyan Zhu, Zhejiang University, Hangzhou, China

There are numerous evidence showing that consumers usually experience emotional dissonance (e.g. purchase regret) and anticipate it in consideration set formation process. Our paper adopts a parallel search paradigm to explore how consumers form consideration sets and use search depth/search breadth to alleviate anticipated regret, and to check how sellers optimally choose their prices and assortment sizes accordingly. We show that sellers may benefit from anticipated regret as it encourages consumers 1) to evaluate more product attributes to alleviate regret; 2) to include less sellers to save search costs. We further show that sellers engage in assortment competition when regret intensity is low but price competition when it is high. Lastly, our results show that anticipated regret can achieve a ``win-win-win" situation for consumers, sellers and social planner.

3 - A Typology Of Physicians' Participation And Their Effect In The Context Of Online Medical Team
Yu Tong, Zhejiang University, Hangzhou, China, Yiqing Li, Zheng Lu

This study proposes a typology of physicians' participation in the context of online medical team. Utilizing collected empirical text data from a leading online medical platform, we applied state-of-art machine learning method to detect different types of physicians' participation. We then investigate how these types of physicians' participation affect patients' continuous engagement, and how such effects are influenced by two types of patient's characteristics—the acuteness of the disease and the sources the patient come from (purely online or offline to online). This research advances the literature on online health IT by conceptualizing physicians' diverse actions in online medical teams and their effects. Our research would also offer practical implications to better manage online medical teams.

4 - Prediction Of Intelligent Speech User Conversion: Psychological Commitment And Behavioral Performance
Yiqun Zhang, School of Management, Zhejiang University, China

In addition to product characteristics and quality of service, different types of information that user access can be helpful to predict user's cloud product conversion behavior. Basing on the commitment-behavior theory and lock-in mechanism, we believe the information user access may affect users' psychological commitment and thus be a good proxy of it. We then test the different effect of psychological commitments in the prediction of users' purchase behaviors. Next, experiments are conducted by using different types of information in the prediction to show which sets of information are more effective to predict cloud computing users' specific purchasing behaviors. Our results not only generate theoretical implications for research on psychological commitment in cloud product marketing, but also offer practical guidelines to cloud computing platform companies.

5 - Effects of Explicit Sponsorship Disclosure on User Engagement in Social Media Influencer Marketing

Zike Cao, Zhejiang University, Hangzhou, China, Rodrigo Belo

Regulators are concerned that users might be deceived by undisclosed sponsored posts by social media influencers. By exploiting the introduction of a new Instagram feature allowing influencers to disclose sponsored posts using a salient header tag, we empirically investigate the effects of explicitly disclosing sponsorship on user engagement based on a large field data collected from Facebook and Instagram. We find header-disclosed posts have significantly higher levels of user engagement than other posts on Instagram, relative to the same posts on Facebook. These results suggest that explicit sponsorship disclosure not only informs users of advertising nature but also earns users' favorability by enhancing transparency about sponsorship. To corroborate the empirical analysis, we further conduct an online behavioral experiment and find consistent results.

■ VSC49

Virtual Room 49

Preference-driven MCDM

Sponsored: Multi Criteria Decision Making

Sponsored Session

Chair: Roman Slowinski, Poznan University of Technology, Poznan, 60-965, Poland

1 - Recommending Multiple Criteria Decision Analysis Methods With A New Decision Support System Based On A Taxonomy

Milosz Kadzinski, Poznan University of Technology, Poznan, 61-138, Poland, Marco Cinelli, Grzegorz Miebs, Michael Gonzalez, Roman Slowinski

We present a decision support system called Multiple Criteria Decision Analysis Methods Selection Software (MCDA-MSS). It helps analysts answering a recurrent question in decision science: "Which is the most suitable Multiple Criteria Decision Analysis (MCDA) method that should be used for a given Decision-Making Problem?". MCDA-MSS includes stepwise guidance to lead complex decision-making processes and choose among an extensive collection (more than 200) of MCDA methods. These approaches are assessed according to an original comprehensive set of problem characteristics. The accounted features concern problem formulation, preference elicitation, desired features of a preference model, and construction of the decision recommendation.

2 - A Multiple Criteria Methodology For Project Portfolio Selection

Maria Barbati, University of Portsmouth, Portsmouth, United Kingdom, José Rui Figueira, Salvatore Greco, Alessio Ishizaka, Simona Panaro

We propose a new methodology that combines a multiple criteria sorting or ranking method with a project portfolio selection procedure. The multicriteria method permits to compare projects in terms of their priority assessed on the basis of a set of both qualitative and quantitative criteria. Then, a set of projects, i.e. a portfolio, is selected according to the priority defined by the multiple criteria method. In addition, the portfolio must satisfy a set of resources constraints, e.g. budget available, as well as some logical constraints, e.g. related to projects to be selected together or projects mutually exclusive. The proposed portfolio selection methodology can be applied in different contexts and, thanks to its adaptability, can be regarded as an alternative tool in the expanding domain of the portfolio project selection field

3 - Bi-objective Benders Simplex Algorithm To Solve Large-scale Two-stage Stochastic Optimization Problems With Multiple Scenarios.

Ali Sohrabi, The University of Auckland, Auckland, New Zealand, Andrea Raith, Richard Lusby

We present a bi-objective Benders simplex algorithm (BBSA) to solve large-scale bi-objective two-stage stochastic linear optimization problems with multiple scenarios. The original problem is decomposed into a bi-objective master (BMASTER) and multiple subproblems (BSUBs). To initially identify the minimizer of the first objective function, multiple BSUBs are solved. After adding cuts to BMASTER, in an iterative process, BMASTER is solved to find a new non-dominated point, and its efficient solution is used to solve multiple BSUBs in the second stage. If BSUB is infeasible, a feasibility cut is added to BMASTER; otherwise, for each scenario, a set of optimality cuts are added to BMASTER. The algorithm stops when there is no new non-dominated point in BMASTER. We apply the proposed algorithm to a capacity expansion problem. Some numerical results will be presented.

4 - Multicriteria Decision Aiding using Representative Value Functions

Salvatore Greco, University of Catania, Catania, 95129, Italy, Dr Sally Giuseppe Arcidiacono, Salvatore Corrente

A representative value function is a compatible value function that highlights necessary and possible preferences in robust ordinal regression. A representative value function can support the decision maker to understand recommendations formulated in terms of necessary and possible preference relations or probabilistic preferences in robust ordinal regression. We reconsider the concept of representative value functions in decision aiding procedures, taking into account some considerations based on decision psychology.

5 - A Preference-driven Imo-drsa Approach To The Index Tracking Problem

Adiel Teixeira De Almeida Filho, Associate Professor, Universidade Federal de Pernambuco, Recife-PE, 50.630-971, Brazil, Julio Cezar Soares Silva

The objective of this work is to present a preference-driven approach to the index tracking problem, considering the reduction of the number of representative examples presented for the investor, while regarding out-of-sample preference satisfaction of the examples that compose a data table for this investment problem.

6 - Scoring alternatives from pairwise winning indices

Salvatore Corrente, Dr., University of Catania, Catania, Italy, Dr Sally Giuseppe Arcidiacono, Salvatore Greco

In this paper we revise in a critical way the procedures used to to summarize the pairwise winning indices results. Pairwise winning indices are provided by Stochastic Multicriteria Acceptability Analysis and they represent the frequency with which an alternative is preferred to another on the basis of same sampled instances of the assumed preference model compatible with the preferences provided by the Decision Maker. The scoring procedures provide a single value to each alternative being representative of the goodness of the alternative itself taking into account the frequency with which it is preferred to the others or, vice versa, the others are preferred to it. The score given to the alternatives gives the possibility to rank them from the best to the worst. A comparison between different methods is performed to look at their strong and weak points.

■ VSC51

Virtual Room 51

Service Science Best Cluster Paper Competition (II)

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Penn State (The Pennsylvania State University), Malvern, PA, 19355-1488, United States

Co-Chair: Weiwei Chen, Rutgers University, Piscataway, NJ, 08854-8081, United States

1 - Pooling Servers for Customer-Intensive Services: Theory and Experimental Evidence

Luyi Yang, University of California, Berkeley, Belmont, CA, 94002, United States

In customer-intensive services where service quality increases with service time, our theory reveals that when agents act strategically, they may speed up under pooling to serve more customers, thus undermining service quality. If this happens, pooling can backfire and result in both lower customer satisfaction and agent payoff. We propose a simple solution to resolve this issue: pooling a certain amount of agents' performance bonuses (incentive pooling) in conjunction with pooling agents (operational pooling). We run an online behavioral experiment that confirms our theoretical findings of agent behavior.

2 - Reducing Judicial Delay in Resource-Constrained Settings: A Data-Driven Queueing Approach

Nitin Bakshi, University of Utah, Salt Lake City, UT, 84112-8939, United States

Shortage of judicial capacity leads to delayed justice in developing and developed nations. Using data from the Supreme Court of India, we develop a framework with data-driven queueing simulations for estimating performance metrics. We find that the court operates in a nearly critically-loaded regime. Consequently, the delays are substantial but small perturbations to capacity or process efficiency lead to dramatic gains. Specifically, our analysis shows that adding a two-judge bench could result in a 75% — 90% reduction in expected delay; capping the number of adjournments allowed in a case at three also results in a comparable delay reduction.

3 - Overbooking with Bumping-Sensitive Demand

Jingxing (Rowena) Gan, Cox School of Business, Southern Methodist University, Dallas, TX, 75225-4036, United States

Overbooking is an integral part of firm revenue management in many industries, including air travel and hospitality. Established models, however, often overlook that the bumping of passengers can have long-term negative consequences on demand. We show how accounting for such effects not only changes optimal overbooking policies, but can significantly boost both revenues and customer welfare. These benefits hold under both traditional ``fixed-compensation" schemes, and more modern ``auction-based" schemes that are increasingly popular in practice.

4 - Does Underuse Variation in Test-Ordering Practice Relate to Higher Care-Delivery Cost?
Seokjun Youn, The University of Arizona, Tucson, AZ, 85721-0087, United States

Recent studies estimate that about 25% of total healthcare spending in the U.S. is waste. Naturally, there has been a sustained call for efforts to reduce such waste of healthcare resources. This study aims to empirically investigate whether hospitals with a higher underuse variation in test-ordering practice (e.g., radiology and lab tests) may face unexpected higher expenditures in subsequent care-delivery stages. We further consider the intervening effects of quality initiatives on the relationship. We provide our findings based on six-year inpatient data from New York and Florida states.

■ VSC52

Virtual Room 52

Service Science IBM Best Student Paper Competition (II)

Sponsored: Service Science

Sponsored Session

Chair: Guiping Hu, Iowa State University, Ames, IA, 50011, United States

Co-Chair: Meng Li, University of Houston, Houston, TX, 77204, United States

1 - Estimating and Exploiting the Impact of Photo Layout: A Structural Approach
Hanwei Li, Massachusetts Institue of Technology, Cambridge, MA, 02139-4936, United States

Product images reveal substantial information and reduce search friction. We define, estimate and optimize the impacts of Airbnb photos on property demand. Specifically, we build supervised learning models to evaluate the quality and content of each Airbnb image, based on which we specify the impact of photo layout. We then propose a novel pairwise comparison model that utilizes customers' booking sequence data to consistently estimate the impact of photo layout on customers' renting decisions. Finally, we perform counterfactual analysis to gauge the revenue gain from the optimal photo layout.

2 - 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

The covert nature of sex trafficking provides a barrier to generating large-scale, data-driven insights to inform law enforcement, policy and social work. We leverage massive deep web data (collected from leading commercial sex websites) in tandem with a novel machine learning framework to unmask suspicious recruitment-to-sales pathways, thereby providing the first global network view of trafficking risk in commercial sex supply chains. This allows us to infer likely recruitment-to-sales trafficking routes, deceptive approaches used to recruit victims, and regional variations in activity.

3 - Mobile Data Caps Expand Access to Bottom-of-the-Pyramid Services — Experimental Evidence from a Mumbai Slum
Alp Sungu, London Business School, London, NW3 5HS, United Kingdom

This study identifies a barrier to digitally delivered BOP services: data shortages. We randomly assign Mumbai settlement dwellers to a data plan with daily usage caps or a standard plan. Our app collecting 9.4 million smartphone usage minutes reveals that absent caps, participants binge on entertainment and later face data shortages. Daily caps increase late-plan access to life-improving information and reduce social media checking, without hurting happiness or sleep. They increase attendance at in-person health camps advertised via WhatsApp. Participants prefer data caps, even when costlier.

4 - 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.

5 - 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.

■ VSC53

Virtual Room 53

SMA Best Student Paper Award

Sponsored: Social Media Analytics

Sponsored Session

Chair: Michel Ballings, University of Tennessee, Knoxville, TN, 37996, United States

1 - Riding the Gravy Trend? Bandwagon Effect vs. Conspicuous Adoption of Music in User-Generated Content
Abhishek Deshmane, IESE Business School, Barcelona, Spain, Xabier Barriola

We develop a theory for content creation grounded in the propensity of the users to conform to the crowd opinion or to conspicuously deviate from the trends which is driven by their differing positions in the hierarchy. We carry out our analysis on a log of user activity on NetEase with a two-stage Heckman selection correction model. Despite the reward structure that clearly favors less creative content, we demonstrate that the socially elite users showcase a higher propensity to deviate from the trends and make the conspicuous choice of adopting music creatively in their own content.

2 - Enterprise Social Media Platform Design and Knowledge Worker Productivity
Samer Charbaji, University of Michigan, Ann Arbor, MI, 48105, United States, Stephen Leider, Roman Kapuscinski

Enterprise social media platforms have been widely adopted by companies to encourage helping behavior among knowledge workers, but their implementation has had mixed success. We conduct a lab experiment that studies the effect of different platform features on helping behavior and performance. We show that private badges for achieving helping goals yield the most help and the best performance, while treatments that provide information on helping behavior have minimal effect. We also find that varying the type and/or number of helping goals can change the pattern of helping behavior but has little effect on the total quantity of help and performance.

3 - Developing a Detection and Interpretation Tool for Rumors Regarding COVID-19 on Twitter using Deep Learning
Lisa Schetgen, Ghent University, Ghent, 9000, Belgium, Bram Janssens, Matthias Bogaert, Dirk Van den Poel

This study introduces a rumor detection framework for COVID-19-related discussions on Twitter. We investigate different machine learning, deep learning and transformer models to determine which model is best suited for the identification of rumors. Furthermore, we use a joint dimensionality reduction and clustering algorithm to cluster the tweets. The results of the two analyses are combined to discover which clusters contain most rumors. Our framework can be used by public health organizations to detect and gain insights into emerging rumors, allowing them to respond with accurate information.

4 - Unifying Algorithmic and Theoretical Perspectives: Emotions in Online Reviews and Sales
Yifan Yu, University of Washington, Seattle, WA, United States, Yang Yang, Jinghua Huang, Yong Tan

Emotion artificial intelligence, the algorithm that recognizes and interprets various human emotions beyond valence, is still in its infancy but attracts much attention from both industry and academia. Based on discrete emotion theory and statistical language modeling, we propose an algorithm to enable automatic domain-adaptive emotion lexicon construction and multi-dimensional emotion detection in texts. With a large-scale dataset of China's movie market from 2012 to 2018, we construct and validate our model and demonstrate the predictive power of eight discrete emotions (i.e., surprise, joy, anticipation, love, anxiety, sadness, anger, and disgust) in online reviews on box office sales.

5 - How Women Promote Greater Social Responsibility on Social Media
Li Xiang, College of Management & Economics, Tianjin University, TianJin, 300072, China, Kejia Hu, Huibin Du

■ VSC54

Virtual Room 54

Lavanya's session

Sponsored: Public Sector OR

Sponsored Session

Chair: Lavanya Marla, U of Illinois at Urbana-Champaign, Urbana, IL, 61801-2925, United States

1 - Heterogeneous Facility Location under Coordination and Collaboration: The Case of Ambulance-Bystander-Drone Coordination

Jungeun Shin, Urbana, IL, United States

Drone can facilitate early medical intervention by delivering automated external defibrillators (AED). AED operation requires a bystander and we explicitly consider the spatial availability of a bystander in location-allocation problems ofambulance-drone EMS system. We develop an optimization framework to maximize demands served with a stringent response time by ambulance-drone-bystander coordinated service and its heuristic with 2-opt ambulance location is offered. Our results indicate the importance of modeling bystander availability to make drone-delivered healthcare systems successful.

2 - Real-time Joint Operations Of UAVs And Ambulances

Xiaoquan Gao, Purdue University, West Lafayette, IN, United States, Nan Kong, Paul Griffin

UAVs have started to transform emergency service logistics applications as emerging delivery tools due to their ease of deployment and rapid response. Using opioid overdose rescue as an example, we formulate a Markov decision process model to jointly optimize the dispatching, relocation, and redeployment of UAVs and ambulances in real-time. For dispatching decisions, we explicitly model the availability of willing bystanders and choose between (1) dispatch an ambulance and (2) dispatch a UAV as the first response and an ambulance to follow up. Since the formulated MDP suffers from the curse of dimensionality, we adopt an approximate dynamic programming approach with a nonparametric representation of the value functions. The simulation results show significant improvement in performance related to myopic and static policies.

3 - An Optimization Model For Vaccine Distribution Via UAVs Or Drones

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.

■ VSC55

Virtual Room 55

Human trafficking II

Sponsored: Public Sector OR

Sponsored Session

Chair: Baris Tezcan, United States

Co-Chair: Daniel Kosmas, Rensselaer Polytechnic Institute, Troy, NY, 12180-2385, United States

1 - 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.

2 - Improving Decision At The US POEs Using An Anti-human Trafficking Focus

Priscila de A. Drummond, University of Texas Rio Grande Valley, Edinburg, TX, 78541, United States, Hiram Moya

Human trafficking is forbidden in almost all countries, which does not prevent it from happening ubiquitously. Although human trafficking does not require crossing borders, the gravity of the crime and the estimated number of victims transnationally trafficked justify investments in prevention programs. The U.S. Ports-of-Entry (POEs) apparatus presents an opportunity to identify possible human trafficking victims and help to disrupt their cycle of exploitation. To improve decisions at the POEs, we propose a deterministic equivalent problem that considers the cost of each possible outcome and the new operation. Different scenarios of exploitation and levels of travelers' flow are examined. We present insights regarding the trade-offs between security levels and operational costs drawn using a numerical example.

3 - Disrupting Sex Trafficking Recruitment Using Community Based Resource Allocation Models

Baris Tezcan, Northeastern University, Boston, MA, United States, Kayse Lee Maass, Lauren Martin, Thomas C. Sharkey, Renuka Kannan, Amy Farrell, Kelle Barrick

A person's risk of being trafficked is greatly influenced by their (lack of) access to community support structures. We model a trafficker's process of recruiting sex trafficking victims using a network where states represent a potential victim's fluctuating vulnerability levels, various trafficking recruitment strategies, and vulnerabilities to being re-trafficked after leaving their trafficker. Potential victims transition from one state to another probabilistically. We aim to allocate resources throughout this network in a way that changes the state transition probabilities with the objective of minimizing the exploitation a victim experiences.

4 - Generating Synthetic Sex Trafficking Networks For Interdiction

Daniel Kosmas, Rensselaer Polytechnic Institute, Troy, NY, 12180-2385, United States, Thomas Sharkey, John E. Mitchell, Kayse Maass, Lauren Martin, Kelle Barrick, Christina Melander, Emily Singerhouse

One of the major challenges associated with applying operations research models to disrupting human trafficking networks is a lack of reliable data sources. Human trafficking operations are intentionally hidden to prevent detection, and data from known operations are often incomplete. We propose a network generator for domestic sex trafficking networks, founded on triangulating multiple sources, including case file analysis and domain expertise. The output models the relationships between traffickers, bottoms, and victims, as well as possible network restructurings. We discuss policy recommendations associated with interdictions determined via a multi-period max flow network interdiction problem with restructuring. We also discuss limitations of our network generator, and suggest where future qualitative research can improve applicability.

■ VSC56

Virtual Room 56

Freestyle O.R. Supreme Game Show

Informs Special Session: Informs Section on Practice

Informs Special Session Session

Chair: Carrie Beam, University of Arkansas, Walnut Creek, CA, 94596-3391, United States

1 - Moderator

Carrie Beam, University of Arkansas, Walnut Creek, CA, 94596-3391, United States

Freestyle O.R. Supreme is our fast-moving live game show, in which students and early-career professionals sign up, are assigned to teams, and are given the opportunity to frame a real life problem and present an overview of a solution in real time. Judges pick the winning team. This is a great opportunity to participate in the conference without having to write a paper or make a poster, and leads to great career networking. Signups will be open the week before the conference.

■ VSC57

Virtual Room 57

TIMES Best Dissertation Award

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

Chair: Morvarid Rahmani, Georgia Institute of Technology, Atlanta, GA, 30308-1149, United States

1 - Operations of Innovative Business Models

Soudipta Chakraborty, University of Kansas, Lawrence, KS, United States

This dissertation focuses on two business models: rewards-based crowdfunding and subscription box services, identifies a few of the unique inefficiencies and challenges that these models bring for small entrepreneurs, and recommends ways to solve them.

2 - Essays on Innovation-Driven Supply Chains
Zhi Chen, National University of Singapore, Singapore, 119245, Singapore

This dissertation advances theories in two areas: (i) innovation contests and (ii) demand forecasting. From a managerial perspective, this dissertation sheds light on several business practices and offers prescriptive insights on how innovation should be sourced and managed.

3 - Commercialization of Logistics Infrastructure as an Offline Platform
Brian Han, Gies College of Business, UIUC, San Gabriel, CA, 91776-6827, United States

This dissertation studies how e-commerce platforms can leverage the logistics infrastructure for commercial activities. As such, it suggests an expansion of e-commerce platforms' business models from the digital world to the physical world.

4 - Towards a Better Design of Online Marketplaces
Zhaohui Jiang, Tepper School of Business, Carnegie Mellon University, Pittsburgh, PA, United States

This dissertation generates new insights into how participants behave in and interact with online marketplaces, and it offers actionable policy recommendations for better designs of these online marketplaces.

■ VSC58

Virtual Room 58

Omnichannel Retail and Warehousing

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Arnab Bisi, Johns Hopkins Carey Business School, Baltimore, MD, 21202-4673, United States

1 - E-commerce Warehouses Under Pandemic: Enhance Picking Viability And Sustainability
Siqiang Guo, The University of Texas at Austin, Austin, TX, United States, Manjeet Singh, Shadi Goodarzi

The COVID-19 pandemic has caused significant challenges for e-commerce warehouses that strive to fulfill surging customer demand while facing a high virus spreading risk in the picking area. This paper proposes an Aisle-Based Constructive Batching Algorithm (ABCBA) that helps e-commerce warehouses pick more efficiently and safely under pandemic conditions while considering scattered storage, zone-wave-batch picking, and pickers' proximity at the same time. Experiments with real data from DHL Supply Chain show that, by using ABCBA, warehouses can simultaneously reduce the total picking time by 50% and decrease the virus spreading risk due to pickers' proximity by 69%. An interesting observation of the algorithm also shows that more strict proximity constraints can surprisingly increase the picking efficiency by reducing the number of aisles visited by pickers.

■ VSC59

Virtual Room 59

Collaborative logistics

Sponsored: TSL/Freight Transportation

Sponsored Session

Chair: Margaretha Gansterer, Univiersity of Klagenfurt, Wien, 1090, Austria

1 - Decentralized And Intertemporal Collaboration
Christof Defryn, Maastricht University, Maastricht, 6211 LM, Netherlands

Contributions to the field on collaborative logistics typically assume a long-term commitment of a small, fixed group of companies. To foster synergy creation while guaranteeing stability and profitability of the group and all its members, dedicated multi-partner optimization frameworks and gain sharing mechanisms have been proposed in the literature. In a context where the number of participants is large and the network structure open - like in the physical internet -, alternative decision support tools are needed. In this talk, we explore the idea of intertemporal collaboration. In such a collaboration, coalition configuration is dynamic and decision making decentralized.

2 - Collaborative Transportation For Attended Home Deliveries
Steffen Elting, University of Vienna, Vienna, Austria, Jan Fabian Ehmke, Margaretha Gansterer

A major challenge of last-mile deliveries is that customers and freight forwarders mutually agree on delivery time windows upon request arrival while future demand is stochastic. This may lead to situations in which some deliveries are costlier than anticipated. We investigate whether the exchange of requests by means of horizontal carrier collaboration can reduce the total costs of delivery for all collaborating carriers. To this end, we integrate ideas of auction-based request exchange in acceptance mechanisms of attended home deliveries. We show that request exchange allows for higher efficiency of attended home delivery operations.

3 - The Multi-depot Vehicle Routing Problem With Profit Fairness
Adria Soriano, University of Vienna, Vienna, Austria

A posteriori gain sharing mechanisms in horizontal collaboration rarely guarantee that all partners feel fairly treated. This work presents a bi-objective optimization problem that adds a fairness objective function to the classical cost minimization function. A solution framework based don ALNS and épsilon-constraint methods is developed. By obtaining the Pareto fronts for several heterogeneous instances, we prove that the economic cost of fairness remains generally below 5%, and also that such custs tend to decrease when fairness is considered for longer time horizons, altohugh remarkable differences are found between different instance types.

4 - Collaborative Vehicle Routing: Computational and Game Theoretical Aspects
Margaretha Gansterer, University of Klagenfurt, Wien, 1090, Austria

Collaboration has been one of the important trends in vehicle routing, as it can help reducing inefficiencies in carrier operations by exchanging transportation requests. A typical mechanism to enable carrier collaboration is to use combinatorial auctions, where requests are not traded individually but are combined into bundles. Previous literature on carrier collaboration has typically focused on issues such as bundle formation or winner determination, typically assuming truthfulness of all agents and absence of any strategic behavior. We consider the interdependencies and problems that arise from bidders acting as buyers and sellers of requests at the same time.

■ VSC60

Virtual Room 60

Game Theory for Security

Sponsored: Military and Security

Sponsored Session

Chair: Shaun Doheney, Amazon Web Services (AWS), Stafford, VA, 22554-6548, United States

Co-Chair: Quanyan Zhu, New York University, New York, NY, 11201, United States

1 - Learning-based Security Assistive Technologies To Mitigate Human Attentional Vulnerabilities
Linan Huang, New York University, Brooklyn, NY, United States

Human is the weakest link in cybersecurity as attackers can exploit innate human vulnerabilities, such as attention limitation, to launch attacks. Accepting these vulnerabilities to be 'unpatchable', we aim to design learning-based security assistive technologies to compensate for the vulnerabilities. In the first work, we generate interactive visual aids to engage users in vetting phishing emails and maximize their accuracy of phishing recognition. Reinforcement learning and Bayesian optimization are applied to optimize the design. In the second work, we introduce Informational Denial-of-Service Attacks (IDoS), which overloads human operators with feints and hides real attacks among feints. We develop a quantitative model to formally define IDoS attacks and quantify the risks. A data-driven approach is developed to evaluate human performance in real-time.

2 - A Power Control Game for Wireless Networks
Melike Baykal-Gürsoy, Rutgers University, Piscataway, NJ, 08854-8018, United States

Consider a friendly interferer allocating a limited amount of jamming power to eavesdropping channels to increase the secrecy of a wireless network. When all channels are under attack, the optimal power allocation policy results from solving a convex optimization problem. We show that the optimal policy can be uniquely obtained via a water-filling scheme. However, if the eavesdropper is strategic, this problem results in a nonzero-sum game. Under certain conditions, we prove that there exists a unique Nash equilibrium (NE) strategy and it is pure. The NE again exhibits water-filling structure.

3 - Partially Observable Stochastic Game And Network Epidemics

yezekael Hayel, Avignon University, Avignon, 84000, France, Olivier Tsemogne, Charles Kamhoua, Gabriel Degoue

Traditionally in a two-player partially observable stochastic games (POSG), one player has an incomplete information over the state of the system and cannot observe the moves of the opponent, who has the full information. These assumptions are not realistic in the context of SIR epidemics where the attacker who perfectly knows the network state cannot infer the moves of the defender. The POSG design is however more suitable to represent a defender trying to protect a network from a strategic malware than any model that aims to find out the optimal behavior for the nodes. We propose a POSG that tackles an attack-defense network SIR epidemic. This novel model gives a good understanding on the question of controlling such an epidemic and to it apply the heuristic search value iteration algorithm.

4 - Efficient Episodic Learning Of Nonstationary And Unknown Zero-sum Games Using Expert Game Ensembles

Yunian Pan, Student, New York University, Brooklyn, NY, United States

Game theory provides essential analysis in many applications of strategic interactions. However, the question of how to construct a game model and what is its fidelity is seldom addressed. In this work, we consider learning in a class of repeated zero-sum games with unknown, time-varying payoff matrix, and noisy feedbacks, by making use of an ensemble of benchmark game models. These models serve as prior side information and imperfectly underpin the unknown game model. We propose an episodic learning algorithm that integrates the model estimation and the strategies learning. The proposed algorithm is shown to achieve a sublinear regret bound. A case study is used to illustrate and corroborate our results. We also discuss the relationship and highlight the difference between our framework and the classical adversarial multi-armed bandit framework.

■ VSC61

Virtual Room 61

The Impact of COVID-19 on Air Transportation

Sponsored: Aviation Applications

Sponsored Session

Chair: Stacey Mumbower, Embry-Riddle Aeronautical University, Columbia, SC, 29208-4011, United States

1 - Predicting Route Churn During A Shock Event: The Domestic U.S. Air Travel Network During Covid-19

Stacey Mumbower, Embry-Riddle Aeronautical University, Daytona Beach, FL, 27330, United States

The COVID-19 pandemic has dramatically impacted air transportation and passenger demand has plummeted. The Coronavirus Aid, Relief, and Economic Security (CARES) Act provided financial assistance to U.S. airlines but required that they maintain a minimum level of service. Even with this requirement, airlines were allowed to modify their networks. Route churn models are used to analyze markets discontinued in response to the pandemic. Changes before and after the minimum service requirements of the CARES Act expired are also assessed. The results reveal market, airport, and airline characteristics associated with route churn. The model helps airport managers better understand how at-risk their airports are of losing service during a shock event. The results also help policy-makers understand how the CARES Act minimum service requirements impacted the industry.

2 - The Impact Of Covid-19 On Airline Labor

Joseph Sobieralski, Purdue University, West Lafayette, IN, United States

The airline industry has faced many threats throughout history, but none quite as rapid and severe as the one posed by the spread of COVID-19. One constant during uncertainty shocks and industry downturns is that airline labor bears the brunt of the decline. During periods of uncertainty shocks, the estimated job loss is nearly 7% of the airline workforce with an upper bound of over 13%. Major airline employment is most impacted, while low-cost and regional airline employment is least impacted. The hardest hit employees are ones related to passenger handling and flight operations, while management employees fair slightly better during these uncertain periods. Further, recovery following uncertainty shocks is estimated to take between 4 and 6 years.

3 - Demand For Air Travel In The Presence Of An Emerging Middle Class: Estimating The Effects Of Social, Financial, And Digital Inclusion

Luca J. Santos, Aeronautics Institute of Technology, São José dos Campos, Brazil, Alessandro V. Oliveira, Dante M. Aldrighi

Brazil's air transport industry more than doubled between 2000 and 2019. A considerable portion of this evolution was due to the observed economic growth and increased competitiveness of airlines. Additionally, until the mid-2010s, there was an increasing consumption of its emerging middle class, as the Gini index of income inequality declined around 13 percent in the period. This paper develops an econometric model of air travel demand that incorporates traditional factors as GDP and ticket prices, and considers other possible drivers such as the evolution of income distribution, and also proxies for financial and digital inclusion. We employ a panel with data from domestic city-pairs with scheduled flights in the empirical model. We utilize Lasso regression methods to select both the regressors and the instrumental variables of the model.

4 - 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.

■ VSC62

Virtual Room 62

Advances in Data-Driven Air Traffic Flow Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Lu Dai, University of California-Berkeley, Berkeley, CA, United States

1 - Spatiotemporal Scenario Data-driven Decision-making Framework For Strategic Air Traffic Flow Management

Junfei Xie, Doctorate, San Diego State University, San Diego, CA, 92182, United States

In this talk, a novel spatiotemporal scenario data-driven decision-making framework for strategic air traffic flow management will be introduced. This framework makes real-time decision-making for large-scale air traffic systems possible, by leveraging historical traffic management initiates (TMIs) for spatiotemporal weather-impact scenarios similar to the current scenario under evaluation. In this framework, most computations are moved to offline and online computations are limited to fine-tuning of the control parameters in the historical TMIs, which significantly expedites the design speed.

2 - Unmanned Aircraft System Traffic Management: A System Control Approach

Jiazhen Zhou, Doctorate, Purdue University, West Lafayette, IN, 47907, United States

With large investments in academia and industry, the technologies of unmanned aircraft systems (UAS's) have been spurring in different public domains, such as cargo delivery, passenger transportation, infrastructure monitoring. The increasing number of UAS's ready to fly in public airspace call for a UAS traffic management system that guarantees the safe and efficient UAS operations. In this presentation, a new perspective of the framework design for the UAS traffic management system is proposed. A control-based traffic management strategy is developed to improve the scalability and to assure the safety of the UAS traffic. Our framework and method serve as potential guidelines for policy making and infrastructure design for future UAS traffic.

3 - Data-driven Approach Using Machine Learning For Flight Path Optimization

Junghyun Kim, Doctorate, Georgia Institute of Technology, Atlanta, GA, 30332, United States

Current in-flight re-planning systems rarely cause accidents in U.S. airspace; however, one potential issue is that the systems are not fully automated; thus, pilots today perform some portions of the in-flight activities manually. Another potential issue is that weather forecasts used for the systems are not always accessible in a timely manner. This research attempts to resolve the potential issues by developing a machine learning-based flight path optimization framework that automatically performs in-flight re-planning continuously with the latest weather information sets available. Statistical analyses are performed using real flights to prove the potential benefits and applicability of the proposed methodology. The results indicate that the framework generates flight routes that reduce flight time by up to two percent in most cases.

4 - Machine Learning Based Aircraft Trajectory Prediction With Historical Data

Yutian Pang, Doctorate, Arizona State University, Tempe, AZ, 85281, United States, Yongming Liu

This presentation covers a brief review of the research works on data-driven aircraft trajectory prediction. Much effort is put into strategic trajectory prediction with convective weather features in the en-route phase. The objective is to pursue an accurate trajectory prediction towards the actual flight data recording. A module-based machine learning framework is proposed with the help of ATC domain knowledge and shows effectiveness. This includes data processing, feature engineering, and spatial-temporal learning, in both deterministic and probabilistic sense. For spatial-temporal learning, we have examined several advanced machine learning techniques (e.g. Bayesian deep learning). Future directions on trajectory prediction span from multi-aircraft trajectory prediction to macroscopic traffic flow prediction in the near-terminal area.

■ VSC63

Virtual Room 63

Recent Advances in Optimization Software II

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Hans Mittelmann, Arizona State University, Tempe, AZ, 85287-1804, United States

Co-Chair: Gregor Hendel, FICO, Germany

1 - Recent Enhancements In Optimization With MATLAB

Steve Grikschat, MathWorks, Natick, MA, United States

MATLAB has solvers for continuous and discrete optimization problems. They can solve both analytical and black-box models, including those with multiple objectives and those black-box models with discrete variables where relaxations do not exist. Recent enhancements to these solvers and guidance on selecting a solver will be presented.

2 - On Affine Conic And Disjunctive Constraints In The Upcoming MOSEK Version

Sven Wiese, Mosek ApS, Fruebjergvej 3, Copenhagen, 2100, Denmark, Erling D. Andersen

MOSEK is a widely used optimization software package for large-scale, possibly mixed-integer linear and conic optimization problems. A novelty in the upcoming MOSEK version 10 is the introduction of affine conic and disjunctive constraints. These two features make it easier to express continuous conic and discrete optimization problems. In this presentation we will discuss why and how these features have been introduced into MOSEK.

3 - 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.

4 - Introduction To Optimization Solver MindOpt

Wotao Yin, Principal Engineer, Alibaba Group US, Seattle, WA, United States

MindOpt is an optimization suite under development by Alibaba, a multinational technology company specializing in e-commerce, retail, and Internet. MindOpt has a linear programming solver with efficient implementations of Simplex methods, an interior-point method, as well as a set of acceleration techniques. It supports multi-core parallel computing and client-server deployment. The solver is used as an engine to support several critical businesses at Alibaba. In addition, everyone can access it through an in-browser terminal for unlimited time. This talk will present the features and performance of MindOpt.

5 - Xpress-R: An R Interface For The FICO Xpress Optimizer

Gregor Hendel, Fair Isaac Germany GmbH, Berlin, Germany

The R programming language for statistical computing is nowadays extremely popular among data scientists. Since its version 8.12, the FICO Xpress Optimizer comes with an R interface that provides users of R with a complete toolbox to formulate, solve, and interact with their mixed-integer linear and convex quadratic optimization problems directly in R. In this talk, we explain the main features of this interface, and demonstrate its usage in a live demo.

6 - Improving CPLEX On Problems Involving Sparsity: A Progress Report

Gianmaria Leo, IBM, Sindelfingen, Germany, Christian Bliek

We report on the improvement of CPLEX's new release with special attention to instances in which a subset of continuous variables with fixed cardinality has to be selected or the smallest set of variables has to be found. These problems are of paramount importance in data science like in the case of sparse regression, sparse support vector machine, etc. We will discuss both performance improvements and steps to make Cplex more accessible and usable to the data science community.

■ VSC64

Virtual Room 64

Combinatorial Optimization II

Contributed Session

Chair: Sam Heshmati, University of Kentucky, Louisville, KY, United States

1 - Self-attention Based Reinforcement Learning for the Knapsack Problem

Jacopo Pierotti, TU Delft, Delft, Netherlands

Combinatorial optimization (CO) problems are at the heart of practical and theoretical research. Due to their complexity, many problems cannot be solved via exact methods in reasonable time; hence, we resort to heuristic solution methods. In recent years, machine learning (ML) brought immense benefits to heuristic solution methods. Among ML methods, reinforcement learning (RL) seems to be one of the most promising methods. In this work, we investigate an RL framework, whose agent is based on self-attention, to achieve good solutions for the knapsack problem (a CO problem).

2 - 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.

3 - 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.

4 - 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.

■ VSC65

Virtual Room 65

Advances in Discrete Optimization

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Jongeun Kim, University of Minnesota, Minneapolis, MN, 55414, United States

1 - An Abstract Branch-and-Cut Model

Aleksandr M. Kazachkov, University of Florida, Department of Industrial and Systems Engineering,, Gainesville, FL, 32611-6595, United States, Pierre Le Bodic, Sriram Sankaranarayanan

Branch-and-cut is the dominant paradigm for solving mixed-integer programming problems, combining intelligent search (via branch-and-bound) and relaxation-tightening (via cutting planes, or cuts) procedures. While there is a wealth of computational experience driving how solvers add cuts, there is simultaneously a relative lack of theoretical explanations for these choices, and for the tradeoffs involved therein. In this paper, we provide a framework for analyzing how cuts affect the size of branch-and-cut trees, as well as their impact on solution time. Our models capture some of the key characteristics of real-world phenomena in branch-and-cut experiments, regarding whether to generate cuts only at the root or throughout the tree, how many rounds of cuts to add before starting to branch, and why cuts seem to exhibit nonmonotonic effects on the solution process.

2 - Lifting Convex Inequalities For Bipartite Bilinear Programs

Xiaoyi Gu, Georgia Institute of Technology, Atlanta, GA, United States, Santanu Subhas Dey, Jean-Philippe P. Richard

The goal is to derive new classes of valid convex inequalities for quadratically constrained quadratic programs (QCQPs) through lifting. Our first result shows that, for sets described by one bilinear constraint together with bounds, it is always possible to lift a seed inequality that is valid for a restriction obtained by fixing variables to their bounds, when the lifting is accomplished using affine functions of the fixed variables. We then study a separable bilinear set, derive a second-order cone representable "bilinear cover inequality", and show its strength as it yields a constant-factor approximation. We study its lifting function, construct a two-slope subadditive upper bound, and lift fixed variable pairs in closed-form, thus deriving a "lifted bilinear cover inequality" valid for general separable bipartite bilinear sets with box constraints.

3 - 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.

4 - 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.

■ VSC66

Virtual Room 66

Stochastic Optimization

Contributed Session

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

1 - Regularized Inverse Optimization Of A Long-term Electricity Price Model

Roozbeh Qorbanian, University of Luxembourg, Luxembourg, Nils Löhndorf, David Wozabal

We present a stochastic long-term price model for the day-ahead electricity market. Long-term price models are important for pricing renewable power purchase agreements which are a key ingredient for companies to meet sustainability targets. We use regularized inverse optimization to estimate parameters of a fundamental long-term power price model of the European electricity market. Based on our model and scenarios of exogenous variables (plant availability, demand, fuel prices, weather), we simulate future hourly electricity prices.

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.

■ VSC68

Virtual Room 68

Advances in Nonlinear and Stochastic Optimization II

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Baoyu Zhou, Lehigh University, Bethlehem, PA, 18015, United States

1 - MADGRAD: A Momentumized, Adaptive, Dual Averaged Gradient Method For Stochastic Optimization

Aaron Defazio, Research Scientist, Facebook, New York, NY, United States

We introduce MADGRAD, a novel optimization method in the family of AdaGrad adaptive gradient methods. MADGRAD shows excellent performance on deep learning optimization problems from multiple fields, including classification and image-to-image tasks in vision, and recurrent and bidirectionally-masked models in natural language processing. MADGRAD builds upon the dual averaging variant of AdaGrad with the addition of a primal-averaging form of momentum and weighted gradient sequences. Both modifications are crucial for good performance on deep learning models.

2 - From Low Probability To High Confidence In Stochastic Convex Optimization

Lin Xiao, Facebook AI Research, Seattle, WA, United States, Damek Davis, Dmitriy Drusvyatskiy, Junyu Zhang

Standard results in stochastic convex optimization bound the number of samples that an algorithm needs in expectation. More nuanced high probability guarantees are rare, and typically either rely on light-tail noise assumptions or exhibit worse sample complexity. We propose a proxBoost procedure that can augment a wide class of stochastic optimization algorithms for strongly convex problems with high confidence bounds, and the overhead cost is only logarithmic in the confidence level and polylogarithmic in the condition number. This procedure is elementary and builds upon two well-known ingredients: robust distance estimation and the proximal point method. We discuss consequences for both streaming (online) algorithms and offline algorithms based on empirical risk minimization.

3 - Complexity Of A Sequential Quadratic Programming Algorithm For Equality Constrained Stochastic Optimization

Michael O'Neill, Lehigh University, Bethlehem, PA, United States, Frank E. Curtis, Daniel P. Robinson

It is well known that for simple constraint sets, algorithms such as the projected stochastic gradient method (PSGM) share the same complexity guarantees as their unconstrained counterparts. In the past year, new stochastic optimization algorithms have been developed for problems with general nonlinear constraints. In particular, a number of sequential quadratic programming (SQP) methods have been proposed to optimize stochastic functions subject to nonlinear equality constraints. However, these methods either lack a complexity analysis or are non-adaptive and need an accurate a-priori estimate of the merit parameter. In this work, we present a stochastic SQP method with an adaptive merit function and prove a worst-case complexity result. We show that under largely standard assumptions, our method exhibits the same rate of convergence as the PSGM.

■ VSC69

Virtual Room 69

Nonlinear Optimization Techniques in Stochastic Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Mohit Tawarmalani, Purdue University, West Lafayette, IN, 47907-2076, United States

Co-Chair: Ashish Chandra, Krannert School of Management Purdue University, West Lafayette, IN,)

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 - Resilient and Flexible Routing

Chuan Jiang, Purdue University, West Lafayette, IN, United States, Sanjay Rao, Mohit Tawarmalani

We show that existing routing mechanisms to ensure no congestion in wide area networks achieve performance far short of the network's intrinsic capability. We propose PCF, a set of novel mechanisms to bridge this gap and provide performance guarantees under f failures. PCF enhances the flexibility of network response and ensures that the performance under failures can be tractably modeled. We show PCF's effectiveness through theoretical results and experiments over 21 topologies. PCF can sustain higher throughput than existing schemes by a factor of 1.11X to 1.5X on average.

3 - 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.

4 - Risk-averse Multi-stage Stochastic Mixed-Integer Programs With Endogenous Uncertainty

Esra Buyuktahtakin Toy, New Jersey Institute of Technology, Newark, NJ, 07103-3918, United States, Sabah Bushaj, Eyyub Yunus Kibis, Robert G. Haight

In this talk, we will focus on tackling the computational difficulty of mean-CVaR stochastic mixed-integer programming problems. To avoid non-linearities in the model, we present a scenario tree binary decision diagram to formulate the endogenous uncertainty. We present cutting plane algorithms that are based on scenario dominance. Computational results will be demonstrated on a forest insect infestation application.

■ VSC70

Virtual Room 70

Robust Optimization and Satisfying

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Qinshen Tang, Nanyang Techonological University, Singapore, 117592, Singapore

1 - On Consistency In Optimization

Louis L. Chen, Naval Postgraduate School, Monterey, CA, 93940, United States, Johannes Royset

It is often the case that optimization problem formulations involve uncertain parameters. Motivated by those settings in which such unknown parameters are learned over time, we investigate the "consistency", or limiting behaviors (of value, solutions, multipliers, etc.) to the optimization problems with respect to the convergence of these parameters. Towards this aim, we will make use of Rockafellians, a concept both old and new, so that we may evaluate the merits and shortcomings of various optimization formulations/practices.

2 - Distributionally Robust Optimization Under Constant Absolute Risk Aversion

Li Chen, National University of Singapore, 117602, Singapore, Melvyn Sim

We focus on distributionally robust linear optimization under constant absolute risk aversion (CARA) with stochastically independent factors. Due to its intractability, we propose a solution framework containing a hierarchy of approximations to obtain tractable and scalable formulations. In particular, we first derive exponential cone program (ECP) reformulations of certainty equivalence of affine functions and piecewise affine convex functions and extend it to the two-stage linear optimization based on a new piecewise affine recourse approximation. The solution framework shows distributionally robust linear optimization under CARA problems can be approximated by ECPs, which can be solved very efficiently by off-the-shelf solvers. Finally, we illustrate our approach can be used to obtain high-quality solutions in several applications.

3 - Conic Robust Satisficing

Arjun Ramachandra, National University of Singapore, Singapore, Singapore

Inspired by the principle of satisficing, we propose an alternative framework for conic optimization under uncertainty, which aims to deliver the solution that is least impacted by uncertainty in achieving the target objective. We show that this new framework can be used to model a wide range of optimization problems including the data-driven setting and argue that the resultant formulation is feasible and tractable using affine recourse adaptation. Further, we numerically demonstrate the modelling and the computational benefits of the robust satisficing framework over classical robust optimization with three numerical examples: portfolio selection, log-sum-exp and adaptive lot-sizing.

4 - Screening With Limited Information: The Minimax Theorem And A Geometric Approach

Ruiqin Wang, National University of Singapore, Singapore, Zhi Chen, Zhenyu Hu

Consider a seller seeking a selling mechanism to maximize the worst-case revenue obtained from a buyer whose valuation distribution lies in a certain ambiguity set. For a generic convex ambiguity set, we show via the minimax theorem that strong duality holds between the problem of finding the optimal robust mechanism and a minimax pricing problem that the adversary first chooses a worst-case distribution and then the seller decides the best posted price mechanism. We further provide a geometric approach to solving the minimax pricing problem for several ambiguity sets. The solutions are then used to construct the optimal robust mechanism and to compare with the solutions to the robust pricing problem.

■ VSC71

Virtual Room 71

Linear Programming

Contributed Session

Chair: Fabio Vitor, University of Nebraska at Omaha, Omaha, NE, 68164-3706, United States

1 - 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.

2 - On The Implementation Of Multidimensional Searches Into A Dual Simplex Solver And A Primal-dual Interior Point Solver

Fabio Vitor, Assistant Professor, University of Nebraska at Omaha, Omaha, NE, United States

The class of multidimensional search algorithms has received attention in the last years as a method to solve linear programs. Differently than the traditional one-dimensional search algorithms, these techniques search over the space of feasible solutions through multiple directions. This talk will present the implementation details of two and three-dimensional search methods into the dual simplex solver HiGHS and the primal-dual interior point solver PCx, both open-source solvers for large-scale linear programming. Computational results on benchmark linear programs will be presented, as well some theoretical advancements in the methods to solve the subproblems of these algorithms.

■ VSC73

Virtual Room 73

Risk & Uncertainty Applications

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Shubhi Asthana, United States

1 - Public Risk Perceptions, Behaviors And Emotion Regulation Under Major Public Health Emergency

Shenming Song, Tsinghua University, Beijing, China, Chen Wang, Dongyuan Zhan

This study focuses on the reposting and commenting behavior of the public in online social media under major public health emergency. We apply event extraction and sentiment analysis for risk information embedding and public emotions mining and propose a mixture of content utility and emotion utility models to depict the public's online social media behavior. We further analyze the public's micro dynamics in their emotions and response to risk information and macro dynamics of their online social media behavior during different stages of the major public health emergency, as well as identify recommended strategies of publishing risk information.

2 - Food Waste And Social Welfare Under Demand Uncertainty

Kohei Onzo, Waseda University, Tokyo, Japan

Systematic food waste in the retail sector has become an increasingly severe issue. To figure out the mechanism behind the occurrence of food waste, we build a model in which the manager must decide the inventory level and the price without being able to predict the exact number of customers whose willingness to pay is uniformly distributed. The model suggests that, in pursuit of profit maximization, waste is always expected to accumulate. We also consider externalities of food waste and social welfare. Contrary to intuition, we show that ex ante market clearing does not generically occur when the government maximizes the expected social welfare through taxation.

3 - Risk Analytics For Renewal Of Purchase Orders

Shubhi Asthana, IBM Research, San Jose, CA, United States, Pawan Chowdhary, Taiga Nakamura

The transactions of goods and services between large businesses are often driven by purchase order (PO). A PO is a document that which details the sale of products and services to be delivered. The demand driven usage of the cloud infrastructure and services can lead to unpredictable nature of cost which can lead to the invoices that may get into a dispute due to PO amount getting exhausted much ahead of the contract end date. To address this challenge, we developed a risk analytics model along with a recommendation engine, enhanced with Human-in-the-Loop (HitL) to rank purchase orders for renewal. We demonstrate the efficacy of our method by showing implementation of the application.

4 - Predicting Risk Preferences From Consumer Physiology: A Deep-learning Approach

Chinmai Basavaraj, University of Arizona, Tucson, AZ, United States, Martin Reimann, Kobus Barnard

We investigate the prediction of consumer choices from fMRI data using advanced deep learning. We developed novel methods using concepts introduced in language processing and applied them on fMRI data collected from participants who repeatedly made risky choices for experiential and monetary scenarios. Our methods resulted in a substantial improvement in choice prediction accuracy. Our results also showed that prediction of risk-seeking for experiential choices is more accurate than for monetary choices when using fMRI data from a memory area of the brain, which aligns with theoretical considerations. Finally, we validate the applicability of our methodology in similar large-scale datasets.

■ VSC74

Virtual Room 74

Behavioral Decision Analysis and Algorithms

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Canan Ulu, Georgetown University, Washington, DC, 20057, United States

Co-Chair: Alessandra Cillo, y, Bocconi University, Milan, 20136, Italy

1 - Taking Advice From Models Or Humans: Does It Make A Difference?

David V. Budescu, Fordham University, Department Of Psychology, Bronx, NY, 10458-5149, United States, Mark Himmelstein

We study forecasters' willingness to rely on algorithmic or human advice empirically. In general, forecasters' performance improves as a function of advice. We demonstrate that the source of advice has little impact on the judges' forecasts for economic and political events. However, when asked which source they prefer, judges prefer algorithmic advice for economic forecasts and human advice for political forecasts. Interestingly, they prefer "hybrid" advice, which combines human and algorithmic inputs, regardless of domain. Several variables related to the similarity between initial forecasts and the advice (but not its source) predict the judges' willingness to update their forecast.

2 - Applicants View Algorithms as Fair but (often) Prefer a Person

Jenn Logg, Georgetown University, Washington, DC, United States

Although more and more companies are utilizing hiring algorithms, across 6 experiments (N=4,016), we find that applicants themselves choose a person over an algorithm to assess their application (Experiment 1: 70%). This preference weakens when the applicant pool is less competitive (Experiment 2: from 67% to 58%). However, people do prefer the algorithm when the hiring manager is a member of the applicant's out-group (Experiment 3: in-group: 69%; out-group: 39%). Applicants have such a strong preference for a person that an algorithm must reach 75% accuracy in its past hiring decisions before they prefer it.

3 - Should Advisors Signal Access To Algorithms?

Alessandra Cillo, Bocconi University, Milan, 20136, Italy, Canan Ulu, Emanuele Borgonovo, Alessandro Ortis, Sebastiano Battiato

We investigate how individuals react to advice coming from advisors who have access to algorithms. We run two studies to understand advice utilization where we ask participants to forecast standardized test scores for high school students and number of views various images receive on a photo sharing website. Participants get advice either from the algorithm, or advisors who have access to an algorithm or from advisors who do not. Our results suggest that advice utilization is significantly lower if advice comes from advisors who do not have access to an algorithm.

4 - Influence Of Algorithms On Risk-taking In Resource Allocation Problems

Pranadharthiharan Narayanan, IE Business School, Madrid, Spain, Jeeva Somasundaram, Matthias Seifert

We examine how risk-taking is influenced by the use of algorithms in resource allocation problems such as the multi-item newsvendor context. Across two studies, we find that participants treated with slightly-and highly-risk-averse algorithmic suggestion (SRA and HRA conditions) act more risk-averse than participants treated with risk-neutral algorithmic suggestion (RN condition). Strikingly, even after the algorithmic suggestion is removed, participants in the HRA condition continue to display higher levels of risk-aversion compared to a control condition (who do not encounter any algorithmic suggestion). Additionally, participants in all treated groups display hedging behavior (i.e., deviation from the algorithm s suggestion to account for its riskiness). Our findings suggest mutability of human risk-attitudes with exposure to algorithmic aids.

5 - Presenter

Jack Soll, Duke University, Durham, NC, 27708-9972, United States

I will serve as a discussant for the papers presented in this session.

■ VSC75

Virtual Room 75

T-Mobile Supply Chain Modernization with Operations Research & Data Science

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Onur Mete,

1 - T-Mobile Forward Supply Chain Multi-echelon Inventory Optimization

Ahmet Oguzhan Ozlu, Senior Operations Research Scientist, T-Mobile, Bellevue, WA, United States, Erdem Eskigun, Renaud Lecoeuche

We present an optimization model framework that assists T-Mobile making the best procurement decisions considering demand uncertainty, dynamic product assortment, product substitution, and vendor contract restrictions. The model periodically calculates optimal network inventory levels and retail-stock-out ratios over a planning horizon with a variety of business constraints, which leads to significant reductions in organization's network inventory and improved supply chain efficiency.

2 - T-Mobile Reverse Supply Chain Planning Optimization

Zhengyang Hu, T-Mobile, Bellevue, WA, United States, Oguzhan Ozlu, Erdem Eskigun

In the reverse supply chain at T-Mobile, returned devices go through multiple steps such as triage, cross-docking, repair, kitting, and become refurbished devices at the end. We developed an optimization model with primary goals of (1) liquidating unnecessary inventory at the right time to maximize liquidation revenue, (2) maintaining inventory at certain levels against internal and external uncertainties, (3) fulfilling claims with refurbished devices and minimizing the usage of brand new device inventory.

3 - T-Mobile Time-series Demand Forecasting With Causal Factors

Charles Wu, Priniciple Data Scientist, T-Mobile USA, Bellevue, WA, United States, Yun Wu

Demand forecast is a key factor to drive decisions about inventory management, supply and production planning and many other areas in T-Mobile. The existing supply chain forecasting tool has failed to deliver the desired results especially with T-Mobile's increasingly frequent and creative promotions. In this work a time-series model was built to forecast the topline demand for handset groups classified by price, features, and OEM. The model consists of three steps: 1) evaluating the holiday effects including holiday lifts and dips; 2) modelling the promotional lifts with factors such as eligible customer type, applicable handset sales penetration, handset price, and promotion duration and frequency; and 3) estimating trend and seasonality. This model showed a consistent high accuracy with a typical APE under 10% in a two-month testing period for the topline sales.

- T-Mobile Retail Inventory Optimization

Erdem Eskigun, T-Mobile USA, Bellevue, WA, United States, Renaud Lecoeuche, Zhengyang Hu

Product proliferation has become a fact of life in supply chains. Having many products, which are often slow moving, can be challenging: forecasts are often inaccurate and safety stock levels are high. From the customer point of view some of these products are substitutable. In this talk, we will present how we manage inventory by considering substitutable products together. We will discuss the advantages and challenges of doing so. We will also consider the implications of considering substitutions when one or more products has limited supply.

■ VSC76

Virtual Room 76

OR/ML Practice at Amazon

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Kerem Bulbul, Amazon.com Services, Inc., Seattle, WA, 98101-1256, United States

1 - Hub Location Selection On Amazon Ground Network

Kursat Kemikli, Lehigh University, Bethlehem, PA, 18015, United States

Hubs operate as consolidation points in transportation networks and lead to cost and speed benefits through economies of scale on inter-hub links. In this work, we focus on identifying hub locations in a ground transportation network where each demand (e.g., customer clusters) and supply node (e.g., fulfillment centers) are uniquely mapped to a hub, and packages flow from supply nodes to demand nodes through one or more hubs. We proposed and evaluated the performance of two alternative solution methodologies, an MILP formulation and an algorithm based on Benders decomposition.

2 - Grocery Inventory Health

Gizem Cavuslar, Amazon.com, Seattle, WA, 98121, United States

Text coming soon.

3 - 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.

4 - 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.

■ VSC77

Virtual Room 77

Navigating the Post-Pandemic Assessment Landscape: Beyond the High-Stakes Exam

Informs Special Session: INFORMS Committee on Teaching and Learning

Informs Special Session Session

Chair: Amanda G Smith, University of Wisconsin-Madison, Madison, WI, 53706, United States

1 - Measuring And Sustaining Assessment Success

Amanda G. Smith, University of Wisconsin-Madison, Madison, WI, 53706, United States

How do we measure and sustain success of new assessment strategies, in the context of pre-determined goals? We will identify strategies to accurately measure the level of success of new approaches to assessment. Adhering to the principle of continuous improvement, we will explore ideas for sustaining successful approaches to assessment and improving on areas that exhibit new pain points.

2 - Finding Purpose In Assessment

Jill Hardin Wilson, Northwestern University, Evanston, IL, 60201-2938, United States

What are we trying to accomplish with course assessments? We will explore the purposes of course assessments and consider the challenges of traditional assessments in supporting these objectives, with an eye towards both inclusion and academic integrity.

3 - Current State Of Assessments

Katie L. Basinger-Ellis, Assistant Instructional Professor, University of Florida, Gainesville, FL, United States

While assessments vary between professors, courses, and disciplines, they intend to challenge the student(s) to perform/prove what they have learned. In the past year, many assessments have moved online due to the pandemic and, in doing so, have made it extraordinarily easy for students to use unauthorized help. These methods make it more difficult than ever to hold students accountable for learning the skills we expect them to know. We will discuss strategies for holding students accountable and overcoming some of the pain points faculty experience when delivering and grading these assessments.

4 - What Concrete Steps Can Be Implemented To Achieve Our Assessment Goals?

Lisa Miller, Distinguished Teaching Professor, University of Minnesota, Minneapolis, MN, United States

We will discuss potential strategies for meeting assessment goals. For example, are there opportunities to utilize your university's learning management software? What new assessment methods were tested during the COVID-impacted 2020-2021 academic year that may translate well into long-term use? How can we get faculty and other instructors on-board with new assessment approaches?

5 - New Approaches To Assessment

Dawn Strickland, ISyE Georgia Tech, Atlanta, GA, 30327, United States

We will discuss new methods and strategies for assessment to address the challenges presented earlier. Please come prepared to share your ideas!

■ VSC78

Virtual Room 78

Undergraduate Operations Research Prize 3

Informs Special Session: Undergraduate Operations Research Prize

Informs Special Session Session

Chair: Kayse Lee Maass, Northeastern University, Boston, MA, 02115-5005, United States

Co-Chair: Jessye Talley, Morgan State University, Baltimore, MD, 21251, United States

1 - A Refined Mean-Field Approximation for Discrete-Time Queueing Networks with Blocking
Yang Pan, Jilin University, Changchun, China

2 - Distributionally Constrained Black-Box Stochastic Gradient Estimation and Optimization
Junhui Zhang, Columbia University, New York, NY, United States

3 - Employing a Cardinality of Upper-Tail Penalty Approximation for Cardinality Minimization Problems
David J. Troxell, Southern Methodist University, Leander, TX, 78641, United States

The cardinality of upper-tail function (CUT) can be employed as a penalty function in optimization settings to directly minimize the number of solution elements that exceed a particular threshold. We propose a new continuous approximation of the CUT function comprised as the difference of two convex functions, and we use the computationally efficient Difference-of-Convex Functions Algorithm (DCA) to lessen the complexity present in Cardinality Minimization Problems (CMP). We reformulate a number of applications into CMP - including economic dispatch, radiation therapy, and portfolio management - and display the numerical advantages of using the new CUT approximation and DCA.

4 - Data-driven Distributionally Robust Home Healthcare Districting with Capacity Planning
Shuo Sun, Tsinghua University, Beijing, China

■ VSC79

Virtual Room 79

Sustainable Agriculture and Operations

Informs Special Session: Agriculture

Informs Special Session Session

Chair: Ying-Ju Chen, Hong Kong University of Science and Technology, Kowloon, Hong Kong

Co-Chair: Haoyu Liu, City University of Macau

2 - Optimal Subsidies To Help Farmers Climbing The Agricultural Value Chain
Chang Dong, Chinese University of Hong Kong, Hong Kong, China

In most developing countries, small-scale farmers only produce primary agricultural goods which come directly from nature, such as cereal grains, olives, almonds, vegetables, fruit, and grapes for wine. These primary agricultural goods are procured by large enterprises, then made into processed agricultural goods, and finally sold to consumers. By investing in the manufacturing capabilities, farmers can enter the more lucrative downstream product market but also expose less to the highly fluctuated market of primary agricultural goods. But cashless farmers have to borrow from the competitive financial market to finance the investment, which is highly inefficient due to adverse selection. We, therefore, study the design of the government interventions to ease farmers' access to the financial market.

3 - Selling Vs. Solution In Promoting Drip Irrigation System In Developing Countries
Jiguang Chen, Xiamen University, Xiamen, China, Ying-Ju Chen, Guangrui Ma, Hau Leung Lee

Dripping irrigation can deliver water and fertilizer together and drip them precisely into the root area of the plant, thus improving agriculture yields. Furthermore, they use resources more efficiently than the conventional flood irrigation: not only the water wastage is reduced, but also overuse of fertilizer is mitigated. Previously, firms adopt a selling business model by selling the system to farmers and letting farmers operate it. However, farmers do not have the knowledge to efficiently operate the dripping. Recently, firms have provided solutions for farmers by letting the firm's professional technicians operate the system. Accordingly, in this solution business model, the farmers do not operate drip irrigation system by themselves, and instead they buy the dripping service from the firm. We study the firm's optimal contract menu with both business models.

4 - Presenter
Hui Xiong, Huazhong University of Science and Technology, School of Management, Wuhan, 430074, China, Lu Hsiao, Cheng-Hsun Hsieh

Food delivery platforms spread across several countries and play an important role in the Coronavirus disease 2019 epidemic. On these platforms, the food sellers pay a commission to the platforms after each sale and the consumers pay a delivery fee. In this paper, we investigate these two levers - the commission rate and the delivery fee, and the influence of the network externalities. We find that the platform should charge consumers no fee for the delivery-to-door service in the scenario without the network externalities. In contrast, the consumers may have to pay for the delivery services when there is the within-group negative externality (competition between sellers). Moreover, we find that the within-group positive externality increases the competition between sellers and the incentive for the platform to charge no commission and collect high delivery fees.

■ VSC81

Virtual Room 81

Electric Mobility as a Service: Advancing Sociotechnical Methods Toward Practical Breakthroughs

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Leila Hajibabai, North Carolina State University, Raleigh, NC, 27695-7906, United States

1 - 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.

2 - A Column And Constraint Generation Approach For An Integrated Charging And Power Distribution Network Design
Amir Mirheli, North Carolina State University, Raleigh, NC, 27695, United States, Asya Atik, Leila Hajibabai

This study develops a mixed-integer bi-level mathematical program with power distribution network design and electric vehicle charging station deployment decisions in the upper level and user equilibrium traffic assignment considering uncertain demand in the lower level. A hybrid technique that integrates a column and constraint generation technique with a macroscopic fundamental diagram concept is developed to solve the problem. The proposed methodology is applied to various case studies to evaluate its solution quality and computational efficiency.

3 - Charging On The Move For Electric Vehicles: A New Vehicle Routing Problem And Solution
Jiahua Qiu, University of Florida, Gainesville, FL, United States, Lili Du

The mobile electric-vehicle-to-electric-vehicle (mE2) charging technique offers a promising solution to the EVs' range anxiety. This study develops a Charging-as-a-Service (CaaS) platform for cultivating this charging technique. Mathematically, the CaaS platform is modeled as a vehicle routing problem (i.e., mE2-VRP), which optimally dispatches the electricity providers (EPs) to charge the demands (EDs) on the move while minimizing the EP fleet size. We develop the Clustering-aided Clarke and Wright Savings (CCWS) algorithm to efficiently decompose and then solve the large-scale mE2-VRP by parallel computing. Our numerical experiments found that the CaaS performs better in low EV penetration markets while traffic congestion is mild. We can improve the performance by proper pricing strategies according to the EDs' energy requests and trip lengths.

4 - Optimal Evacuation Plan for Electric Vehicles in Hurricane
Qianwen Li, University of South Florida, Tampa, FL, United States, Xiaopeng Li

This study proposes a capacity-constrained STA model to solve the optimal scheduling, routing, and charging for EVs in hurricane evacuation. An optimization objective of minimizing the network clearance time is used to evacuate people as soon as possible. The model inputs are evacuation origins, destinations, initial electricity level, and evacuation departing time window, which is utilized to model evacuation flexibility and help with system optimality. The model outputs are evacuation departing time, evacuation routes, and charging plans along the evacuation routes. Charging station capacities are configured. The roadway capacity is constrained to guarantee mobility.

■ VSC82

Virtual Room 82

Last-Mile Logistics for E-Commerce

Sponsored: TSL/Facility Logistics

Sponsored Session

Chair: Dipayan Banerjee, Georgia Institute of Technology, 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 - Parallel Drone Scheduling Traveling Salesman Problem With Weather Impacts

Lan Peng, University at Buffalo, Buffalo, NY, 14260, United States, Chase Murray

The weather condition is a critical factor for drone delivery, however, it has received limited attention in the existing literature. This research considers that severe weather may prevent drones from operating in multiple periods of the day. Furthermore, the endurance and speed of drones are impacted by wind speed and wind direction which may change over the day. In this talk, two variants of a parallel drone scheduling traveling salesman problems (PDSTSP) have been discussed, which includes a static PDSTSP with deterministic weather information, and a dynamic PDSTSP with stochastic weather information. Computational testing reveals encouraging results.

3 - Does Parking Matter In Routing Last-Mile Deliveries?

Sara Reed, University of Kansas, 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.

4 - Stochastic Intra-City Service Network Design

Ozgur Satici, The University of Alabama, Tuscaloosa, AL, United States, Iman Dayarian

We consider a crowd-based service network design for intra-city package delivery service in a stochastic environment. The network consists of courier company stores that can serve as sorting facilities, and inter-facility transport is performed by a set of contracted drivers and crowd-shippers that are augmented by third-party drivers employed on an as-needed basis. Taking the stochastic information for future demand and crowd-shipper availability, a two-stage stochastic model, based for minimizing the system cost on a rolling time horizon is formulated and solved using Bender's Decomposition. The first stage problem represents the allocation of the contracted drivers, then, in the second stage, available crowd-shippers and third-party drivers are integrated into the network, freeing some of the contracted drivers to be removed from the plan to decrease the cost.

5 - 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.

■ VSC83

Virtual Room 83

Advances in Transportation Management

Sponsored: TSL/Intelligent Transportation Systems

Sponsored Session

Chair: Monika Filipovska, Northwestern University, Evanston, IL, United States

1 - How To Split The Costs Among Travellers Sharing A Ride? Aligning System's Optimum With Users' Equilibrium

Andres Fielbaum, TU Delft, Delft, Netherlands, Rafal Kucharski, Oded Cats, Javier Alonso-Mora

How to form groups in a mobility system with shared rides, and how to split the costs within the travellers, are non-trivial tasks, as two objectives conflict: 1) minimising total costs, 2) making each user content.

Here, we propose cost-sharing protocols for a shared ride. We show that the notions of Nash and Strong are not useful here, and prove that determining whether a Strong Equilibrium exists is an NP-Complete problem. Hence, we propose three alternative equilibrium notions, and three cost-sharing protocols, for which the optimal solutions are an equilibrium for each of the mentioned intermediate notions of equilibrium. This game can be seen as a game-version of set cover.

2 - Improving Public Transit Routing Through Multilevel Partitioning

Prateek Agarwal, Indian Institute of Science, Bangalore, India, Tarun Rambha

Shortest path problems in transit networks typically find Pareto-optimal journeys involving travel time and transfers. We propose a new multilevel nested partitioning method that can speed up existing popular approaches like RAPTOR, Trip-based Public Transit Routing. Empirical results on country-level open GTFS datasets are also demonstrated.

3 - 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.

4 - Information-adaptive Routing Strategies In Stochastic Dynamic Transportation Networks With Real-time Connected Vehicle Data

Monika Filipovska, Northwestern University, Evanston, IL, United States, Hani S. Mahmassani

Modeling travel time variability in transportation networks allows for more comprehensive knowledge of the network state and risk-based decision-making. In stochastic dynamic networks, past and current network state information can be used to adjust the knowledge of future network states and corresponding optimal routing solutions. This study considers the problem of optimal routing strategies in stochastic dynamic networks, adaptive to en-route information in a connected vehicle environment. An approach that combines a reactive and proactive routing strategy is presented, along with approximations targeted at improving its computational complexity for large-scale implementations.

■ VSC84

Virtual Room 84

Nicholson Student Paper Competition: I

Award Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, Pittsburgh, PA, 15217-1420, United States

Co-Chair: Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States

1 - Efficient Reinforcement Learning in a Complex Environment
Shi Dong, Stanford University, Stanford, CA, United States

We design a reinforcement learning agent and establish theoretically that this agent can operate effectively in any environment. The generality of our agent-environment interface and the novelty of our analysis position our result to inform the design of agents in complex real environments. We show that the time it takes to attain near-asymptotic performance does not depend on environment complexity, and that the ultimate per-period loss is a constant scaling of the distortion introduced by the agent's state representation. Our result solves an open problem in approximate dynamic programming

2 - Fair Exploration via Axiomatic Bargaining
Jackie W. Baek, MIT, Cambridge, MA, 02139-4301, United States

We study the problem of fairly sharing the cost of exploration between multiple groups in multi-armed bandits. Using axiomatic bargaining as the backbone of our fairness framework, we develop policies that yield the Nash bargaining solution. We show that on the one hand, the 'price of fairness' under such policies is limited, while on the other hand, regret optimal policies are arbitrarily unfair under generic conditions. We complement our theoretical results with a case study on warfarin dosing where we are concerned with the cost of exploration across multiple races and age groups.

3 - Affinely Representable Lattices, Stable Matchings, and Choice Functions
Xuan Zhang, Columbia University, New York, NY, 10025-7952, United States

We introduce a property of distributive lattices, affine representability, and show its role in efficiently solving linear optimization problems over lattice elements, as well as describing the convex hull of the lattice elements. We apply this concept to the stable matching model with substitutable and quota-filling choice functions, thus giving efficient algorithms and a compact polyhedral description for this model. This model generalizes all models for which similar results were known. Our paper is the first that proposes efficient algorithms for stable matchings with choice functions

Sunday, 12:30PM - 1:30PM

■ Poster

Poster Hall

Poster Session

Poster Session

1 - Optimal Switching In A Dyanmic, Stochastic, And Operating Envrionment
Byunghee Choi, Lebanon Valley College, Annville, PA, United States

The value of flexibility in operating hydroelectric power plants is apparent and it depends on outside factors that impact their performance. They often compete for water flow with downstream water demands, which result in asynchronous water uses. This paper considers the dynamic problem of optimal water allocation for hydroelectric generation. Our main contribution is to present a novel numerical solution to this problem, with the following considerations: (i) multiple stochastic processes with jump diffusion, (ii) a number of contingent decisions with reversibility, and (iii) characterization of risk and uncertainty with dynamic constraints.

2 - Integrated Optimization Of Berth Allocation In Sea-rail Intermodal Container Terminals Considering Train Loading Plan
Yan Sun, School of Transportation and Logistics, Southwest Jiaotong University, chengdu, China, Zuoan Hu, Yidong Wei

To improve the operation efficiency of sea-rail intermodal container terminals, the collaborative problem of key resources at the container terminals, including vessel, berth and train, is investigated. A multi-objective integer programming model is proposed for the integrated scheduling of berth allocation with time periodicity constraints of trains and vessels. The model also considers the capacity restriction, vessels' priorities and desired berth position, and sets the objectives of minimizing total dwelling time and berth deviations of all vessels. To solve it, the combination of ideal point method and adaptive genetic algorithm is developed, and numerical experiments are conducted.

3 - Research On Optimization Of Placing-in And Taking-out Wagons On Branch-shaped Sidings Considering Double Interests
Zhihang Yi, School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, China, Zuoan Hu, Yidong Wei

A reasonable plan for placing-in and taking-out wagons should consider both the railway and the consignor. To achieve the dual optimization of the interests of both parties, a multi-objective optimization model is proposed, in which the objective is to minimize the total cost and maximize the time satisfaction considering the constraints of the locomotive capacity, the plan of train arrival and departure and the order of placing-in and taking-out. NSGA-II is used to solve this model. The results show that this model can provide plans under different satisfaction level adapting to various situations which has more application value.

4 - Robust Optimization Of Multimodal Transportation Routes Considering Mixed Time Windows
Jia Cai, School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, China, Zuoan Hu, Yidong Wei

To solve the multimodal transportation route optimization problem with uncertain transportation time, considering the operation time window of intermediate nodes, fixed departure time of transport modes and receiving time window of terminals, a scenario-based robust optimization model of multimodal transportation route is established with the objective of minimizing the sum of transportation, transfer and storage costs. Then, a genetic algorithm is designed to solve the model to obtain a robust transportation scheme around Bohai Sea region. Finally, the relationships among the robustness of the solution, regret coefficient and time fluctuation range are discussed.

5 - Imitating Human Learning Process Of Driving With Explainable Deep Learning (DL) Models
Jiqian Dong, Purdue University, West Lafayette, IN, United States, Sikai Chen, Runjia Du, Yujie Li, Samuel Labi

This study is motivated by the need to enhance interpretability of DL model in autonomous driving, and therefore proposes an explainable DL-based framework to generate a textual description of the driving environment while making decisions from images. The framework imitates the learning process of human drivers by jointly modeling image and language while using language to induce the visual attention. The results demonstrate the proposed model successfully learns the useful features from the input image by exhibiting high performance in generating explainable reasons and driving decisions.

6 - Trends Over Time Of Digital Forensics Use In Federal Criminal Courts
Ryan Aponte, University of Florida, Gainesville, FL, United States, Christie Nelson, Fred Roberts, Dennis Egan

We examine criminal court case text data from Thomson Reuters Westlaw and use keyword searches to gain insight into the use of digital forensics in the federal criminal court system. We also search for trends over time in digital forensics applications. This enables a better understanding of the direction of the field, such as from analyzing personal computers to mobile devices and the internet of things. With this novel understanding, the Federal Law Enforcement Training Centers and the Department of Homeland Security will be able to provide more tailored training to law enforcement.

7 - Transformer Model For Vehicle Trajectory Prediction Of Congested And Heterogeneous Traffic
Yufei Xu, Georgia Institute of Technology, Atlanta, GA, United States, Yu Wang, Srinivas Peeta

Accurate vehicle trajectory prediction enables optimal and proactive motion planning for Connected and Autonomous Vehicles (CAVs). Various deep learning techniques have been applied to predict vehicle trajectories. However, robust methods for accurate vehicular trajectory prediction of congested urban areas with heterogeneous traffic agents are still lacking. We propose to adopt an emerging deep learning method, the Transformer model, for the trajectory prediction. Numerical studies illustrate the effectiveness of the proposed approach.

8 - Using Data Science To Prevent Human Trafficking
Christie Nelson, Rutgers University, Princeton, NJ, United States, John Betak

Data science methods of social media text (Twitter and other sources) were performed to understand the behaviors of human traffickers of minors. Specifically, for the purpose of preventing trafficking and aiding the victims of those trafficked through public transit in the US. Analysis of hashtags and terminology used through social media and other websites was done to understand where trafficking is taking place and any seasonality or trends that are taking place.

9 - A Sustainable Supply Chain Management Knowledge Graph Tool For Understanding Retail Demand Variations In Response To Climatic Shifts In Seasonal Trends.

Reginald Bryant, Research Scientist, IBM Research, Nairobi, Kenya, Smitkumar Marvaniya, Ranjini Bangalore

Enabling resiliency in supply chain networks against impacts of climatic variations is becoming a priority in many industries. At its core, our work is designed to serve as a bulwark against not only climatological events but also other disruptions for increased agility in sustainable supply chain management. Specifically, we focus on the consumer retail industry. We will present a novel knowledge-graph generation framework for systematic exploration of all possible what-if scenarios the could arise due to weather-related demand fluctuations brought on by climate change.

10 - 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.

11 - 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.

12 - Identifying Covid-19 Risk Factors In Inpatient Care

Yang Ren, Doctoral Student, University of South Carolina, Columbia, SC, United States, Dezhi Wu, Long He, Joseph Johnson

COVID-19 pandemic has strikingly challenged healthcare systems worldwide, however, our understanding to the COVID-19 disease is still limited. This study is based on 1005 inpatients' extensive and detailed daily COVID medical health records in a US hospital system. In this exploration study, we used KMeans, PCA, Random Forest, XGBoost, and SelectKBest to cluster patients into different groups, and predict the COVID-related risk factors. We found that the most important features are two vaccines given in recent history including influenza vaccine and pneumococcal vaccines. Future research will investigate inpatients' comorbidities to understand their relationships to the COVID.

13 - Applying Machine Learning Models In Mom-centric Prenatal Care

Edward Tsien, Doctoral Student, University of South Carolina, Columbia, SC, United States, Dezhi Wu, Ana Lopez-Defede

Infant mortality is a significant global health problem, mainly caused by poor birth outcomes such as low birth weight, premature gestation age, and congenital disabilities. With access to a large prenatal dataset from a U.S. hospital system, in this research-in-progress project, we used unsupervised machine learning methods including PCA and K-Means to explore our dataset. Next, we plan to use supervised learning and deep learning algorithms to predict baby birth outcomes.

14 - A Comparison Analysis On Users' Vaping-related Posting Patterns Between Twitter And Reddit

Dezhi Wu, Associate Professor, University of South Carolina, Columbia, SC, United States, Avineet Kumar Singh, Patricia Cavazos-Rehg, Erin Kasson, Ming Huang

The use of e-cigarettes and vaping products has drastically increased, especially among youth and young adults in recent years. Despite unknown negative health outcomes and non-FDA-approved vaping products, many users intend to use these products to quit combustible smoking. Based on social media data extracted during an outbreak of EVALI in the US, we aim to understand vaping-related user posting behaviors and their impacts. Distinctive user posting patterns were found between Twitter and Reddit on vaping-related keywords, sentiment, vaping products, and health outcomes. This study implies that Twitter can be used for public health surveillance and Reddit can be used to inform outreach.

15 - 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.

16 - 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.

17 - Alternative Capital Asset Pricing Model

Mian Arif Shams Adnan, Department of Mathematics and Statistics, Bowling Green State University, Bowling Green, OH, United States

The Alternative Capital Asset Pricing Model (ACAPM) describes the relationship between systematic risk and asymmetric return for assets. This model does give central return which is less influenced by the outlier or volatility of the assets like stock prices. Attempts have been made here to make the CAPM more dynamic or usable not only in general situations but also in the adverse situation.

18 - 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.

19 - A Recycling Network Bonus Strategy For Dockless Bike Sharing System

Jingran Liang, Tsinghua University, Beijing, China, Zhi-Hai Zhang

The rapid development of dockless bike-sharing system leaves plenty of bikes need recycling in urban cities. A spatial bonus strategy is introduced to motivate riders to contribute in recycling bikes. We apply a functionally robust approach to capture the relation uncertainty and propose a functionally robust programming model. To effectively solve the resulting model, we develop a modified cutting surface envelop algorithm. Meantime, we develop an error-decentralized approximation approach and propose an OA-based algorithm where the quality and feasibility of solutions obtained are guaranteed. Numerical experiments demonstrate the performance of proposed algorithms.

20 - Risk Pooling And Centralization For Resource Optimization During The Pandemic

Peeyush Mehta, Indian Institute of Management-Calcutta, Kolkata, India, R. K. Amit

We model the resource allocation problem during the on-going COVID-19 pandemic as a multi-stage problem. Exploiting the classical risk pooling benefits, centralized resources are determined. Next, the decentralized allocation is optimized for maximizing the service levels. We examine the impact of demand correlation and other influencing factors on the resource requirements. We also analyze the impact of rolling horizon implementation on the resource allocation. Managerial insights are provided to serve as an input for policy makers.

21 - Branch-and-price-and-cut Approach To The Robust Recycling Network Design In Bike-sharing

Sen Huang, Tsinghua University, Beijing, China

Dockless bike-sharing systems grow rapidly in China and the resulting problem of recycling broken bicycles has become serious. This paper studies a robust recycling network design problem which integrates the location selection and the routing problem with uncertain recycling demand. A two-stage robust model is presented and reformulated into a single-stage vehicle-routing problem. We develop a branch-and-price-and-cut approach to solve the model. Numerical experiments and case study are conducted to evaluate the proposed algorithm and the performance of the robust recycling network. Finally, we make conclusions and present some work that can be further explored in the future.

22 - Reducing Traffic Congestion On San Francisco Bay Area Bridges And Highways

Ramesh Bollapragada, Professor & Director of Research, San Francisco State University, San Francisco, CA, United States

In this work, we show how advanced forecasting models such as TBATS (Trigonometric, Box-Cox transform, ARMA errors, Trend, and Seasonal components) helped reduce the Traffic Congestion on San Francisco Bay area Bridges and Highways. The data analysis is based on the real data of traffic by day, hour collected for a period of over 15 years from Caltrans and MTC. In addition to reduction of traffic congestion, productivity improvements to the order of hundreds of millions of dollars in the SF Bay area are achieved.

23 - 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.

24 - Beverage SKU Volume Forecasting Considering Structural Granularity

Shiyang Huang, Anheuser-Busch LLC, New York, NY, United States

In practices of revenue management teams of brewer companies, the business decisions are usually made on different granular levels, hence sales volume forecasting should be made on all corresponding levels to meet the business requirements. It is observed that direct forecasting of SKUs' volume could be biased but SKU market share is more likely to be modeled properly. Therefore, the sales volume of single SKUs is not necessarily to be forecasted directly but calculated with forecasted market share combining with aggregate volume forecasting on higher levels. Following this idea, a minimum variable product is developed and the forecasting accuracy is comparable with existing forecasting tools.

25 - 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.

26 - 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.

27 - Research On Optimization Of Placing-in And Taking-out Wagons On Branch-shaped Siding Considering Time Satisfaction

Zhihang Yi, School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, China

A reasonable plan for placing-in and taking-out wagons should consider both the railway and the consignor. To achieve the dual optimization of the interests of both parties, a multi-objective optimization model is proposed, in which the objective is to minimize the total cost and maximize the time satisfaction considering the constraints of the locomotive capacity, the plan of train arrival and departure and the order of placing-in and taking-out. NSGA-II is used to solve this model. The results show that this model can provide plans under different satisfaction level adapting to various situations which has more application value.

28 - Impact Of Blockchain On Supply Chain

Snehamay Banerjee, Professor, Rutgers University, Camden, NJ, United States, Kuanchin Chen, Damodar Y. Golhar

We undertake a review of 161 refereed journal articles to identify the topics covered and the challenges faced by modern supply chain and how blockchain can mitigate some of these challenges. While topics like transparency/traceability, and tracking are most widely discussed individually, correlation between these and other topics like scalability and, latency are not researched in detail. Using machine learning algorithm, we examine cooccurrence among trends in topical coverage for blockchain use in supply chain management and show why it is important to examine these topics together. We also discuss future research directions for blockchain in supply chain management.

29 - 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.

30 - Assessing TV Advertising Effectiveness Using Web Browsing Data

Leen De Schaepdrijver, Doctoral Researcher, Vlerick Business School, Ghent, Belgium

The current study explores how TV advertising exposure influences online web visits, providing a way to empirically measure the effect of TV ads. We use a unique dataset from 1885 customers of a European telecommunications company consisting of TV viewing data enriched with ad characteristics, spanning over 100 TV commercials, and combine this with web browsing data on an individual level. Using a generalized linear mixed model, we investigate the effect of media placement and ad creative characteristics on web visits. This approach allows to measure the effect of TV ads on an individual level rather than aggregated per (pre/post) time window, as is the current approach in academic literature.

31 - 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.

32 - Effect Of Covid-19 On Traffic Crashes: A Comparative Analysis

Tianjian Li, Lamar University, Beaumont, TX, United States, Jesus Torres, Yueqing Li

Reports from the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) show that there were more crash fatalities during the COVID-19 pandemic in 2020 than before (around a 7.2% increase as compared to 2019), although people drove less. This study aims to compare the patterns of traffic crashes between the pandemic (2020) and 2019. Data mining methods were used to identify the patterns of traffic crashes by exploring the publicly accessible data. The results showed that the pandemic has changed some drivers' driving behavior. The research shall help people to drive more safely in the pandemic or similar situations.

33 - Purchasing's Contribution To Supply Chain Emission Reduction

Julius Eggert, EBS Business School, Oestrich-Winkel, Germany, Julia Hartmann

Does environmental purchasing and supplier management (EPSM) help to reduce greenhouse gas (GHG) emissions in the supply chain and, thereby, mitigate climate change? And, if so, under which conditions? Taking these two questions as a starting point, we collect longitudinal data from 260 companies and analyze them using hybrid panel data analysis. We find that the increase of EPSM leads to a significant reduction of the GHG emission intensity of buying firms' supply chains and that this reduction is stronger for companies operating in industries where emission management is more material.

34 - 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.

35 - 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.

36 - The Application Of Operations Research For Acute Ischemic Stroke Treatment Processes: A Review Of Recent Developments

Gizem Koca, Dalhousie University, Halifax, NS, Canada, Noreen Kamal

Stroke is a devastating disease, as the leading cause of severe disability. However, there are two treatments for ischemic stroke: thrombolysis and endovascular thrombectomy. These treatments are highly time-dependent and synergistic to be given to the patients together or alone, depending on their contraindications. This study reviews the existing operations research methodologies for the acute stroke process and analyzes the existing studies. This study aims to illustrate the possible ways that simulation models can contribute to the optimization of the acute stroke treatment process.

37 - 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.

38 - 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.

39 - 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).

40 - 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.

41 - Portfolio Rebalancing With Illiquid Assets: An Impulsive Control Problem

Lynesia R. Taylor, North Carolina State University, Raleigh, NC, United States

Consider a portfolio consisting of liquid and illiquid assets. The investor's liquid and illiquid wealth are modeled as stochastic differential equations (SDE). We consider a control problem governed by these SDEs. We will model the transferring between liquid and illiquid as an impulsive control problem. Numerical examples are given to validate the correctness for our results.

42 - 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.

43 - An Epidemiological Compartment Model Capturing Covid-19 Dynamics In Classrooms

Sam L. Dekhterman, University of Illinois Urbana-Champaign, Urbana, IL, United States, Carolyn Beck

We consider epidemic processes, with a focus on capturing the dynamic evolution of COVID-19 amongst students. Namely, we model students traveling to and from a classroom building, entering and attending one-hour lectures. We use an epidemiological compartment model incorporating susceptible, asymptomatic-infected, infected-symptomatic, and recovered subsets of the population, and discuss effects of varying model parameter values on disease transmissibility. Our model structure aims to balance identifiability from data, and fidelity to scientific knowledge of the virus dynamics. Student trajectories are modeled using differing sources, routes and destinations.

44 - Detection Of Non-technical Losses In Electrical Power Distribution Systems Using Statistical Techniques And Artificial Intelligence

Gladys Maquera, Universidad Peruana Unión, Juliaca, Peru, Blanca R. M. Sosa

Electric power distribution systems stop billing annually for non-technical losses, caused by fraud, meters, internal procedures, & others. The objective is to detect points and moments where these losses will occur. A methodology is proposed to identify possible points of energy theft, using the differences in consumers energy consumption. The results are presented with real data and statistical techniques such as correlation, factor analysis, main components, & time series are used. Results show that the analysis of the differences in energy consumption allows detecting non-technical losses.

45 - A Framework For Predicting Rebounds In Financial Markets Based On Visibility Graph And Stock Temporal Network

Yuxuan Xiu, Tsinghua University, Shenzhen, China, Wai Kin (Victor) Chan

This research proposes a framework that forecasts the rebounds in the financial market. We first transform the logarithmic price time series of the stock index to a Visibility Graph (VG), and detect the faster-than-exponential decline of the stock index price based on the degree of the nodes. Meanwhile, a prediction-guided method is proposed to detect and quantify the abnormal changes of the time-evolving stock correlation network. Finally, we propose a hybrid metirc to predict the financial rebounds, which is a combination of the VG and the anomaly of the stock temporal network. Experimental results on New York Stock Exchange dataset demonstrate the validity of our proposed approach.

46 - 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 FCFS 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.

47 - Superstructure Optimization As A Systems Approach To Identify Optimized Pathways For Lignin Valorization

Yajie Wu, Penn State University, State College, PA, United States, Camila Gonzalez Arango, Stephen Chmely, Juliana Vasco-Correa

Lignin, the second most abundant polymer, is found in most plant cells in a range of 15 to 40% dry weight of the total lignocellulosic biomass constituting a polymer with promising industrial value. Due to its inherent recalcitrance and heterogeneity, transforming lignin into value-added products is expensive and inefficient. Therefore, we constructed a superstructure of the lignin valorization processes and the deterministic economic optimization (MINLP) problem for the superstructure. The optimal solution is also analyzed under uncertainty domain, which provides insights and suggestions on the selection of the value-added products.

48 - Order Picking With Collaborative Robots And In-store Customers In Retail Stores

Joyjit Bhowmick, Rensselaer Polytechnic Institute, Troy, NY, United States, Jennifer A. Pazour, Iman Dayarian

We propose new order picking policies to synchronize collaborative robots (cobots) with stochastically arriving in-store customers and dedicated pickers to fulfill online orders from retail stores. While emerging research has considered cobots in warehouses, where both cobots and pickers are controllable, we capture the uncertain arrivals and behaviors of in-store customers. A stochastic integer program is formulated to govern item allocation and routing decisions for cobots and dedicated pickers. Experiments show the potential to cost-effectively meet high demands for curbside pickup and home delivery services.

49 - Impact Of Connected Autonomous Vehicle Technology On Market Penetration And Routing Behavior

Tingting Xie, National University of Singapore, Singapore, Singapore, Yang Liu

Before a massive deployment of fully automated connected and autonomous vehicles (CAVs) can be witnessed, CAVs with different automation levels and human-driven vehicles (HVs) will coexist on road networks for a long time.

50 - Optimal Routing Policy For A Mixed Traffic Flow Of Connected Vehicles And Regular Vehicles With En-route Information

Zhenyu Yang, National University of Singapore, Singapore, Singapore, Yang Liu

Travelers often acquire en-route traffic information and update their routes. We examine travelers' information acquisition and routing behavior in a mixed traffic flow of connected vehicles and regular vehicles with uncertainties. Travelers' decisions are characterized as a mixed-flow user equilibrium with recourse and formulated as a policy-based variational inequality problem. To solve the problem efficiently, we derive an equivalent convex optimization program and solve it by a tailored bi-conjugate Frank-Wolfe algorithm. Experiments show that information may not always reduce congestion, while improving RVs' information technology can help achieve system optimum with mild tolls.

51 - Impact Of Emission Standard On Inventory Management

Mamta Sahare, Indian Institute of Management Indore, Indore, India

India's emission standard has proposed single-phase adoption of Bharat stage BS-VI in 2016. This meant less time for reforming the automotive supply chain which can impact their inventory levels. This study uses institutional theory to build the research model and investigate the impact of emission standards on inventory levels. This study uses event study methodology on the firm-level data. Data is collected from automotive dealers and manufacturers before and after the announcement on BS-VI. This study helps the policymakers and automotive supply chain entities in implementing emission norms to reduce the detrimental impact on automotive supply chain performance.

52 - 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.

53 - 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.

54 - 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.

55 - Contract Information Extraction Using Watson NLP And Human-in-the-loop

Amal Mehta, IBM, San Jose, CA, United States, Pawan Chowdhary, Shubhi Asthana, Juan Cappi, Taiga Nakamura

IT service providers sell high-valued service contracts to customers. Since the value of a contract can reach into millions of dollars, they need to be monitored continuously for spend leakage. Spend-leakage is a loss resulting from a mismatch in terms between contracts and invoices. Our work uses an NLP model to extract information from contracts as a step in spend-leakage triaging. The method utilizes a customer profile database, extraction tags, and template outline to accurately extract industry-specific information into in a template format. The extracted template information is checked using human-in-the-loop (HITL) and is then passed into a NLP model as training labels.

56 - 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.

57 - 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.

58 - State of the Art: Machine Learning Techniques in Cancer Prediction

Shilpa Balan, California State University-Los Angeles, Los Angeles, CA, United States, Ellen Keshishian

The early diagnosis of cancer has become an important need in cancer research to improve the accuracy of predicting cancer recurrence, mortality, and survival rates. A variety of machine learning techniques such as Artificial Neural Networks, Bayesian Networks, Support Vector Machines (SVM), and Decision Trees have been applied in predictive models for cancer research to improve the precision results. For example, for breast cancer diagnosis, the SVM machine learning method is popularly used to detect early signs of the tumor types. In this work, a literature review of the machine learning approaches applied in the prediction of cancer is illustrated.

59 - Exploring International Traveler's Destination Choice Through A Decision Tree Machine Learning Method

Guei-Hua Huang, National Pingtung University, Pingtung, Taiwan, Yung-Jan Chuo

Past studies have revealed several important factors influencing international travelers' destination choice. However, the findings are inconsistent and limited to understand the phenomenon. Drawing on socio-cultural perspective, this study aims to discuss whether national cultural difference affects international travelers' destination choice. This study investigates if Hofstede's six cultural dimensions identify international traveler's patterns. Global travel data obtained from United Nations World Travel Organization is analyzed by adopting a decision tree-machine-learning approach in order to group countries by their travel patterns through cultural dimensions.

60 - Contract Information Extraction Using Watson NLP And Human-in-the-loop

Amal Mehta, IBM, San Jose, CA, United States, Shubhi Asthana, Pawan Chowdhary, Juan Cappi, Taiga Nakamura

IT service providers sell high-valued service contracts to customers. Since the value of a contract can reach into millions of dollars, they need to be monitored continuously for spend leakage. Spend-leakage is a loss resulting from a mismatch in terms between contracts and invoices. Our work uses an NLP model to extract information from contracts as a step in spend-leakage triaging. The method utilizes a customer profile database, extraction tags, and template outline to accurately extract industry-specific information into in a template format. The extracted template information is checked using human-in-the-loop (HITL) and is then passed into a NLP model as training labels.

61 - 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.

62 - Last Mile Delivery Area, Based On Travel Time

HanByul Ryu, Inha Univ., Namgu, Korea, Republic of, Daisik Nam

The research purpose is to design an in-an-hour delivery network platform, which proposes a multi-level delivery system that consists of micro-fulfillment centers (MFCs) and micro-transport centers(MTCs). MFC distributes items to MTCs. MTC plays a role as last-mile delivery. The proposed method includes three sub-modules: 1) optimization of the allocation of MTCs and MFC in an urban area, 2) computation of delivery region by considering either travel time or euclidian distance, 3) recommendation of the best travel mode by considering road facility and its travel restriction.

63 - Flight From Covid-19: Multiscale And Multilayer Analyses Of The Novel Cascade Type

Alla Kammerdiner, NRC, Fort Walton Beach, FL, United States, Alexander Semenov, Eduardo L. Pasiliao

In interconnected networks, disruptions in an upstream network can amplify and cause cascading effects. This paper identifies a new type of cascade between the epidemic network and the flight network. Using a novel dataset, we examine the interaction between the two networks and quantify the strength of the flight network's response to the epidemic network activation. We study the contemporaneous changes in the two networks during the early stages of viral spread on the epidemic network and find evidence in support of cascade dynamics. In a multilayer network structure represented by airlines, we find that the cascade changes the multilayer structure, and some layers are more resilient than others.

64 - 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.

65 - An Efficient Shortest Path Based Routing Heuristic for Drone-assisted Delivery Problems

Abhishake Kundu, Texas Tech University, Lubbock, TX, United States, Timothy I. Matis

Drone-assisted delivery problems typically comprise drones and trucks that synchronize and are able to deliver packages in the context of last-mile logistics. The objective is to minimize the time for the completion of all deliveries. Due to its NP-Hard nature, such problems cannot be solved to optimality beyond 20 node instances in a reasonable amount of time. We present a novel Shortest Path-based order-split heuristic that can solve certain classes of drone-assisted delivery problems for larger instances (200 nodes) and performs better than the best-known heuristics in literature.

66 - Increasing Volunteer Retention in Non-Profit Organizations Through Optimization of Volunteer to Task Assignments

Milan Preet Kaur, Rensselaer Polytechnic Institute, Waterloo, ON, N2V2J8, Canada

In nonprofit organizations, service capacity relies on volunteers. Due to limited resources and high volunteer turnover rates, nonprofits need an ideal way to utilize volunteers. Our research focuses on creating a multi-period integer linear program that optimally assigns volunteers and employees to tasks for a nonprofit's planning horizon. Our model captures the impact of volunteer-task assignments on the nonprofit's performance and future volunteer retention by accounting for task preferences of volunteers and the organization. We simulate a food bank case study that portrays different scenarios in the nonprofit and captures the uncertainty in volunteer arrival and retention patterns.

67 - Hybrid Artificial Immune Algorithm For Optimizing A Van-robot E-grocery Delivery System

Dan Liu, Florida Atlantic University, Boca Raton, FL, United States

Driverless delivery robots (DDRs) are becoming a new attractive option for instant delivery. However, meeting the instant requirements necessarily increases the need for more DDRs, thus increasing the economic and ecological costs. To optimize the economic costs, environmental effects, and customer satisfaction of the delivery network simultaneously, the goals of this study is to formulate a multi-objective multi-depot two-tier location routing problem with parcel transshipment (MOMD-2T-LRP-PT) for a van-robot system and develop a "k-prototype cluster" and an artificial immune algorithm (HAIA) to solve it. We tested HAIA with NSGA-II using different data sets including a real case test.

■ Poster Competition

virtual poster hall

Virtual 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 - Reinforcement Learning With Distance-based Incentive/penalty (dip) Updates For Highly Constrained Industrial Systems

Hyungjun Park, Pohang University of Science and Technology, Pohang, Korea, Republic of, Daiki Min, Jong-Hyun Ryu, Dong Gu Choi

Reinforcement learning (RL) methods have limited applicability to industrial systems because of various system constraints. To overcome this challenge, this study devise a novel technique to enable the optimization of a policy under the systems. By employing a value-based RL, the proposed method is not suffer from searching a constrained policy. This study devise two distance-based update schemes, incentive and penalty updates, which can optimize constrained policy. In the penalty scheme, a shadow price-weighted penalty cost achieve efficient, constrained policy learning. This study applies the proposed method to the microgrid control, and the numerical study verifies its superiority.

3 - A Blockchain-enabled Approach For Cyber-physical Security In Advanced Manufacturing

Zhangyue Shi, Oklahoma State University, Stillwater, OK, United States, Chenang Liu

The cyber-enabled environment may pose the manufacturing system under high risk of cyber-physical attacks. Specifically, attacks could occur in design phase, in-situ phase, or post manufacturing to maliciously tamper G-code or sensor data. In addition, the cyber-attacks may also illegally access the G-code or collected data without authorization. Therefore, it is critical to develop an effective approach to protect manufacturing system from these attacks. In this study, a blockchain-enabled approach, which also integrates asymmetry encryption and camouflage technique, is proposed to protect the cyber-enabled manufacturing system against these two types of attacks.

4 - 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.

5 - Impact Of Connected Autonomous Vehicle Technology On Market Penetration And Routing Behavior

Tingting Xie, National University of Singapore, Singapore, Singapore, Yang Liu

Connected and autonomous vehicles (CAVs) and human-driven vehicles will coexist on roads. We develop a combined nested logit-multinomial logit model to investigate the impact of CAV on vehicle market penetration and travelers' behavior. The problem is formulated as a variational inequality (VI). We examine the existence and uniqueness of the VI solution and provide sufficient and necessary conditions of the equilibrium. A path-based modified self-regulated averaging algorithm embedded with the column generation is developed to solve our problem. Numerical experiments demonstrate algorithm effectiveness and show the travel time saving from CAV technology is more pronounced for long trips.

6 - Optimal Routing Policy For A Mixed Traffic Flow Of Connected Vehicles And Regular Vehicles With En-route Information

Zhenyu Yang, National University of Singapore, Singapore, Singapore, Yang Liu

Travelers often acquire en-route traffic information and update their routes. We examine travelers' information acquisition and routing behavior in a mixed traffic flow of connected vehicles and regular vehicles with uncertainties. Travelers' decisions are characterized as a mixed-flow user equilibrium with recourse and formulated as a policy-based variational inequality problem. To solve the problem efficiently, we derive an equivalent convex optimization program and solve it by a tailored bi-conjugate Frank-Wolfe algorithm. Experiments show that information may not always reduce congestion, while improving RVs' information technology can help achieve system optimum with mild tolls.

7 - Viewpoint-invariant Concurrent Exercise Repetition Counting

Yu Cheng HSU, City University of Hong Kong, Kowloon, Hong Kong, Qingpeng Zhang, Efstratios Tsougenis, Kwokleung Tsui

Counting the repetition of exercise and physical rehabilitation is a common task in rehabilitation and exercise training. The existing methods less emphasize the concurrent motions in the same video. We present a novel method for counting view-angle and motion agnostic concurrent motion through skeleton data from the vision-based pose estimation method. The overall mean absolute error (MAE) for mm-fit was 0.06 with off-by-one Accuracy (OBOA) 0.94. MAE for University of Idaho Physical Rehabilitation Movements Dataset (UI-PRMD) dataset was 0.06 with OBOA 0.95. We have also tested in a variety of camera locations and concurrent motions with MAE 0.06 and OBOA 0.88.

8 - 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.

9 - A Python API For Accessing Forest Inventory And Analysis Database In Parallel

Ashkan Mirzaee, University of Missouri, Columbia, MO, United StatesThe Forest Inventory and Analysis (FIA) Program of the US 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.

10 - Spatial Pricing Of Ride-sourcing Services In A Congested Transportation Network

Zhaomiao Guo, University of Central Florida, Orlando, FL, United States, Fatima Afifah

We investigate the impacts of spatial pricing on ride-sourcing services in a Stackelberg framework considering traffic congestion. In the lower level, we use combined distribution and assignment approaches to explicitly capture the interactions between drivers' relocation, riders' mode choice, and all travelers' routing decisions. In the upper level, a transportation network company (TNC) determines spatial prices to minimize imbalance in a two-sided market. We show the existence of the optimal pricing strategies for locational imbalance minimization, and propose effective algorithms with reliable convergence properties.

11 - Multi-Branching Temporal Convolutional Network For Sepsis Prediction

Zekai Wang, Oklahoma State University, Stillwater, OK, United States, Bing Yao

Sepsis is among the leading causes of morbidity and mortality in modern intensive care units. Accurate sepsis prediction is of critical importance to save lives and reduce medical costs. However, real-world medical data are often complexly structured with a high level of uncertainty (e.g., missing values, imbalanced data). In this paper, we propose a novel predictive framework with Multi-Branching Temporal Convolutional Network (MB-TCN) for robust prediction of sepsis. The MB-TCN framework efficiently handles the missing value and imbalanced data issues. Experimental results show that MB-TCN outperforms existing deep learning methods.

12 - A Generative Adversarial Network-based Ensemble Characteristic-to-expression Synthesis Approach And Its Applications In Healthcare Analytics

Yuxuan Li, Oklahoma State University, Stillwater, OK, United States, Chenang Liu

This study is to develop a characteristic-to-expression synthesis approach for healthcare analytics. However, existing methods are hard to handle the mapping from low dimension characteristics to high dimension expressions considering the uncertainty and randomness. Thus, this work proposed a novel characteristic-to-expression synthesis approach, and its novelty lies in considering inherent randomness by GAN-based architecture, correcting the iteration by mismatching, and improving the model robustness by ensemble learning. A numerical simulation study and a real-world healthcare case study were conducted to validate the performance and potential of the proposed method.

13 - 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.

14 - 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.

15 - Holistic Ai For Wildlife Analytics

Leonard Boussioux, MIT, Cambridge, MA, United States, Charles A. Kantor

While worldwide ecosystems face a mass extinction of species, demographic data related to shifts in species diversity and abundance has substantial taxonomic, spatial, and temporal biases and gaps. Available methods to study and monitor species and their population trends are often antiquated and inefficient. There is a need for efficient, rigorous, and reliable methods to study and monitor wildlife. We introduce a systematic and holistic framework to build efficient AI tools adapted to wildlife data, challenges, and needs. We illustrate our methodologies with real-world datasets provided by several museums and crowdsourcing platforms and show the impact of our state-of-the-art tools.

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

In 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.

17 - A Stochastic Programming Approach For An Enhanced Performance Of A Parallel Multi-committees Byzantine Fault Tolerant Algorithm
Tiejun Ma, The University of Edinburgh, Edinburgh, United Kingdom, Yifei Xie, Btissam Er-Rahmadi, Xiao Chen, Jane Hillston

Performance and scalability challenges of Byzantine fault-tolerant (BFT) algorithms can be addressed by parallelizing the consensus execution via multiple committees. We propose a Stochastic Programming (SP) model to optimally parallelize a previously designed BFT algorithm via optimal committees' number and the peers' allocation. The SP model maximizes the transaction throughput while embedding both random peer-to-peer delays and their failures. Tests run in Microsoft Azure Cloud shows 18%-improved throughput. We develop a sample average approximation technique and a heuristic algorithm which improves the scalability by at least 900% with no more than 4.72% throughput degradation.

18 - Last Mile Delivery Area, Based On Travel Time
HanByul Ryu, Inha University, Incheon, Korea, Republic of, Daisik Nam, MinYoung Park

The research purpose is to design an in-an-hour delivery network platform, which proposes a multi-level delivery system that consists of micro-fulfillment centers (MFCs) and micro-transport centers(MTCs). MFC distributes items to MTCs. MTC plays a role as last-mile delivery. The proposed method includes three sub-modules: 1) optimization of the allocation of MTCs and MFC in an urban area, 2) computation of delivery region by considering either travel time or euclidian distance, 3) recommendation of the best travel mode by considering road facility and its travel restriction.

19 - Platform Governance Responding To Changing User Attributes: The Case Of Incumbent And Entrant Blog Platforms
Takahiro Inada, Doctoral Candidate, Kyoto University, Kyoto, Japan, Nobuyuki Inamizu

This study attempts to explain the mechanism by which entrants win the competition against incumbents in peer-to-peer transaction platforms through differences in governance practices (especially participation constraints). We conducted a case study of an incumbent and entrant blog platforms in Japan, followed by an agent-based simulation (ABS) based on it. This study revealed it is effective to enter the market at the right timing and with the proper governance that fits the environmental changes. Thus, this study clarified the conditions for successful entry. We also revealed why an incumbent platform did not change its governance even though it was aware of the changing environment.

20 - Quantifying The Impact Of Ecosystem Services For Landscape Management Under Wildfire Hazard
Marie Pelagie Elimbi Moudio, University of California, Berkeley, Berkeley, CA, United States, 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.

21 - Exploring International Traveler's Destination Choice Through Machine Learning
Guei-Hua Huang, National Pingtung University, Pingtung, Taiwan, Yung-Jan Chuo

Past studies have revealed several important factors influencing international travelers' destination choice. However, the findings are inconsistent and limited to understand the phenomenon. Drawing on socio-cultural perspective, this study aims to discuss whether national cultural difference affects international travelers' destination choice. This study investigates if Hofstede's six cultural dimensions identify international traveler's patterns. Global travel data obtained from United Nations World Travel Organization is analyzed by adopting a decision tree-machine-learning approach in order to group countries by their travel patterns through cultural dimensions.

22 - 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.

23 - Optimal Pricing Of Information
Shuze Liu, University of Virginia, Charlottesville, VA, United States, Weiran Shen, Haifeng Xu

A decision-maker looks to take an active action (e.g., purchase) or a passive action. The payoff of the active action depends on the private type and a state of nature that is only known to the seller.

We fully characterize the optimal pricing mechanism for the seller in closed-form. We show a threshold mechanism that reveals the realized state is above some threshold or not is optimal. The payment and the threshold are generally different from different buyer types and are carefully tailored to accommodate the different amount of risks each buyer type can take. The proof of our results proposes novel concepts, such as the mixture of upper/lower virtual values which may be of independent interest.

Sunday, 1:30PM - 2:30PM

■ 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.

■ 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.

■ 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, Cambridge, MA, United States

3 - A Stochastic Integer Programming Approach to Air Traffic Scheduling and Operations

Alexandre Jacquillat, MIT 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, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Pengyi Shi, Purdue University, 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, TX, United States

2 - Panelist

Shane Henderson, 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, 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, DC, 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, Yale 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.

■ VSD02

Virtual Room 02

Machine Learning in Finance

Sponsored: Data Mining

Sponsored Session

Chair: Guanhao Feng, City University of Hong Kong, Kowloon, Hong Kong

1 - Manager Uncertainty And The Cross-section Of Stock Returns

Tengfei Zhang, Louisiana State University, Baton Rouge, LA, United States

This paper evidences the explanatory power of managers' uncertainty for cross-sectional stock returns. I introduce a novel measure of the degree of managers' uncertain beliefs about future states: manager uncertainty (MU), defined as the count of the word "uncertainty" over the sum of the count of the word "uncertainty" and the count of the word "risk" in filings and conference calls. I find that manager's level of uncertainty reveals valuation information about real options and thereby has significantly negative explanatory power for cross-sectional stock returns. Moreover, a short-long portfolio sorted by manager uncertainty has a significantly positive premium and cannot be spanned by existing factor models. An application on COVID-19 uncertainty shows consistent results.

2 - Factor Pricing Using Interpretable And Arbitrage-free Trees

Xin He, City University in Hong Kong, Hong Kong, China

We propose a regression tree factor model (RTFM) that provides a unified framework to generate the stochastic discount factor for linear factor model. The regression tree offers an alternative top-down solution to security sorting for splitting the cross-section of stocks based on their firm characteristics. In particular, we design a multi-period tree model for the imbalanced panel data structure of individual stocks. The tree split criterion follows the non-arbitrage condition by fitting the SDF model with time-varying factor loadings. Additional applications include multiple SDFs through boosting regression trees, OOB variable importance through the random forest, and time-series splitting with macro predictors. Using U.S. equity data, we find RTFM outperforms Fama-French factor models for different pricing and prediction measures.

3 - Did Trading Bots Resurrect the CAPM?

Jinhua Wang, Cambridge University, Cambridge, United Kingdom

The surge in intra-day correlation of returns coincided with the advent of electronic, automated trading in U.S. markets. When firms are included in a major index, they enter the radar of high frequency arbitrageurs and algorithmic traders. These trading robots monitor security prices continuously, increase quoting activities significantly and cause individual stock's returns to align more closely with the market.

■ VSD03

Virtual Room 03

Machine Learning in Action

Sponsored: Data Mining

Sponsored Session

Chair: Sara Masoud, Wayne State University, Detroit, MI, 48201-1111, United States

1 - Classification of Proficiency Level for Grafting Operations using Motion Analysis in VR-based Simulation

Md Tariqul Islam, Systems & Industrial Engineering, The University of Arizona, Tucson, AZ, United States

Machine learning has been a prominent method for evaluating individual's proficiency in different research domains. Hand motion data of grafting operations can provide cardinal information of worker's task specific (e.g., cutting, clipping, joining) and psychomotor skills. In this work, we propose a generalized assessment framework using the real-time motion data using data gloves and image data from videos to evaluate and classify the skill levels (e.g., intermediate, expert) during grafting operations of an individual utilizing a machine learning method. The proposed work can significantly reduce the training costs as well as provide users with access to high-fidelity training scenarios.

2 - A Generative Adversarial Network-based Decision-making Framework To Mimic Pedestrian Behaviors With Both Perceived And Objective Crowdedness

Yijie Chen, The University of Arizona, Tucson, AZ, United States

In this work, we propose a Generative Adversarial Network (GAN) based decision making framework to mimic and analyze pedestrian behaviors via both subjective and objective evaluations of individual perception towards crowding scenarios. For the generated set of potential decisions of pedestrians, the image-analysis-based classifier works as the discriminator to analyze the spatial complexity and human crowdedness. Under the proposed framework, a model is trained with both the real-world and simulated datasets. The real-world dataset improves the loss function with correct decisions, and the simulated dataset improves the loss function with alternative decisions that should not be rejected.

3 - 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.

4 - Prediction of ED Patient Disposition: Analysis by Treatment-Stage

SeungJin Wang, Wayne State University, Detroit, MI, United States, Ratna Babu Chinnam, Seth Krupp, Mike Nauss

There is growinginterest in leveraging Electronic Health Record (EHR) data for patient-floworchestration. This talk will explore the accuracy of ED patient dispositionprediction as a function of the treatment stage. Proposed machine learningmodels leverage evolving demographic, vital, lab test and clinical note datafor predictions. We will also discuss the performance of various pre-processingand feature extraction techniques. Results from Henry Ford Health System arequite promising.

5 - 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.

6 - Pm2.5Forecasting Utilizing Graph Convolutional And LSTM Neural Networks

Sara Masoud, Wayne State University, Detroit, 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.

■ VSD04

Virtual Room 04

Optimization for Statistical and Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Young Woong Park, Iowa State University, Ames, IA, 50011-2027, United States

1 - Efficient Sequential Experiment Design For Generalized Linear Models

Yongchun Li, Virginia Tech, Blacksburg, VA, 24060-6536, United States, Weijun Xie

This paper studies the D-optimal design of generalized linear models (GLMs) by selecting a fixed number of experiments to maximize the log-determinant of the Fisher information matrix (FIM). However, the FIM often involves the unknown regression parameters of GLMs, and experiments are often selected sequentially due to resource constraints. To address these issues, we propose a new sequential experimental design framework, where at each time period, we update the uncertainty set of regression parameters based on the existing experimental results and select a handful of new experiments. We develop an efficient solution algorithm and prove that the regret is upper bounded by O(T^(-1/2)). We further extend the proposed framework to sequential sampling selection of stochastic programming models and sequential parameter tuning of machine learning problems.

2 - 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.

3 - 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.

4 - Self-supervised Representation Learning For Off-policy Deep Reinforcement Learning

Young Jae Lee, Korea University, Seoul, Korea, Republic of, Jaehoon Kim, Youngjoon Park, Seoung Bum Kim

Deep reinforcement learning (DRL) has achieved great success in building intelligent agents in sequential decision-making problems such as games. However, training an agent is impractical and sample-inefficient because it requires a lot of trial and error and numerous samples. To improve the sample-efficiency, we propose a method that combines the off-policy DRL method with self-supervised contrastive learning. We define positive and negative samples depending on the continuity of time to perform contrastive learning. We also apply a new loss function to learn the spatiotemporal representation of the environment. We evaluate the performance of our method through Atari games.

■ VSD05

Virtual Room 05

Innovative Machine Learning Models for Biomedical Data Analysis and Clinical Decision Making

Sponsored: Data Mining

Sponsored Session

Chair: Dongping Du, Texas Tech University, Lubbock, TX, 79409-3061, United States

Co-Chair: Ying Lin, University of Houston, Houston, TX, 77204, United States

1 - Early ICU Mortality Prediction And Survival Analysis For Respiratory Failure

Yilin Yin, Northeastern University, Boston, MA, United States, Chun-An Chou

Respiratory failure is the one of major causes of death in critical care unit. During the outbreak of COVID-19, critical care units experienced a shortage of mechanical ventilation because of respiratory failure. To help this, the early mortality risk prediction in patients who suffer respiratory failure can provide timely support for clinical treatment and resource management. In the study, we propose a dynamic modeling approach for early mortality risk prediction of the respiratory failure patients based on the first 24 hours ICU physiological data. Our proposed model is validated on the eICU collaborate database. We achieved a high performance and significantly improved AUCPR 4% on Day 5 since ICU admission, compared to the state-of-art models. In addition, we illustrated that the survival curve includes the time-varying information for the early survival analysis.

2 - Neural Network-based Survival Analysis For Skin Cancer Prediction In Heart Transplant Recipients

Kuo-Chun Chiu, Texas Tech University, Lubbock, TX, United States, Dongping Du

Heart-transplant recipients are at high risk of developing skin cancer due to intense immunosuppression. Accurate prediction of skin cancer among heart transplant recipients will enable early cancer screening and benefit long-term health management. Standard survival models such as Cox proportional hazards model are commonly used in clinical practice to predict the probability of a patient developing skin cancer. However, these models cannot capture the complex correlations among various risk factors. This study investigated the performance and interpretability of several neural network-based survival models for the risk assessment of post-transplant skin cancer.

3 - Unsupervised Ensemble Learning Methods To Prioritize Causal Noncoding Variants For Human Diseases

Shiva Afshar, University of Houston, Houston, TX, United States

There is strong evidence that many psychiatric disorders are linked to genetic variants. But, due to the complexity of the human genome, few causal genes or variants have been identified. Ensemble learning models have been widely used in the literature to prioritize causal genes and variants for human diseases. But most of existing works were developed using supervised ensemble learning methods that entail gold-standard causal variants, while the number of recognized causal variants is small. In this study, we developed a deep learning-based unsupervised ensemble learning model to prioritize causal noncoding variants using functional genomic annotations and disease relevant gene regulatory networks from the human brain.

■ VSD06

Virtual Room 06

Operations and Economics of Emerging Transportation Technologies and Shared Mobility Services

Sponsored: Data Mining

Sponsored Session

Chair: Amirmahdi Tafreshian, University of Michigan, Ann Arbor, MI, 48109-2125, 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 - Simulation-based Data Upscaling For Microtransit Deployment Portfolio Planning

Joseph Y. J. Chow, New York University, Brooklyn, NY, 11201-3826, United States, Srushti Rath, Bingqing Liu, Gyugeun Yoon

Mobility operators interested in deploying their services across hundreds of cities lack detailed data on user behavioral responses to their deployment policies. A day-to-day network equilibrium method is introduced to determine "upscaled" performance data for sample city scenarios to support portfolio planning. Within-day simulations parameterize several policies (virtual stop access threshold, user-operator cost ratio, rebalancing locations) to allow calibration to data. Data from Via deployments in six cities in the U.S. are used to calibrate the market simulations from which over 150 scenarios are then generated.

3 - Team Competition In On-demand Service Platforms

Qi Luo, Assistant Professor, Clemson University, Clemson, SC, 29634, United States, Tingting Dong, Xiaotong Sun, Xiaotong Sun, Yafeng Yin

On-demand service platforms, such as ridesharing and food delivery, are emerging marketplaces that coordinate freelancing labor and rising demand. Stabilizing labor supply remains a bottleneck in operating these platforms, owing to freelancers' varying and weak elasticity. We propose an innovative team competition model that combines intrateam coordinations and interteam competitions to maximize system welfare. The optimal team competition scheme is a generalized Nash game as a bilevel optimization with participation constraints. We solve the problem by combining quasi-variational inequalities and a decomposition heuristic. The optimal team formation can smooth out the scheduling inconsistency and improve the overall supply-demand balance.

4 - 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, Ehsan Kamjoo

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.

■ VSD07

Virtual Room 07

Modeling Uncertainty in Data Analysis/Mining

Sponsored: Data Mining

Sponsored Session

Chair: Behnam Tavakkol, Stockton University, Secaucus, NJ, 07094, United States

1 - A Fuzzy Kernel K-medoids Algorithm For Clustering Uncertain Data

Behnam Tavakkol, Assistant Professor, Stockton University, Galloway, NJ, 07094, United States

Fuzzy methods have long been used for clustering traditional (certain) data objects. They are used to produce non-crisp cluster labels. For uncertain data, however, besides some uncertain fuzzy k-medoids algorithms, not many other fuzzy clustering methods have been developed. In this work, we develop a fuzzy kernel k-medoids algorithm for clustering uncertain data objects. The developed fuzzy kernel k-medoids algorithm is superior to existing fuzzy k-medoids algorithms in clustering data sets with non-linearly separable clusters.

2 - Safe Semi-Supervised Learning Using Bayesian Neural Networks

Minjung Lee, Korea University, Seoul, Korea, Republic of, Jinsoo Bae, Seoung Bum Kim

Most of the semi-supervised learning (SSL) methods have been developed under the ideal assumption that the class distributions of the labeled and unlabeled data would be matched. However, the unlabeled data often includes mismatch classes, which incurs a decrease in SSL performance. This study proposes a new SSL method using Bayesian neural networks (BNN) that operated safely even in realistic situations where the class distributions are mismatched. The proposed method utilizes the model uncertainty of BNN to filter unlabeled data and augment data for improving generalization performance. As a result of experiments using CIFAR10, the proposed method showed better performance than the previous SSL methods.

3 - Alternate Forecast: Mixture Models For Probabilistic Forecasting

Sumanta Mukherjee, Advisory Research Scientist, IBM Research, Bangalore, India, Siddhant Haldar, Surya Shravan Kumar, BhanuKiran Vinzamuri, Vikas Raykar

Prediction intervals represent the uncertainty associated with a forecast. This uncertainty can stem from data insufficiency or distributional bias. The state of art methods assumes unimodal distribution for efficient estimation of the prediction interval. This assumption often fails in a non-linear forecasting setup. In this work, we propose a model agnostic ensemble framework for efficient Gaussian Mixture Model-based representation of prediction interval capable of addressing this issue. Each mixture component represents an alternate forecast with associated uncertainty.

4 - Non-parametric Uncertainty Bias And Variance Estimation Via Nested-bootstrapping And Influence Functions

Kimia Vahdat, North Carolina State University, Raleigh, NC, United States, Sara Shashaani

In using limited datasets, modeling the uncertainty via nonparametric methods provides arguably more robust estimators of the unknown. We propose a novel nested bootstrap method that accounts for the uncertainty from various sources (input data, model, and estimation) more robustly. We utilize influence functions to estimate the bias due to input uncertainty and devise a procedure to correct the estimators' bias in a simulation optimization routine. Implementations in the context of feature selection via simulation optimization on a simulated dataset prove a significant improvement in robustness and accuracy.

■ VSD08

Virtual Room 08

Advances in Sentiment Analysis and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Hongwei Wang, Tongji University, Shanghai, 200092, China

1 - Prior Gains And Subsequent Trade Size: The Moderating Role Of News Announcements

He He, University of Southampton, Southampton, United Kingdom, Tiejun Ma, Ming-Chien Sung, Johnnie Johnson

We examine an dataset of 285,725 trades of 4,857 retail traders from 2004 to 2013, matched to a news archive of over 20 million news items. We find that individuals increase trade size following prior gains, but the magnitude of the increase depends on news sentiment - amplified/reduced by the news sentiment

that was consistent/inconsistent with the prior gain-generating decisions. The findings suggest that individual traders may respond differently to the same piece of news depending upon the relationship between the news sentiment and their prior gains (i.e. consistent or not), thus providing individual-level evidence for models based on heterogeneous beliefs of investors.

2 - 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.

3 - Informational Content Of CEO Tweets And Stock Market Predictability

Kang-Pyo Lee, University of Iowa, Iowa City, IA, United States, Suyong Song

This paper shows that CEO tweets contain informational content on the U.S. stock markets and provide investors with value-relevant information on predicting the stock movement. Using large-scale text data, we predict the movement in the major stock indexes. We create a large and unique sample of CEO users on Twitter and use hashtag indexes as predictive regressors. We find that hashtags in CEO tweets have predictive power on the stock return, trading volume, and volatility. In addition to the hashtag-based prediction, we propose CEO sentiment indexes to gauge tone in financial contexts of tweets. The sentiment-based prediction supports our hypothesis on the informational content of CEO tweets.

4 - Impact Of News On Cryptocurrency Values During The Covid-19 Pandemic

WenYi Lee, Shih Hsin University, Taipei, Taiwan, Paul Chiou

This paper studies the impact of market sentiments on values of cryptocurrencies by analyzing the related news. Our methodology is useful as the increasing systemic risk during the COVID-19 intensified ambiguity of asset values, particularly those of no pricing theory. Unlike stocks demonstrating asymmetric relationship between sentiments and returns, both positive and negative news affect the values of various cryptocurrencies.

5 - Sentiment Analysis On Stock Market: The Case Of Gme

Sheng-Lien Lee, National Chi Nan University, Nantou, Taiwan, Jing-Rung Yu, Paul Chiou, Hao-Feng Deng

Our research aims to examine how investor sentiments affect stock returns and trading volumes. We generate sentiment scores by using Stock Market Lexicon (SML) and considering emoji. The impact of opinions of investors expressed in an extensive dataset of tweets on Twitter on intraday stock returns and trading volume is analyzed by regression models.

■ VSD10

Virtual Room 10

Learning Theory in Health Care Applications

Sponsored: Health Applications Society

Sponsored Session

Chair: Amin Khademi, Clemson University, Clemson, SC, 29634, United States

1 - A Value Of Information Approach To Designing Sequential Clinical Trials For Precision Medicine

Andres Alban, INSEAD, Fontainebleau, 77300, France, Stephen E. Chick, Spyros Zoumpoulis

We formulate a model of a clinical trial in which predictive and prognostic patient characteristics are observed. Prognostic characteristics have an effect on patient outcomes but do not interact with treatments, while predictive characteristics do have treatment interaction. The goal of the trial is to determine the effectiveness of each treatment for any set of predictive characteristics. A trial observes patients arriving with random characteristics and sequentially determines the treatment assigned to each arriving patient. We develop an expected value of information policy that assigns patients to the treatment that maximizes the value of information gained.

2 - Learning When-to-Treat Policies

Xinkun Nie, Stanford University, Stanford, CA, 94305-7567, United States

Many applied decision-making problems have a dynamic component: The policymaker needs not only to choose whom to treat, but also when to start which treatment. For example, a medical doctor may choose between postponing treatment (watchful waiting) and prescribing one of several available treatments during the many visits from a patient. We develop an "advantage doubly robust" estimator for learning such dynamic treatment rules using observational data under the assumption of sequential ignorability. We prove welfare regret bounds that generalize results for doubly robust learning in the single-step setting, and show promising empirical performance in several different contexts. Our approach is practical for policy optimization, and does not need any structural (e.g., Markovian) assumptions.

3 - Combining Pre-approval Clinical Trials And Post-approval Spontaneous Adverse Event Reporting For Improved Safety Signaling

Yunliang Chen, University of California, Berkeley, Berkeley, CA, United States, Fernanda Bravo, John M. Silberholz

A classical question in pharmacovigilance is how to combine pre-approval RCTs and post-approval surveillance data to increase the power for side effect detection. A key step is to learn the degree to which the observational data is biased before one can combine it with unbiased clinical trial data. In this work, we propose a model that uses information about common toxicities to help de-bias the observational data on rare toxicities through the correlation of bias among different toxicities (e.g., correlation due to co-reported drugs, indications, and patient health). Using Bayesian statistics, we analyze the benefit of "cross"-debiasing and identify the situation where such benefit is largest. Numerical experiments using real data from the FDA Adverse Event Reporting System (FAERS) suggest significant values of using cross-debiasing to improve drug safety signaling.

4 - 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.

■ VSD11

Virtual Room 11

Applied Projects from the Center for Healthcare Engineering & Patient Safety at University of Michigan

Sponsored: Health Applications Society

Sponsored Session

Chair: Amy Cohn, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - Scheduling Family Medicine Residents to Shifts in Multiple Clinics Using Multi-criteria Optimization Methods

Marina A. Epelman, University of Michigan, Ann Arbor, MI, 48109-2117, United States, Matthew Howard, Allison Vanderstoep, Carolyn Wu, MohammadAli H. Jardaly, William Pozehl

The Family Medicine residency at the American University of Beirut Medical Center (AUMBC) is a 4-year program offering a variety of patient care training opportunities. Each year, a Chief Resident must create monthly clinical schedules for all the residents. The schedules must ensure clinics are adequately staffed while fairly distributing the workload. Previously, the Chief Resident hand-built these schedules, a time-consuming and error-prone process. We develop a linear programming-based tool to automate this process. The tool incentivizes fairness and schedule consistency to improve resident satisfaction and well-being. Finally, our tool is designed such that novices to mathematical optimization can easily use it effectively. The tool reduces the burden to the Chief Resident and improves the quality of the schedules.

2 - Simulating The Impact Of Including Predictive Modeling In Appointment Decision-making For Chronic Liver Disease

Adam VanDeusen, University of Michigan, Ann Arbor, MI, 48109-2117, United States, Amy Cohn, Sameer Saini, Grace Su

Chronic liver disease (CLD) is a potentially fatal disease, and it is difficult to detect because of its long asymptomatic phase. New predictive models use a technique called analytic morphomics to help diagnose CLD earlier and more accurately. We use discrete-event simulation to model how patients referred for CLD could be assigned to appointments based on the severity of patients' disease under various diagnostic models. We consider each model's predictive power and policies about collecting patient data used for model inputs. This work can help clinics assign CLD patients more accurately to an appointment type to align with patient needs as they determine how to best incorporate a predictive modeling tool into appointment decision-making.

3 - Multi-criteria Objective Functions In A Real-world Clinical Provider Scheduling Problem

Amy E. Cohn, University of Michigan, Ann Arbor, MI, 48109-2117, United States, William Pozehl, Daiwen Zhang

Personnel scheduling problems in healthcare (e.g. nurses, physicians, or residents) are often multi-criteria in nature, seeking to simultaneously address patient and clinical needs, provider well-being, and maybe other goals. In practice, these problems can often not be solved by using a hierarchical approach or a single weighted linear optimization function. We present our real-world experience in finding high-quality solutions to address these competing goals within a complex scheduling environment.

4 - A Two-stage Partial Fixing Approach For Solving The Residency Block Scheduling Problem

Junhong Guo, University of Michigan-IOE, Ann Arbor, MI, 48109-2117, United States, William Pozehl, Amy Cohn

We propose a two-stage solution framework to address the computational challenge of solving a large-scale medical resident block scheduling problem. The first stage focuses on the resident assignments for a subset of predetermined units through solving a smaller problem relaxation, where those units are selected by solving a network-based model. The second stage tries completing the rest of the schedule construction after partially fixing those assignments from the first stage, where cut generation mechanisms are developed to prune off the bad decisions if infeasibility arises. Experiments using real-world inputs from our clinical collaborator show that our approach can speed up the schedule construction at least 5 times for all instances and even over 100 times for some huge-size ones compared to conventional MIP techniques.

■ VSD12

Virtual Room 12

Care Coordination in Health Systems

Sponsored: Health Applications Society

Sponsored Session

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

1 - Nudging Patients Towards Cost-effective Providers: Analysis Of An Insurer's Effort- And Cash Reward-based Mechanisms

Mili Mehrotra, University Of Illinois Urbana Champaign, Champaign, IL, 61820-6915, United States, Fang Fang, Harihara Prasad Natarajan

Health insurance companies (HIC) have come to recognize that misalignments between patients' choices of providers and the HIC's cost-effective preferences can result in significant cost to the HIC. Such misalignments may occur either because enrollees are unaware of their options or because they do not have an incentive to choose the cost-effective provider. This work examines how an insurer can exert effort and offer cash rewards to nudge patients towards cost-effective providers.

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.

3 - A Queueing-theoretic Framework For Evaluating Transmission Risks In Service Facilities During A Pandemic

Kang Kang, University of Minnesota, Minneapolis, MN, 55455-0150, United States, Sherwin Doroudi, Mohammad Delasay, Alexander Wickeham

We propose a new modeling framework for evaluating the risk of disease transmission during a pandemic in small-scale settings driven by stochasticity in the arrival and service processes, i.e., congestion-prone confined-space service facilities, such as grocery stores. We propose a novel metric inspired by R0, the "basic reproduction number" concept from epidemiology, which measures the transmissibility of infectious diseases. We derive this metric for various models by leveraging a novel queueing-theoretic notion: sojourn time overlaps. We showcase how our metric can be used to explore the efficacy of a variety of interventions aimed at curbing the spread of COVID-19 inside service facilities. We discuss a variety of directions for adapting our transmission model to incorporate some more nuanced features of disease transmission.

4 - The Impact Of Competition On Vertical Integration In Healthcare

Kenan Arifoglu, University College London, London, WC1E 6BT, United Kingdom, Hang Ren, Tolga Tezcan

By developing a stylized analytical model, we study the vertical integration (care coordination) between a hospital (acute care provider) and a nursing facility (post-acute care provider). We show that the vertical integration always leads to higher care quality. However, under competition, we find that the vertical integration can make the hospital worse off and decrease overall social welfare. In doing so, we identify the impact of competition on vertical integration in healthcare and provide an alternative explanation why some hospitals do not provide post-acute care in house and delegate it to a nursing facility.

■ VSD13

Virtual Room 13

Optimal Large-Scale Policies in Emerging Healthcare Problems

Sponsored: Health Applications Society

Sponsored Session

Chair: Hadi El-Amine, George Mason University, Fairfax, VA, 22030, 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 - Large-scale Population Screening Under Operational Constraints

Hadi El-Amine, George Mason University, Fairfax, VA, 22030, United States, Marwan Shams Eddin, Hrayer Aprahamian

We consider a setting in which a decision-maker has partial information on the variation of system parameters over a finite time horizon. The decision-maker would like to determine optimal points in time to make a minimal number of decision adjustments due to operational constraints. We provide a novel mathematical framework that determines robust solutions. We then present refinements to significantly reduce computational time. Our case study on large-scale population screening demonstrates that the proposed framework can lead to significant reductions in costs and misclassification errors.

3 - 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.

4 - 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.

5 - Improving Rural Healthcare Access Using A Collaborative Network Between Hospitals

Amarnath Banerjee, Texas A&M University, College Station, TX, 77843-3131, United States, Hrayer Aprahamian, Sohom Chatterjee, Pouya Sharifi

There is a growing disparity in access to quality care in rural America due to the increasing rate of closure of rural and critical access hospitals. The factors influencing these closures are economic reasons and low utilization of expensive resources necessary to provide the services. A data-driven model exploring the creation of a network of hospitals that can share expensive resources and services to address the economic factors and increasing the utilization of resources is proposed here. The network will enable the hospitals to provide the most vital and popular set of services driven by patient needs. Strategies for keeping the care local for patients and incentivizing such networks by payers will be discussed. Publicly available data is used to showcase the findings, which will also reduce the burden on the hospitals to generate custom information from the data.

■ VSD14

Virtual Room 14

Best student Paper Award II

Sponsored: Revenue Management and Pricing

Sponsored Session

■ VSD15

Virtual Room 15

Innovative Business Models and Platforms

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Luyi Yang, University of California, Berkeley, Belmont, CA, 94002, United States

1 - The Important Role Of Time Limits When Consumers Choose Their Time In Service

Pnina Feldman, Boston University, Questrom School of Business, oston, 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.

3 - Operating Three-sided Marketplaces: Pricing, Spatial Staffing And Routing In Food Delivery Systems

Zhe Liu, Imperial College Business School, London, 10027-6945, United Kingdom, Junwei Huang

We study a food delivery platform's joint pricing, staffing and routing problem under endogenous participation of three sides: restaurants, customers and deliverers. Using a state-dependent queueing model where service rates depend on the imbalance of all three sides due to spatial frictions, we study the system's equilibrium behavior in heavy traffic and show through asymptotic analysis how platform controls balance capacity utilization and service quality. We show the platform's value is threefold: (i) increased market output as the platform boosts demand for restaurants and offers faster delivery for customers;
(ii) delivery resource pooling that saves the restaurants' logistic costs and increases deliverer utilization; (iii) efficient network routing that reduces cross-location pickups, hence customer waiting and deliverer idleness.

■ VSD16

Virtual Room 16

Ridesharing

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Peter Frazier, Cornell University, Ithaca, NY, 14853, United States

1 - Dynamic Pricing Provides Robust Equilibria for Stochastic Ridesharing Networks

J Massey Cashore, Cornell University, NY, United States

Algorithms designed for stochastic systems often use fluid limits, making them essentially deterministic. We propose a two-level hierarchical model, focusing on ridesharing networks, that retains the tractability fluid limits provide while being substantially more robust. We obtain prices by solving a stochastic program arising from a stochastic large-market limit. The dynamic nature of our mechanism is important: a static variant using top-level state dependent prices, without reacting to the realized distribution of drivers, is not subgame-perfect. A simple example shows the static mechanism can substantially underperform the dynamic one.

2 - Price Cycles In Ridesharing Platforms

Chenkai Yu, Columbia University, New York, NY, United States

In ridesharing markets such as Uber and Lyft, it is observed that drivers sometimes collaboratively manipulate the system, going offline when the price is low, and returning after the price has risen due to a seemingly lack of supply. This leads to cyclic fluctuations in prices and available drivers, resulting in poor reliability and social welfare. We study a continuous control model, prove that such online/offline strategies may form a Nash equilibrium among drivers, and propose methods that effectively mitigate driver gaming under certain market conditions.

3 - 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.

4 - Scalable Deep Reinforcement Learning For Ride-hailing

Jim Dai, Cornell University & CUHK-Shenzhen, Ithaca, NY, 14853, United States, Jiekun Feng, Mark Gluzman

We consider a Markov decision process (MDP) model of a ride-hailing service system, framing it as a reinforcement learning (RL) problem. The simultaneous control of many agents (cars) presents a challenge for the MDP optimization because the action space grows exponentially with the number of cars. We propose an "atomic-action" decomposition method for the MDP actions by sequentially assigning tasks to the drivers. This novel decomposition method resolves the scalability problem in matching cars with passengers. Numerical examples demonstrate the effectiveness of this decomposition together with the deep proximal policy optimization algorithm.

5 - Dynamic Spatial Matching

Yash Kanoria, Columbia Business School, 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).

■ VSD17

Virtual Room 17

Operations Management and Public Policy

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Maxime Cohen, McGill University, Montreal, QC, H3W 1X4, Canada

Co-Chair: Dmitry Mitrofanov, Boston College, New York, NY, 10012-1106, United States

1 - Incentivizing Group Testing In The Covid-19 Pandemic

Tong Wang, London Business School, London, United Kingdom, Kamalini Ramdas, Ali Aouad

We propose group testing with an incentive scheme to boost the efficiency and uptake of mass testing during the pandemic. Individuals are encouraged to form their own groups and participate in testing. Samples in the same group are pooled and tested in the first stage. If the result is negative, every individual in the group receives a reward based on the group size. Otherwise, individual tests are conducted in the second stage to detect infected individuals. Under this incentive scheme, individuals choose groupmates who have the same risk level. This assortative property allows the central planner to design an optimal reward scheme such that private risk levels are revealed via peer-selection during group formation. Furthermore, with the revealed risk levels, the central planner can implement group testing with heterogeneous group sizes, which saves more test capacity.

2 - 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.

■ VSD18

Virtual Room 18

Information Systems and Societal Impact

Sponsored: Information Systems

Sponsored Session

Chair: Shu He, University of Connecticut, Storrs, CT, 06269-9013, United States

1 - Cross-market Acquisition Of Giant Platforms

Zhou Zhou, City University of Hong Kong, Hong Kong, China, Marshall Van Alstyne

This research studies the impact of cross-market acquisitions of giant platforms on start-ups' entry into emerging markets. Our model shows that the acquisition reduces the post-acquisition entry but may increase the pre-acquisition entry. The net effect of the acquisition on the entry is positive when the pre-acquisition gain is greater than the post-acquisition loss. We then discuss three cases in which a giant platform strategically increases its market position in the acquisition. The net effect of the acquisition on start-ups' entry varies in different cases. Our findings indicate that regulators should analyze the specific situation of each acquisition before making a decision to approve an acquisition.

2 - Creation Or Destruction? Stem Opt Extension And Employment Of Information Technology Professionals

Xue Guo, The University of North Carolina at Charlotte, Charlotte, NC, United States, Jing Gong, Min-Seok Pang

The use of temporary work visas and related immigration policies has attracted a significant controversy and policy debates in the U.S. On the one hand, foreign IT professionals complement domestic IT professionals by facilitating innovation, entrepreneurship, and expanding local employment. On the other hand, the foreign professionals substitute the domestic counterparts by intensifying labor-market competition, reducing wage and number of local workers. This study examines the effects of an extension in the Optional Practical Training (OPT) program for graduates in science, technology, engineering, and mathematics (STEM) on the local labor markets. Our results demonstrate that an increase in the supply of foreign IT professionals as a result of the OPT extension boosts the employment of domestic IT professionals. Contributions and implications are discussed.

3 - The Impact Of Ridesharing On Patients' Healthcare Access

Ayush Sengupta, PhD Student, University of Connecticut, Storrs, CT, United States, Shu He, Miao Bai, Xinxin Li

This paper empirically examines how the entry of Uber, an online ridesharing platform, impacts patients' access to healthcare. We leverage the sequential entry of Uber in different locations in a natural experiment setting and use the staggered difference-in-differences (DID) econometric model to estimate this impact. Our dataset includes yearly observations of hospital-level Emergency Department (ED) visits in the United States. We examine the impact of Uber's entry on the pattern of ED visits and explore how this impact varies across visits at different urgency levels and at hospitals with different characteristics. Our findings have important managerial and policy implications and contribute to the growing stream of research on the social effects of sharing economy.

4 - The Impact Of Energy Information System On Energy Consumption Elasticity

Minhyung Lee, KAIST College of Business, Seoul, 2455, Korea, Republic of, Min-Seok Pang, HanByeol Stella Choi, Heeseok Lee

While prior literatur on Green IS proposes that energy information can help save energy consumption, we theorize that this is not necessarily the case. Drawing upon loss aversion theory from behavioral economics, we put forth that when electricity consumers face uncertainty in electricity usage and are subject to a punitive tariff system, they limit their electricity consumption to avoid utility bills beyond predetermined budgets. Real-time consumption information decreases such uncertainty for them, who in turn increase electricity usage. Our analyses of a large-scale dataset from South Korea validate our prediction. Specifically, we obtain a counterintuitive finding that residents with energy information systems (EIS) installed in apartment complexes increase their electricity consumption as temperature rises to a greater extent than others without EIS.

■ VSD19

Virtual Room 19

Recent advances in load balancing

Sponsored: Applied Probability Society

Sponsored 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, 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 - A New Queueing Identity With Applications To Multiserver Scheduling
Ziv Scully, Carnegie Mellon University, Pittsburgh, PA, United States

We present a new queueing identity. The identity provides a way to bound mean response time and related metrics in multiserver systems using advanced scheduling policies, such as SRPT (shortest remaining processing time) and Gittins. In its simplest form, the identity relates the number of jobs in a system to "r-work", the amount of work in the system due to jobs whose remaining service time is below r. This simple form yields a new bound on SRPT's mean response time in the M/G/k, improving upon the previous state of the art in some cases. We apply the general form of the identity to solve several other open problems. These include: bounding mean response time of Gittins in the M/G/k, bounding mean slowdown of RS (a variant of SRPT) in the M/G/k, and bounding mean slowdown in an immediate-dispatch model using RS at each server and a work-balancing dispatching policy.

33 - Stein's Method For Heavy-traffic Analysis With Applications In Load Balancing And Scheduling
Xingyu Zhou, Wayne State University, Detroit, MI, 43220, United States

In this work, we apply the framework of Stein's method (i.e., Braverman et al) to provide a sharp analysis of queueing systems in heavy traffic. The use of Stein's method enables us to utilize the bounds established by the drift method to directly characterize the stationary distribution in the heavy traffic limit. More importantly, it also provides the convergence rate characterization in terms of the Wasserstein distance. We illustrate the power and elegance of this new analysis through applications in both load balancing and Max-Weight scheduling.

4 - 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.

5 - Pass-and-Swap Queues
Céline Comte, Eindhoven University of Technology, Eindhoven, Netherlands, Jan-Pieter Dorsman

Order-independent (OI) queues, introduced by Berezner et al. in 1995, expanded the family of multi-class queues that are known to have a product-form stationary distribution by allowing for intricate class-dependent service rates. In this presentation, we introduce pass-and-swap (P&S) queues, an extension of OI queues where, upon a service completion, the customer that completes service is not necessarily the one that leaves the system. After defining P&S queues and proving that their stationary distribution indeed has a product form, we demonstrate that closed networks of P&S queues can be applied to describe the dynamics of new and existing load-balancing protocols in clusters of machines in which jobs have assignment constraints. These include the ALIS (assign to the longest idle server) and the first-come-first-served cancel-on-complete redundancy protocols.

■ VSD20

Virtual Room 20

Control of Queueing Systems and Applications

Sponsored: Applied Probability Society

Sponsored Session

Chair: Yuan Zhong, University of Chicago / Booth School of Business, Chicago, IL, 60637-1610, 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 - The Benefit Of Sequential Learning In Economic Optimization
Chihoon Lee, Stevens Institute of Technology, Hoboken, NJ, United States, Jeunghyun Kim, Dongyuan Zhan

In a sequential maximum likelihood estimation, one collects the data until the observed Fisher information reaches a specified precision level. One notable advantage of the sequential estimator is that its mean squared error does not depend on the parameter to be estimated. We show such a feature of the estimator (i.e., 'known' variance) contributes to reducing the optimality gap in a classical revenue maximization problem when customers valuation function has unknown parameters.

3 - 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.

4 - 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.

■ VSD23

Virtual Room 23

Data Analytics and Machine Learning for Pattern Recognition and Decision Making in Smart Health

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Bing Si, State University of New York at Binghamton, Binghamton, NY, 13905-1464, United States

Co-Chair: Chen Kan, University of Texas-Arlington, Euless, TX, 76039-6215, United States

1 - A Weakly Supervised Ordinal Learning Model In Health Care Applications
Lujia Wang, Georgia Institute of Technology, United States

Ordinal classification models are desired in many health care applications, e.g., classifying the severity levels of a disease based on clinical imaging. Precisely labeled samples can be scarce, making it difficult to train a reliable ordinal classifier. More samples exist with label ambiguity, i.e., their labels are not unique but from an interval of classes. We proposed a weakly supervised ordinal learning to integrate the two types of samples in training ordinal classifiers. We applied the weakly supervised ordinal learning to a precision medicine application that used magnetic resonance imaging to classify regional genetic alteration status of brain tumors. Our model outperformed several existing algorithms.

2 - A Novel Sparse Model-based Algorithm To Cluster Categorical Data For Improved Healthcare Screening And Public Health Promotion

Lan Jiang, State University of New York at Binghamton, Binghamton, NY, United States, Bing Si

Screening for interpersonal violence is critical to mitigate the consequences of violence, but current studies indicate a large variation in provider-reported violence screening rates ranging from 10% to 90%. Recognizing this disparity, a recent study collected providers' socio-demographics, attitudes and beliefs towards violence screening, and practice environment characteristics. Motivated by the newly available data, we propose a novel sparse categorical Factor Mixture Model to identify provider clusters based on heterogeneous categorical variables. An Expectation Maximization framework integrated with Gauss-Hermite approximation was developed for model estimation. The model was validated in both simulation and the real-world dataset. The findings facilitate targeted intervention to promote violence screening and improve women's health.

3 - 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.

■ VSD24

Virtual Room 24

Adaptive online learning of high-dimensional data

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ruizhi Zhang, University of Nebraska-Lincoln, Lincoln, NE, 68583, United States

Co-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 - Thompson Sampling Based Partially Observable Online Change Detection For Exponential Family Distributed Data

Jie Guo, Tsinghua University, Beijing, China, Chen Zhang, Hao Yan

In high-dimensional online monitoring, due to limited sensing resources, only a subset of variables can be observed at each time. Targeting at it, this research proposes a partially observable sequential change detection scheme for exponential family-distributed data process. It's built on composite decomposition by projecting data onto normal bases and abnormal bases, which enables efficient estimation for unobserved variables and inference for sparse changes. Notable test statistics are constructed for change detection. By further formulating the test statistic as reward function in Combinatorial Multi-Armed Bandit, the sensor selecting process can be achieved via Thompson sampling.

3 - 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.

4 - Online Prediction For High-dimensional Discrete Event Data

Chen Xu, ISyE Georgia Tech, Atlanta, GA, United States, Yao Xie

Modeling high-dimensional spatio-temporal discrete event data is an active research area. Nevertheless, issues such as high data dependency and non-stationarity are challenging. We present two approaches to tackle the problem. Firstly, we construct an interactive categorical process that jointly captures the dynamics between multiple time series. We efficiently solve model parameters using variational inequality with theoretical guarantees. Secondly, we propose a marked spatial-temporal Hawkes process that utilizes auxiliary features to make binary predictions. For more insights, we then develop a novel conformal prediction method and use it to predict categorical responses with confidence. We demonstrate the efficacy of the first model on solar ramping event prediction and that of the second on wildfire occurrence and size prediction.

■ VSD25

Virtual Room 25

New Directions in Operations Management

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Georgia Perakis, Massachusetts Institute of Technology, Belmont, MA, 02478-1706, 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 - Improving Emergency Department Operations With Predictive-prescriptive Analytics

Asterios Tsiourvas, MIT, Cambridge, MA, 02139, United States ", Maureen Canellas, Dessislava Pachamanova, Georgia Perakis, Omar Skali Lami

In the US, the Emergency Department (ED) is the primary point of admission to the hospital. ED congestion has been associated with low quality treatment for patients. Even before COVID-19, ED congestion had worsened substantially across the US. This work explores ways to improve ED operations through predictive-prescriptive models for optimal clinical resource utilization for patients arriving in the ED. Our approach combines machine learning for dynamic patient categorization and prediction of length of stay with prescriptive models for patient allocation. The project is conducted in cooperation with the University of Massachusetts Medical School and UMass Memorial Medical Center.

3 - Supply Chain Characters As Predictors Of Cyber Risk: A Machine-learning Assessment

Retsef Levi, MIT, Sloan School of Management, 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.

4 - A Multipeak SIR Based Model for Learning Waves and Optimizing Testing

Leann Thayaparan, Massachusetts Institute of Technology, Somerville, MA, 02144-1805, United States, Georgia Perakis, Divya Singhvi, Omar Skali Lami

The COVID-19 pandemic has been marked by behaviour-driven waves, which traditional epidemiology models are not equipped to handle. We propose a novel multipeak SIR model, which can systematically detect and model the waves of the disease using the SIR model's compartmental structure and a change-point detection martingale process. We create a dynamic process where new waves can be flagged and learned in real time (less than a week). We show that the multipeak model improves MAPE by 10%-15% for the United States, and by 25%-40% in the specific regions that were hit by the multiple waves.

■ VSD26

Virtual Room 26

Marketplace Design and Operations

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Xuanming Su, University of Pennsylvania, Philadelphia, PA, 19104-6340, United States

Co-Chair: Chloe Kim Glaeser, University of North Carolina at Chapel Hill Kenan-Flagler Business School, Chapel Hill, NC, 27514-5923, 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 - Information Provision In Two-sided Platforms: Optimizing For Supply

Wenchang Zhang, United States

While information design has gained significant attention in the recent literature as a tool for shaping consumers' purchase behavior, little is known about its use and implications in two-sided marketplaces. We develop a dynamic game-theoretic model of a two-sided platform, and we focus on illustrating the potential benefits of optimal information provision in terms of managing supply-side decisions, including supplier entry/exit and pricing.

3 - Intertemporal Pricing with Resellers: An Empirical Study of Product Drops

Dayton T. Steele, University of North Carolina-Chapel Hill, Chapel Hill, 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.

4 - 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.

■ VSD27

Virtual Room 27

Behavioral Operations II

Contributed Session

Chair: Ishita Sar, Indian Institute of Technology-Kharagpur, Kolkata, 700090, India

1 - 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.

2 - Impact Of Information Policy On Capacity Allocation In Emergency Department

Guanlian Xiao, University Of Calgary, Calgary, AB, Canada, Marco Bijvank

Emergency department in general provides service to multiple priority classes of patients, to ensure quality of service and meanwhile maintain sufficient throughout. In this work we study capacity allocation to two priorities of patients under two information settings, expected delay and exact delay. Emergency department make capacity reservation decision for higher priority of patients, the remaining capacity is shared if the reserved capacity is fully occupied. Lower priority patients make join-or-balk decisions based on their observed delay. The goal of emergency department is to maximize the number of low priority patients while provide timely service to high priority patients.

3 - Automation, Job Design, And Productivity: Field Evidence

Jie Gong, National University of Singapore, Singapore, Ivan Png

The task perspective of automation emphasizes that machines substitute for human labor. Here, we discuss a different effect: If worker effort exhibits increasing differences in two tasks, automation of one task would reduce the marginal cost of the remaining task. Conventionally, the supermarket cashier's job encompasses two tasks — scanning purchases and collecting payment. Singapore supermarkets divided the job, with humans scanning and machines collecting payment. In a within-subjects field experiment, cashiers in the new job design scanned over 10 percent faster. Productivity rose by reducing the marginal cost of effort in scanning, rather than through learning or less task-switching.

4 - Assessment Of Driving Comfort With Exposure To Different External Stimuli

Ishita Sar, Indian Institute of Technology-Kharagpur, Kharagpur, India, Aurobinda Routray, Biswajit Mahanty

A safe and comfortable journey experience is the result of good driving behaviour. Here, driving comfort has been assessed for different external stimuli through 70 driving sessions. After visualizing tri-axial acceleration with histograms, time-series plots, and Kalman filter-based jerk estimation, a comfort index (CI) has been proposed to quantify driving comfort post and prior exposure of the drivers to external stimuli. RMS values of acceleration followed by FFT have been considered for defining CI. Auditory stimuli are observed to provide better driving comfort while visual stimuli are responsible for driving discomfort. Olfactory stimuli are observed to be neutral to driving comfort.

■ VSD29

Virtual Room 29

SME Financing

Sponsored: MSOM/iForm

Sponsored Session

Chair: Lingxiu Dong, Washington University in St. Louis, Saint Louis, MO, 63130-4899, United States

Co-Chair: Fasheng Xu, Syracuse University, Syracuse, NY, 13244-4418, United States

1 - Presenter

Long Ren, University of International Business and Economics, Beijing, China

The paper studies the multifaceted impact of loan programs offered by a retail platform to its small and medium-sized enterprise (SME) sellers. We examine and compare two scenarios: In the platform-only scenario, the platform takes advantage of its proprietary information and serves as the sole lender to the sellers; in the platform-bank scenario, the platform shares or sells its information to a bank, who could potentially extend more attractive loan offers to the sellers. We show how such programs can affect the operational decisions of sellers, the profits of all players involved, and consequently, the competitive landscape on the retail platform.

2 - Financing A Sustainable Supply Chain

Xiaole Chen, Lingnan College, Sun Yat-sen University, Guangzhou, China, Vernon Hsu, Guoming Lai, Yang Li

Supply chain sustainability is still in jeopardy even after more than a decade of corporate investment in social responsibility programs. In this paper, we explore the role of financing in establishing an ethical, environmentally-friendly supply chain and its impacts on the profits of the supplier, the buyer, and the chain as a whole. We demonstrate the financial challenges of building social responsibility in supply chains and suggest implementable remedies.

3 - Advance Selling To Ease Financial Distress

Shuang Xiao, Zhongnan University of Economics and Law, Wuhan, 430074, China, Yiangos Papanastasiou, S. Alex Yang

Unable to provide service during the Covid-19 pandemic, many small businesses have experimented with alternative ways of generating income. One approach that has gained traction is the use of advance selling, whereby the firm asks consumers in its local community to support the business by paying in advance for consumption at a future date. In this paper, we develop a game theoretic model to investigate whether and how advance selling schemes can be successfully implemented by firms facing financial distress.

■ VSD30

Virtual Room 30

Empirical and Behavioral Research in Service Operations

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Hyun Seok (Huck) Lee, Korea University Business School, Corvallis, OR, 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.

2 - Using Wisdom of Crowd to Predict Covid-19 Cases and Deaths

Dayoung Kim, California State University Fullerton, Fullerton, CA, 92831, United States

Dayoung Kim, National University of Singapore, Singapore, Singapore

In a pandemic, hospitals must optimize facilities based on rapidly changing demand for beds. We investigate whether the wisdom of the crowd, facilitated by a prediction market, can improve accuracy in predicting the number of COVID-19 cases and deaths. 560 subjects were randomly assigned to either an incentivized survey (n=280) or a prediction market (n=280) condition. Subjects were asked to predict the number of COVID-19 cases and deaths in 4 countries (Mexico, Singapore, Turkey and USA), 4 and 8 weeks in the future. Subjects were rewarded based on prediction accuracy (in the incentivized survey) and shareholdings (in the prediction market), 4 and 8 weeks later. The prediction market was significantly more accurate than the incentivized survey in predicting COVID-19 outcomes. The prediction market also led to less dispersed predictions. Our results show that a prediction market can serve as a forecasting tool for public health officials to use in a pandemic.• Keywords: COVID-19, prediction, prediction market, randomized controlled trial• Co-Authors: Teck-Hua Ho (NUS), Lawrence Jin (NUS)

3 - Modeling Drivers' Choices In A Crowdsourced Delivery System

Hyunsuk Baek, Arizona State University, Tempe, AZ, United States, Stanley Lim, Elliot Rabinovich, Rui Yin

We model the choices crowdsourced drivers make when selecting: (1) order bundles for last-mile delivery and (2) the locations where to pick up these bundles. We apply the model empirically to the operations of a last-mile delivery platform during a four month period in order to identify crowdsourced driver, order bundle, and pick-up locations attributes contributing to these choices. We then show how these insights can improve the management of the pick-up locations.

■ VSD31

Virtual Room 31

Service Economics

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Pnina Feldman, Boston University, Boston, MA, 2215, United States

Co-Chair: Ricky Roet-Green, University of Rochester, Rochester, NY, United States

1 - Paying By The Hour: Are Wages The Cost Of Waiting?

Simin Li, A.B. Freeman School of Business, Tulane University, New Orleans, LA, 60208-0898, United States, Achal Bassamboo, Martin Lariviere

Since Naor (1969), assuming customers evaluate purchasing a time-consuming service based on its full price (i.e., the sum of the explicit monetary price and a weighting of the expected sojourn time) has been a standard assumption because of its tractability. But are there settings in which it actually holds? Here we present a micro foundation for when it does. We show that whether consumers purchase based on the full price depends on their characteristics, particularly their compensation structures.

2 - Service Capacity And Pricing For Correlated Price - And Crowd-Sensitive Demand

Toghrul Rasulov, The University of Texas at Dallas, Richardson, TX, United States, Andrew E. Frazelle, Shouqiang Wang

We study a service provider's pricing and capacity decisions when customers are heterogenous both in their valuation and in their sensitivity to crowds. We use copulas to model such multidimensional heterogeneity and examine the effects of the dependence structure on the firm's optimal decisions. We show that as these two dimensions of heterogeneity become more positively correlated, it is optimal for the provider to increase its service capacity, but the optimal price may not be monotone.

3 - Food Delivery Service And Restaurant: Friend Or Foe?

Manlu Chen, Renmin University of China, Beijing, China, Ming Hu, Jianfu Wang

With emerging food delivery services, customers can hire delivery workers to pick up food on their behalf. To investigate the long-term impact of food delivery services on the restaurant industry, we model a restaurant serving food to customers as a stylized single-server queue with two streams of customers. One stream consists of tech-savvy customers who have access to a food delivery service platform. The other stream consists of traditional customers who are not tech-savvy enough to use a food delivery service and only walk in by themselves. We study a Stackelberg game, in which the restaurant first sets the price of the food, the same for online and offline customers; the food delivery platform then sets the delivery fee; and, last, rational customers decide whether to walk in, balk, or use a food delivery service if they have access to one.

4 - Should Competing Firms Cooperate To Reduce Congestion?

Jagan Jacob, Xavier University, Cincinnati, OH, 45207, United States

We consider a duopoly in the presence of congestion-sensitive customers. Firms can invest either independently (competition) or jointly (co-opetition) in congestion-reduction (CR) activities. We find that co-opetition generates more profit and social welfare than competition if the joint marginal CR cost is less than a threshold. When prices are regulated, only the firm with the higher marginal CR cost will invest to reduce congestion.

5 - 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.

■ VSD32

Virtual Room 32

Assortment, Pricing, and Shipping in Retailing

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Lai Wei, Boston College, Chestnut Hill, MA, 2467, United States

1 - Dynamic Pricing For Truckload Transportation Marketplaces
Yufeng Cao, Shanghai Jiao Tong University, Shanghai, 30324-3623, China, Anton J. Kleywegt, He Wang

We consider a dynamic pricing problem for a for-hire truckload transportation marketplace. Both loads and carriers arrive randomly to the market. Each load has a deadline, and the market operator wants to get a carrier to book the load before the deadline. We formulate an infinite horizon Markov decision process (MDP), which captures randomness in the arrival processes on both sides of the marketplace, as well as the choice behavior of carriers. To solve this MDP, we study a discrete-time fluid approximation. It results in a simple pricing policy whose price for each load depends on the time remaining until the deadline. We show that this policy is asymptotically optimal with a loss ratio of order O(1/) on the long-run average reward, where represents the scale of demand and supply. We also present a continuous-time fluid model and several practical extensions.

2 - A Customer Choice Model Of Impulse Buying In Social Commerce
Yuan Guo, Duke University, Durham, NC, 27705-3861, United States, Fernando Bernstein

Social commerce integrates user interactions and user-generated content with commercial activities in the context of social media platforms. Examples include the "shop now" feature on Instagram and store links on Tik Tok. A social media user's on-site purchase decision involves a transformation of the mindset from "social" to "shopping" stimulated by the impulse to purchase, but is restricted by the short attention span over contents on social media. We propose a novel choice model to capture users' shopping behavior on social media sites. We also examine two strategies to sell through social media: provide on-site shopping feature or include link to external website.

3 - Impact Of Free Shipping Threshold On Different Channels: Evidence From An Online Retailer
Fujie Jin, Kelley School of Business, Indiana University, Bloomington, IN, 47405-1701, United States, Fei Gao, Jianbin Li

This paper uses a quasi-experiment setting to explore the impact of changes in the free shipping threshold on purchasing behavior across different channels. We use a unique transaction level dataset from a large online pharmacy-type retailer, around the time of an exogenous change in the free shipping threshold, to study how such a change influences purchasing behavior differently for customers on the PC channel and on the mobile channel. We find that customers are more likely to increase their basket size to meet the free shipping threshold on the PC channel than on the mobile channel. The specific way that customers increase their basket size also different across the two channels. On the mobile channel, users are more likely to increase the quantity purchased for given products, on the PC channel, users are more likely to substitute high priced-products for lower priced ones.

4 - Coopetition In Platform-based Retailing: On The Platform Entry
Haotian Song, NYU, New York, NY, 10012, United States, Lian Qi, Wenqiang Xiao

Platforms owners with direct access to product info may find some product spaces attractive to enter, thereby competing directly with the sellers. Such a practice is often perceived by the sellers as a potential threat, intensifying market competition and eroding their market shares. To protect their product spaces, some sellers may deliberately underinvest in product-value-enhancement efforts, hurting not only themselves with reduced sales but also platforms with shrunk referral fees. We examine this strategic interaction between a platform and a representative seller in a two-stage game. We provide necessary and sufficient conditions to address the questions of what product spaces the platform should enter, how the entry influences the seller, how the seller reacts in anticipation of the potential entry, and when the platform should commit non-entry in advance.

5 - Snob And Follower Effects In Luxury Products Competition
Lai Wei, Boston College, Chestnut Hill, MA, 2467, United States

One unique feature of luxury products is the coexistence of two opposite externalities: snob customers experience negative externalities with product sales while follower customers experience positive externalities. In this paper, we study the effects of these externalities on the optimal strategy under a competitive market and social welfare. We find that the insights known for regular products in the competitive setting no longer hold. Specifically, for the selling structure, we observe the existence of a new form of equilibrium, a partial segmentation, where one type of customers, which could either be the snob or the follower, exclusively purchase the product with higher quality and the other type of customers may purchase either of the two products. In terms of customer welfare, we surprisingly find that competition does not necessarily benefit customers.

■ VSD33

Virtual Room 33

Emerging Topics in Supply Chain

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Woonam Hwang, University of Utah, Salt Lake City, UT, 84112-8939, 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 - Optimal Subsidy Policy With Innovation Spill-over: Technology Push Or Demand Pull?
Myeonghun Lee, Korea Advanced Institute of Science and Technology, Seoul, 48109, Korea, Republic of, Hakjin Chung, Hyun-Soo Ahn, Sanwon Kim

We study how the government should utilize the push and pull subsidies to populate beneficial technologies such as electric vehicles and solar panels. In particular, we examine how these subsidies and technology spillovers influence the firm's R&D and production decisions and resultant market outcomes as well as how the spillovers change the subsidy allocations.

3 - 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.

4 - Proximal Capacity And Pricing Across Two-sided Distributed Business Models
Nitin R. Joglekar, Boston University Questrom School of Business, Boston, MA, 02215-1704, United States, Kyungmin Lee, Marcus A. Bellamy

We focus on a platform's pricing policy by zone and proximal price and capacity in neighboring zones. Emphasizing spatial and temporal movements on the supply side, we use data on dynamic pricing and capacity behavior from UberX services to investigate. Managerially, our paper offers firms managing platforms with reference price sensitivity levels of demand that maximize profit, welfare or both.

5 - To Hinder Or To Facilitate: Retailers' Strategy Of Consumer Information Sharing And Target Segment

Buqing Ma, University of Science and Technology of China, Hefei, China, Guang Li, Guangwen (Crystal) Kong

Motivated by the phenomenon that some retailers with high-end brand images, such as Neiman Marcus, prefer to hinder consumers from sharing information through online reviews, we study an online retailer's strategy of hindering or facilitating consumer information sharing in a supply chain and its dependence on the retailer's brand image and target consumer segment. We employ a two-period model in which consumers, with heterogeneous valuation of a product, arriving in the first period make purchase decisions based on the retailer's brand image and can find out the product quality only after their purchase, and consumers arriving in the second period learn about the product quality from the first-period consumers if the online retailer's website facilitates information sharing among consumers. We find several interesting results.

■ VSD34

Virtual Room 34

Circular Economy strategies and Products' End of Life Cycle

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Anna Saez de Tejada Cuenca, IESE Business School, Washington, DC, 20057, United States

1 - Does Extended Producer Responsibility Improve Eco-innovation: An Empirical Study Of Product Take-back Programs

Yuqi Peng, University of South Carolina, Columbia, SC, 29209, United States, Yan Dong, Sriram Venkataraman, Sining Song

This research empirically examines the causal relationship between a take-back program, a key initiative of Extended Producer Responsibility, and producer innovation outcomes. We find that adopting take-back programs significantly motivates producers to file more eco-patents. We also explore the heterogeneity across take-back programs and producer industries.

2 - Show, Don't Tell: Education And Physical Exposure Effects In Remanufactured Product Markets

Huseyn Abdulla, PhD Candidate, Mays Business School, Texas A&M University, 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.

3 - Life Cycle Assessment Of Value Recovery From Hard Disk Drives

Hongyue Jin, University of Arizona, Tucson, AZ, United States, Kali Frost, Ines Soursa, Alex Bevan, Miha Zakotnik, Carol Handwerker

The current business practices for used hard disk drives (HDDs) are limited to reuse or shredding, not optimal for environmental sustainability. Life cycle assessment was conducted to quantify and compare several recovery technologies and business models with primary data collected from the industry. LCA results showed that reusing HDDs is the most environmentally friendly option, followed by reuse of magnet assembly, magnet-to-magnet recycling, and metal recycling under certain conditions. Environmental hotspots were also identified, revealing the significant contribution of reverse logistics transportation, highlighting the need for optimizing the reverse supply chain to reduce the environmental footprint of HDD value recovery.

4 - Warranty Length, Product Reliability, And Secondary Markets

Necati Tereyagoglu, University of South Carolina, Columbia, SC, 29208-4011, United States, Wayne Fu, Atalay Atasu

Inspired by particular variations in warranty length specifications in the U.S. automotive industry, we show how secondary market interference can be one possible driver for such variations. Using an analytical model of a monopolist finitely durable good producer, we first study the interaction between product reliability and the producer's warranty length choice in the presence of secondary market interference. We then utilize data from the U.S. automotive industry to explore the implications of our theoretical findings. Our analysis suggests a U-shaped association between warranty offerings and product reliability, and points to the theoretically predicted dependency between producers' secondary market interference and warranty length.

5 - Carrots Versus Sticks: How Do Curbside Tactics Impact Household's Recycling Performance?

Erin McKie, The Ohio State University, Columbus, OH, United States, Aravind Chandrasekaran, Sriram Venkataraman

Many reuse opportunities are only feasible with environmentally compliant, household-level behaviors. Recognizing this, policymakers are increasingly using a range of tactics to promote recycling that meets quality standards. However, the effectiveness of these mechanisms is unclear, and stakeholders remain divided on the appropriateness of their use. We add clarity to this debate by investigating the role of information-only and information plus penalty feedback mechanisms in correcting households' curbside recycling behaviors. To answer our research questions, we analyze data from a large 2019 curbside auditing effort that occurred in a midwestern city. Our analysis includes data on over 25,000 audits across 12,000 households. In sum, our study informs policymakers on how curbside feedback mechanisms can be more effectively leveraged.

■ VSD36

Virtual Room 36

Renewable Energy Planning and Operation with Decision Dependent Uncertainty

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Yunhe Hou,

Co-Chair: Feng Liu, Beijing, China

1 - Robust Scheduling of Virtual Power Plant Under Exogenous and Endogenous Uncertainties

Yunfan Zhang, Tsinghua University, Beijing, China, Feng Liu, Zhaojian Wang, Yifan Su, Weisheng Wang, Shuanglei Feng

We propose a novel risk-aware stochastic adaptive robust optimization (SARO) model for robust self-scheduling of virtual power plant (VPP) participating in the day-ahead energy-reserve market. Exogenous uncertainties (or called decision-independent uncertainties, DIUs) associated with market prices and available wind generations, as well as endogenous uncertainties (or called decision-dependent uncertainties, DDUs) pertaining to real-time reserve deployment requests are considered. A tractable solution methodology based on improved Benders decomposition is developed to effectively solve the proposed SARO model with both DIUs and DDUs. Comparative results show that the proposed method can mitigate conservatism of robust strategy by capturing a satisfactory trade-off between profitability and real-time operation feasibility.

2 - Stochastic Service Restoration Strategy Considering Decision-dependent Cold Load Pick-up

Yujia Li, PhD, The University of Hong Kong, Hong Kong

Cold load pickup (CLPU) phenomenon is known as the persistent power inrush upon a sudden load pickup during distribution service restoration. Today a shortened outage duration become common due to the rising installation of distributed energy resources, which has consequently introduced a strong interdependence between CLPU pattern and load pickup decisions. Therefore, a novel modelling technique based on mixture distribution is proposed to tractably capture the decision-dependent uncertainty (DDU) inherent in CLPU process. Then, a two-stage stochastic decision-dependent service restoration model is constructed, and progressive hedging algorithm (PHA) is utilized to accelerate the computation by parallel computing. A numerical test has verified the efficiency of our proposed model and quantified the potential values of adopting the DDU-based formulation.

3 - Distributed Control And Optimization For Resilient Distribution Systems With Extremely-high PV Penetration

Wei Sun, PhD, University of Central Florida, Orlando, FL, United States

This talk will present a scalable grid architecture with hierarchical and distributed communication and control. Two advanced grid functions will be introduced, 1) the distributed Volt/VAR optimization and frequency control algorithms to optimally dispatch the real and reactive power of multiple PVs based on distributed cooperative control and optimization; and 2) the distributed distribution system restoration strategy to optimally determine the PV generation, network configuration, switching status, and load pickup, in order to restore the entire system or energize unfaulted out-of-service areas. These functions are tested in 1 million-node distribution system on the Multi-Agent OpenDSS platform. Both steady-state and time series simulations are executed for the integrated T&D systems with parallel implementation and hardware-in-the-loop simulation.

4 - Tri-level Robust Optimization Of Distribution Grid Topologies For Integrating Distributed Renewables

Shunbo Lei, University of Michigan, Ann Arbor, MI, United States, Feng Qiu, Jie Yan

The growing penetration of distributed renewables in distribution grids has made the effective integration of renewables a major concern. Dynamic reconfiguration of distribution grid topologies, which relies on the real-time operation of smart switches, is potentially an efficient strategy. In this work, we study the problem of identifying critical smart switches that optimally enable the dynamic reconfiguration of distribution grid topologies to minimize renewable curtailments. Considering the uncertainties of renewables and loads, the problem is formulated as a tri-level robust optimization model solved by a nested column-and-constraint generation algorithm. Illustrative cases show that renewable curtailments can be significantly reduced by a small number of smart switches that operate only several times in daily operation.

5 - Renewable Energy Planning With Decision-dependent Uncertainty Induced By Spatial Correlation

Wenqian Yin, PhD, The University of Hong Kong, Hong Kong, 00000, China, Yunhe Hou

Due to the spatial correlation of renewable resources, the uncertainty in regional aggregated renewable power is related to the region size, which further indicates the dependency of uncertainty on planning decisions. Motivated by this, we present a stochastic approach for renewable energy planning with decision-dependent uncertainty (DDU). We discuss the modeling and computational challenges of the planning method with DDU, and develop an efficient solution method. The impacts of DDU on renewable energy planning are demonstrated in case studies.

1 - Presenter

Liang Liang, PhD, Harbin Institute of Technology, Shenzhen, Shenzhen, China

The EVs and renewable resources can build a zero-carbon emission transportation and power systems. The limitation of battery capacity and charging technology are the bottleneck of using EVs to replace regular vehicles. In this presentation, the wireless power transfer (WPT) chargers charge the EVs when these cars stop at the crossroad. An operation strategy is proposed to coordinate operation resources, such as renewables, battery systems and reactive power supporting devices, to accommodate the voltage fluctuations at the PCC point. The challenge of stochastic renewable outputs and sequential pules type loads can be well accommodated and the integration capacity can be enhanced.

■ VSD37

Virtual Room 37

Decision Making Under Uncertainty in Power Systems

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Richard Paul O'Neill, ARPA-E, Silver Spring, MD, 20904-2924, United States

Co-Chair: Ashley Arigoni, QS-2 (subcontractor to ARPA-E), Denver, CO, 80209-4510, United States

Co-Chair: Joseph King,

Co-Chair: Richard Wilson, ARPA-E, United States

1 - Grace: A Grid That Is Risk-aware For Clean Electricity

Dalia Patino-Echeverri, Duke University, Durham, NC, 27708-0227, United States

In this presentation, we will discuss progress made towards a new energy management system that determines operating reserve requirements through a process that minimizes risk-adjusted expected costs. We present lessons learned from the implementation of this work in the Duke Energy Progress / Duke Energy Carolinas power system.

2 - Machine Learning Prediction Of Grid Balancing Needs And Exploration Of Renewable Curtailment As A Grid Balancing Resource Via Production Simulation

James Nelson, United States

E3 has deployed machine learning techniques to address the challenging issue of data sparsity and complex correlations between demand, wind, and solar resource uncertainty. Machine learning is used to dynamically adjust uncertainty predictions based on system conditions, thereby lowering balancing requirements on average (relative to incumbent methods) while providing adequate coverage of extreme forecast error events. E3 uses production simulation to quantify the cost and carbon emissions benefits of machine learning-based reserve requirements and to explore how wind and solar generators could participate in supplying grid balancing via targeted curtailment.

3 - Using A New Approach For Predictive Analytics To Enable Grid Decarbonization

Robert Miller, Castalune, United States

As energy systems become more dynamic and decentralized, many operational and planning decisions are disproportionately influenced by a relatively small number of energy events. The unpredictability of these events results in an approach that is extremely conservative and restrictive, impeding many efforts to decarbonize the economy, such as labeling renewables as unreliable or volatile rather than intermittent. The continued development of electric vehicles and controllable load are examples of trends that will increase the frequency of impactful energy events. Castalune is building software so decision-makers can find leading indicators of impactful energy events, enabling effective mitigation actions to be pursued.

4 - Risk-Aware Market Clearing

Pascal Van Hentenryck, ISyE Georgia Tech, Atlanta, GA, 30318, United States

This talk presents the Risk-Aware Market Clearing project which aims at revisiting the pipeline of independent system operator under the lens of stochastic and risk optimization. It will review progress on forecasting load and renewable energy, optimization algorithms for market clearing, machine learning methods to approximate these optimizations, and system-level risk assessment. Illustrations of this progress on real transmission systems will also be presented.

■ VSD38

Virtual Room 38

Energy Modelling Platform for North America - Supporting Worldwide Open Modelling Efforts

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Taco Niet, Sustainable Energy Engineering/Simon Fraser University, Surrey, BC, V3T 0N1, Canada

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

Co-Chair: Kelly Eurek, National Renewable Energy Laboratory, Lakewood, CO, 80226-2818, United States

Co-Chair: Denis Lavigne, Royal Military College St-Jean, St-Jean-sur-Richelieu, QC, J2W 1E9, Canada

1 - Linking The United Nations Sustainable Development Goals To The Regionalized Climate, Land, Energy And Water Model.

Mariana Rodriguez Arce, Electric Power & Energy Research Laboratory, University of Costa Rica, Heredia, Costa Rica, Jairo Quirós, Taco Niet

The pursuit of the SDGs can be strengthened with efficient policies supported by modeling frameworks that consider climate mitigation, adaptation policies, and the exploration of interactions between multiple sectors. This project investigated the linkages between a regionalized CLEWs model and the 17 UN SDGs. The linkage with the 17 SDGs was evaluated based on the 232 indicators, determining those that can be incorporated into the model and estimating the corresponding impact on Costa Rican policy. Including the SDG indicators in the model helps demonstrate additional benefits of the National Decarbonization Plan, illustrating new connections between science and policy, assuring peace and security, freedom, development, and a healthy environment.

2 - An Open Energy Outlook For The United States

Joseph F. DeCarolis, North Carolina State University, Raleigh, NC, 27607, United States, Aranya Venkatesh, Katherine Jordan, Aditya Sinha, Paulina Jaramillo

This talk provides an overview of a project to develop an Open Energy Outlook for the United States. The modeling effort employs Tools for Energy Model Optimization and Analysis (Temoa), an open source energy system optimization model. The project has three objectives: examine net-zero CO2 emissions pathways for the US energy system, maximize transparency in the modeling effort, and involve the broader modeling community in the analysis. We present an overview of our efforts to improve transparency as well as some preliminary results from the analysis.

3 - The Role of U.S.-Canada Electricity Trade in North American Decarbonization Pathways

Sina Motalebi, Simon Frasier University, Surrey, BC, Canada, Taco Niet, Trevor Barnes, Le Lu, Benjamin D. Leibowicz

Electricity trade potential between U.S. and Canada and the impacts on cost effective emissions reduction has not been studied in detail. We implement a capacity expansion model (2020-2050) and cover the integrated generation and transmission system using the Open Source Energy Modeling System (OSeMOSYS). Results indicate that expanded electricity trade allows for cost and emission reductions compared with restricted trade. Flexibility of Canadian hydroelectric resources allows for arbitrage of intermittent wind and solar power located primarily in central and southern U.S. states. This indicates the need for coordinated energy policy to ensure reliable, low cost, energy service.

■ VSD39

Virtual Room 39

Forecasting I

Contributed Session

Chair: Ali Eshragh, University of Newcastle, Collghan, 2308, Australia

1 - An Investigation Of Approaches For Temporal Hierarchical Reconciliation For Multi-step Forecasting

Anna Yanchenko, Duke University, Durham, NC, United States, Wesley M. Gifford, Brian Quanz, Nam Nguyen, Pavithra Harsha

In many forecasting settings, hierarchical structure exists across a collection of time series, such as product category information in a retail setting. In these cases, it is often beneficial to consider hierarchical forecasting approaches and/or hierarchical reconciliation of the predictions. Here, we consider a hierarchical structure based on temporal aggregations and investigate the performance of reconciliation methods for time series with different underlying dynamics and model structures. We find that reconciliation based on the structure of the hierarchy, combined with simpler forecasting models, can outperform more complex forecasting models for temporal hierarchies.

2 - Robust Feature Based Model Agnostic Explainability For Time Series Forecasting

Sumanta Mukherjee, IBM Research, Bangalore, India, Vikas Raykar, Bhanukiran Vinzamuri, Giridhar Ganapavarapu, Nupur Aggarwal

Explainability is the degree to which a human can understand the cause of a decision made by a model. Various notions of explainability has been studied in supervised learning paradigms like classification and regression. In this work we formalise the notions of local and global explanations in the context of time series forecasting. We propose a robust interpretable feature based algorithm to explain the forecast of any forecaster. The method is model agnostic and needs access to only the fit and forecast methods. We evaluate the explanations in terms of sensitivity, faithfulness and complexity. For robustness we aggregate multiple explanations from bootstrapped versions of the time series.

3 - Efficient Leverage Score Sampling Algorithm For The Analysis Of Big Time Series Data

Ali Eshragh, University of Newcastle, Callaghan NSW, Australia

We apply methods from randomized numerical linear algebra to develop improved algorithms for the analysis of big time series data. We first develop a new fast algorithm to estimate the leverage scores of an autoregressive (AR) model in big data regimes and show that the accuracy of approximations lies within (1+O( )) of the true leverage scores with high probability. These theoretical results are subsequently exploited to develop an efficient algorithm for fitting an appropriate AR model to big time series data. Our proposed algorithm is guaranteed, with high probability and has a worst case running time that significantly improves those of the state-of-the-art alternatives in big data regimes.

■ VSD40

Virtual Room 40

Heterogeneity in Energy System Modelling

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Michael Bucksteeg, University of Duisburg-Essen, Germany

1 - Advanced Price Forecasting In Agent-based Electricity Market Simulation

Christoph Fraunholz, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Machine learning and agent-based modeling are two popular tools in energy research. In this article, we propose an innovative methodology that combines these methods. For this purpose, we develop an electricity price forecasting technique using artificial neural networks and integrate the novel approach into the established agent-based electricity market simulation model PowerACE. In a case study covering ten interconnected European countries and a time horizon from 2020 until 2050 at hourly resolution, we benchmark the new forecasting approach against a simpler linear regression model as well as a naive forecast. Our results show that the neural network approach clearly outperforms the benchmark models. Moreover, we find the choice of the model-endogenous forecasting method to have a strong impact on the simulated electricity prices.

2 - Impact of Hyperbolic Discounting on Renewable Transformation Paths

Michael Bucksteeg, University of Duisburg-Essen, Essen, Germany

The optimization of investments in infrastructure and facilities represents a main field of application of energy market models. However, investment decisions are commonly simplified using constant and global interest rates. At the same time, the progressing decentralisation of energy systems is associated with an increased heterogeneity of market actors calling for a stronger differentiation of financing conditions in energy market models. While several contributions address the technical and spatial dimension of investment requirements, this study focuses on modelling intertemporal decisions of heterogeneous individuals. Consequently, an investment model of the electricity sector under hyperbolic discounting is developed and a case study to analyse the impact on renewable transformation paths is performed.

3 - A General Approach To Model Heterogenous Investors In a Convex Optimization Framework

Christoph Weber, University Duisburg-Essen, Essen, 45141, Germany

A general convex non-linear constrained optimization problem is formulated to enable the description of the aggregate of individual decision problems across different parts of the energy system with a focus on investment decisions in renewable generation and demand-side choices regarding heating and mobility. Heterogenous agents are incorporated based on logit models of discrete choices. By reformulating the individual optimization problems using dual instead of primal variables and combining the individual optimization problems through market clearing constraints, a non-linear yet convex optimization problem is obtained that corresponds to a partial equilibrium model for one or several commodities (e.g. energy carriers).

4 - Accomodating Bounded Rational Behavior Of Electricity Consumers In Short-term Markets

Kenneth Bruninx, KU Leuven, Leuven, 3001, Belgium

When faced with uncertain market outcomes, small-scale electricity consumers, such as electric vehicle owners, may exhibit bounded rational behavior. In this talk, I propose a tractable price-search algorithm based on ADMM and local linearization to mimic the coordination between uncertain electricity markets, an aggregator and bounded rational electric vehicle owners. This algorithm allows, for the first time, studying the role of bounded rationality and aggregators in multi-agent, multi-period problems. In a case study, I illustrate that an aggregator may create value (up to 27.5€/year/EV owner) for bounded rational electric vehicle owners by derisking their participation in the electricity market.

5 - Modeling Solar Prosumage: Mixed Complementarity Problems Vs. Coupled Linear Programs

Carlos Gaete Morales, DIW Berlin, Berlin, Germany, Wolf-Peter Schill

In many electricity markets, consumers have incentives to meet parts of their energy demand with self-generated electricity from PV-battery systems. This concept is referred to as prosumage. Günther et al. (2021) analyze the effects of various tariff designs on optimal PV and battery capacity choices in Germany. They use an MCP to link the optimization problems of prosumage households and the wholesale market. Numerically solving this MCP for a full year in hourly resolution is challenging. We propose an alternative approach where two LPs are iteratively solved, investigate aspects of convergence and optimality, compare computational expenses, and explore extensions of the model setup.

■ VSD41

Virtual Room 41

Overcoming Uncertainty In Modelling Electric Grids

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Mehrdad Pirnia, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

1 - Distributionally Robust Generation Expansion Planning With Unimodality and Risk Constraints

Farzaneh Pourahmadi, University of Copenhagen, Copenhagen, Denmark, Jalal Kazempour

In this work, we develop a distributionally robust generation expansion planning model, accounting for a family of potential distributions of wind forecast error uncertainty. Aiming to include more realistic distributions, we construct more informed moment-based ambiguity sets by adding structural information of unimodality. We include unit commitment constraints and model the risk of

operational limit violations in two distinct forms: chance and conditional value-at-risk (CVaR) constraints. Using an out-of-sample analysis, we conclude the chance-constrained model exhibits a better out-of-sample performance only if accurate distributional information is available; conversely, if accurate information is unavailable, the CVaR-constrained model outperforms. These two models have a similar performance when unimodality information is excluded.

2 - Prosumers' Investment Decisions Under Different Pricing Schemes

Kazuya Ito, National Graduate Institute For Policy Studies, Tokyo, 278-0022, Japan, Makoto Tanaka, Yihsu Chen, Ryuta Takashima

With the recent ruling of FERC Order 2222 that allows prosumers to directly participate in the wholesale markets, their role becomes more important in the power sector. This study investigates prosumers' investment decision in distributed renewable resources under different pricing schemes, such as a net-metering and a net-billing policy. We illustrate the effects of different pricing policies on the market equilibrium and the social surplus.

3 - Multistage Stochastic Market Clearing Formulations And Price Interpretations

Saumya Sakitha Sashrika Ariyarathne, Southern Methodist University, Dallas, TX, 77340, United States, Harsha Gangammanavar

In this talk, we will present alternative formulations of stochastic market clearing problem which are based on different algebraic representations of non-anticipativity constraints of multistage stochastic programming. These formulations result in prices that have alternative interpretations under different power system settings. We will present these interpretations along with computational results for well known testbeds.

4 - Application-Driven Learning via Joint Prediction and Optimization of Demand and Reserves Requirement

Tito Homem-de-Mello, Universidad Adolfo Ibañez, Santiago, 750000, Chile, Alexandre Street, Joaquim Dias-Garcia, Francisco David Munoz

In power systems, operators typically adopt an open-loop approach by first forecasting loads to minimize errors with respect to historical data, and then determining reserve requirements based on error estimates. Next, energy and reserves are scheduled and the system is operated following the dispatch schedule, deploying reserves as needed. In this paper, we present a new closed-loop learning framework in which the processes of forecasting and decision-making are merged and co-optimized through a bilevel optimization problem. We show convergence of the method, present two solution algorithms and illustrate the application of the method in large-scale case studies.

5 - Chance-constraint Model For The Operation Of Energy Storage

Mehrdad Pirnia, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

In this research, we propose a chance-constraint method to model the operation of storage capacities, when participating in electricity market as both reserve and arbitrage entities. The main source of uncertainty in the proposed model is the imperfect forecast of wind generation. We discuss the activities of storage capacities under different state of charge, and formulate such conditions when batteries are participating as reserve capacities along with gas generators.

■ VSD42

Virtual Room 42

Bayesian Optimization

Sponsored: Computing Society

Sponsored Session

Chair: Peter Frazier, Cornell University, Ithaca, NY, 14853, United States

Co-Chair: Raul Astudillo, Cornell University, Ithaca, NY, 14853-3801, United States

1 - Corruption-robust Bayesian Optimization

Ilija Bogunovic, ETH Zurich, Zurich, Switzerland

We consider a novel variant of Bayesian optimization in which the point evaluations are not only corrupted by random noise but also with adversarial corruptions. We introduce robust algorithms based on Gaussian process models, randomized selection, enlarged confidence bounds, and the principle of optimism under uncertainty. We present a novel theoretical analysis upper bounding the cumulative regret in terms of the corruption level, the time horizon, and the underlying kernel, and we argue that certain dependencies cannot be improved. We observe that distinct algorithmic ideas are required depending on whether one is required to perform well in both the corrupted and non-corrupted settings, and whether the corruption level is known or not.

2 - Bayesian Optimization at Facebook

Eytan Bakshy, Facebook, Menlo Park, CA, United States

Bayesian optimization is a popular method for sample-efficient optimization that is typically applied to low-dimensional offline problems, such as tuning of machine learning hyperparameters or simulation optimization. Through the use of real-world problems encountered at Facebook, I will discuss problems that occur in practice when applying Bayesian optimization to problems like policy search and parameter tuning in the context of online field experiments (A/B tests), and various solutions to solve these problems.

3 - Grey-Box Bayesian Optimization Of Nested Functions

Raul Astudillo, Cornell University, 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.

4 - Bayesian Optimisation Beyond Modestly-Dimensioned Continuous Problems

Xingchen Wan, University of Oxford, Oxford, United Kingdom

Bayesian optimisation (BO) is an area within machine learning in which demand outstrips supply, driven by industrial interest in automated machine learning (AutoML). However, most "standard" endeavours in BO have focused on continuous-valued and modestly-dimensioned problems, although real-life problems can be considerably higher-dimensional, more heterogeneous and thus more "exotic". This talk introduces some recent advances of BO in these challenging data structures that significantly differ from the "standard": we propose NAS-BOWL for BO in a graph-like space for neural architecture search, and Casmopolitan for high-dimensional spaces with categorical variables. I hope these could be first steps towards broadening the scope of application of BO beyond its current limitations.

■ VSD44

Virtual Room 44

Economics and Computation IV

Sponsored: Auctions and Market Design

Sponsored 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, 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.

■ VSD45

Virtual Room 45

Behavioral Operations Job Market Candidate Showcase

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Andrew M. Davis, Cornell University, Ithaca, NY, 14853, United States

1 - Human Decision-making In Dynamic Resource Allocation
Jiawei Li, University of Michigan, Ann Arbor, MI, United States

2 - Mitigating The Negative Effects Of Customer Anxiety Through Access To Human Contact
Michelle A. Shell, Boston University, Dover, MA, 02030-1820, United States

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

4 - Retailer Inventory Sharing In Two-tier Supply Chains: An Experimental Investigation
Rihuan Huang, Cornell University, Ithaca, NY, 14853-6900, United States

5 - Moderator
Andrew M. Davis, Cornell University, Ithaca, NY, 14853, United States

This session includes job-market candidates who have expertise in behavioral operations management.

■ VSD46

Virtual Room 46

Online Health Communities

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Zhiya Zuo, City University of Hong Kong, Kowloon, 52240, Hong Kong

1 - To Initiate or to Hijack? Social Support Seeking in Online Health Communities from a Human Territoriality Perspective
Zhiya Zuo, City University of Hong Kong, Kowloon, 52240, Hong Kong, Xi Wang, Yulin Fang

Online health communities (OHCs) have become prevalent for patients alike to exchange support for each other. Mostly from social network and social capital perspectives, past literature pays extensive attention to effective social support seeking. In this study, we set out to investigate a common yet rarely explored support seeking behavior that we term as "thread hijacking", the phenomenon of a hijacker taking the floor in a thread initiated by an initiator rather than creating her own. Based on human territoriality and psychological ownership theories, we propose a theoretical framework predicting the extent to which hijacking affects both hijacker and initiator support seeking and community engagement. We empirically test our hypotheses using data from an OHC on breast cancer. Theoretical and practical implications are discussed.

2 - Patient Empowerment Through Online Depression Communities In China
Renwen Zhang, National University of Singapore, Singapore

Online support groups have drawn considerable attention from scholars in the past decades. However, we know little about how culture shapes the way people use and understand online support groups. Drawing on ethnographic research in a Chinese online depression community, we examine how online support groups function in the context of Chinese culture for people with depression. Through online observations and interviews, we uncover the unique interactions among users in this online support group, such as peer diagnosis, peer therapy, and public journaling. These activities were intertwined with Chinese cultural values and the scarcity of mental health resources in China. We also show that online support groups play an important role in fostering individual empowerment and improving public understanding of depression in China.

3 - Gamified Monetary Incentives On Professional Knowledge Sharing In An Online Health Community: A Longitudinal Study With Two Experiments
Shanshan Guo, Shanghai International Studies University, Shanghai, China, Yuanyuan Dang

The Internet has been proven to be a positive enabler on knowledge sharing (KS), little systematic work has examined the correlation between monetary incentive and physicians' performance. Using two field experiments, we investigate whether gamified incentives work on PHKS in OHCs as one-time incentives or repeated incentives and what factors can moderate the effects of gamified monetary incentives on PHKS in OHCs. The results show that gamified monetary incentives do work for PHKS, but repeated monetary incentives would have a smaller effect. What's more, for public PHKS, non monetary incentives has no effect.

■ VSD47

Virtual Room 47

Machine Learning in Finance

Sponsored: Finance

Sponsored Session

Chair: Renyuan Xu,

Co-Chair: Zhengyuan Zhou,

1 - AI Applications in Investments and Managerial Decision-making
Lin William Cong, Cornell University, Ithaca, NY, 14853, United States, Murillo Campello, Luofeng Zhou

In this talk, I discuss applications of deep reinforcement learning (DRL) in portfolio management and corporate finance. The first application directly optimizes the objectives of portfolio management via DRL instead of the conventional supervised-learning-based paradigms that entail first-step estimations of return distributions or risk premia. Our multi-sequence neural network AlphaPortfolio model is tailored to distinguishing features of financial data and allows potential market interactions and training without labels. AlphaPortfolio yields stellar out-of-sample performances that are robust under

various economic restrictions and market conditions. Moreover, we project AlphaPortfolio onto simpler modeling spaces to uncover key drivers of investment performance, including their rotation and nonlinearity. The "economic distillation" tools we invent can be used for interpreting AI and big data models in general. In the second application, we build a DRL framework to find the most effective combination of managerial actions for a given business objective and to use historical actions to back out managers' objectives in practice, be it long versus short horizon, or enterprise value versus equity value maximization, or ESG considerations, etc. DRL derives the optimal control/action trajectory under known reward structure; once combined with an inverse reinforcement learning module, our model is equivalent to the popular generative adversarial networks and reveals managers' various considerations when making decisions.

2 - Reinforcement Learning in Finance - Simulators and Domain Knowledge

Sumitra Ganesh, J.P.Morgan AI Research, New York, NY, United States

Deep Reinforcement Learning (RL) has achieved considerable success in several domains (robotics, games) where a simulator is readily available to provide the large of amount of experience most RL algorithms need. In applying these techniques to the financial domain, we will present recent work that addresses two questions: (a) How can we build a realistic simulator for economic systems? (b) How can we leverage domain knowledge to make RL algorithms more sample efficient?

■ VSD48

Virtual Room 48

Future of Work

Sponsored: eBusiness

Sponsored Session

Chair: Brian Lee, Pennsylvania State University, State College, PA, 16801, United States

1 - Monitoring Policies And Gig Workers' Job Preferences

Chen Liang, University of Connecticut, Storrs, CT, 06268-1713, United States, Jing Peng, Yili Kevin Hong, Bin Gu

To help employers make informed decisions about whether to adopt monitoring and what monitoring policy to use, we investigate how three common aspects of monitoring affect workers' willingness to accept monitored jobs, as well as the underlying mechanisms, through online experiments on two gig economy platforms (Amazon Mechanical Turk and Prolific). The three aspects of monitoring are intensity, transparency, and control. We find that, as the monitoring intensity increases, workers become less likely to accept monitoring. Furthermore, we find that transparency increases workers' willingness to accept monitoring only when the monitoring intensity is low. Interestingly, providing control over high-intensity monitoring does not significantly reduce workers' privacy concerns either, rendering this well-intentioned policy ineffective.

2 - Gendered Heterogeneity In The Effect Of Teleworkability On Labor Market Outcomes During The Covid-19 Pandemic

Jingbo Hou, Arizona State University, Tempe, AZ, 85281-6709, United States, Chen Liang, Pei-yu Chen, Bin Gu

With the massive COVID-19 lockdown, teleworkability plays an important role in determining whether workers can maintain productivity and keep their jobs. However, the impact of teleworkability is likely to be heterogeneous, varying by worker characteristics, such as gender and childcare constraints. This study examines the heterogeneous impact of teleworkability on workers' labor market outcomes (including unemployment, work absence, and layoff). Using stay-at-home order as a measure of labor market disruption, we find that teleworkability can offset the increase in unemployment due to the stay-at-home order by 17%, that in work absence by 22%, and that in layoff by 19%. Specifically, the positive effect of teleworkability is i) stronger for females than males; ii) stronger for females with kids than their male counterparts as well as those without kids.

3 - The Influence Of Status Biases On Crowd-evaluations Evidence From Online Coding Contests

Swanand Deodhar, Indian Institute of Management Ahmedabad

Crowd-based evaluation processes are premised on the assumption that peer evaluation is unbiased. However, peer evaluation may have a status bias as high-status contributors will attract less scrutiny of their contributions. We empirically test this possibility using an online platform for coding contests, Codeforces. It provides contestants with the ability to identify errors in other contestants' submissions for points. We present qualitative evidence followed by large-scale quantitative evidence based on a quasi-experiment to show that the sudden and arbitrary status loss caused affected users to attract systematically more peer evaluations, in the form of increased hacking attempts. We discuss the implications of our findings for the design of crowd-evaluation processes, their efficiency in detecting faults, and for managing the peer evaluation.

4 - Unveiling The Myth Of Behavioral Tracking Using The Internet Of Things (IoT): A Case Of Insurance Telematics

Brian Lee, Pennsylvania State University, State College, PA, 16801, United States, Xinxin Li, Siyuan Liu

IoT empowers firms to devise personalization strategies through behavioral tracking. However, its effectiveness in discerning consumer types to assist personalization strategies has rarely been discussed. Collaborating with an insurance company, we utilize the individual-level data from a field experiment to show that tracking using IoT devices induces a behavioral change under monitoring. Such a behavioral change spills over into the post-monitoring period and manifests through both habit formation and crowd-out effects. More importantly, the magnitude of the behavioral changes depends on the drivers' unobserved intrinsic behavior, which significantly undermines the informativeness of the tracked behavioral data in discerning individual types. These findings call for attention toward utilizing IoT-tracked data for personalization strategies.

■ VSD49

Virtual Room 49

Theory and Applications of AHP/ANP in Supply Chain Management

Sponsored: Multi Criteria Decision Making

Sponsored Session

Chair: Birsen Karpak, Youngstown State University, Youngstown, OH, 44555-0001, United States

Co-Chair: Petrillo Antonella, Parthenope University of Naples, Italy

1 - Model-based Approaches For Interoperability Of Next Generation Supply Chain Management Systems: State Of The Art And Future Challenges: Contributions From Ahp/anp

Gregory Zacharewicz, IMT - Mines Ales, Ales, France

Supply chains are more than ever challenged by competitors. However, supply chain management systems (SCMS) reach a limit in collaborative environments and interoperability objective. Thus, SCMS need to be more interoperable. This presentation can be summarized as follows: (1) it will relate existing work and it examines barriers, and (2) it will propose a conceptual framework and challenges that model based approaches must overcome to achieve interoperability . (3) It will draw out how the use of Analytic Hierarchy Process/Analytic Network Process (AHP/ANP), and co-simulation to support the model-based approaches in the journey from concepts to technical deployment. It will focus on how Business Process Model could be an interesting solution for defining AHP/ANP & HLA execution scenario.

2 - Selection of Sustainable Suppliers Using An Integrated MCDM Approach: A Case Study of Turkey

Sezin Güleryüz, Bartin University, Bartin, Turkey

In this study, the problem of sustainable supplier selection (SSS) is discussed. Since SSS considered a decision process that includes high uncertainty, conflicting goals, multiple interests and perspectives, this work proposes a framework to evaluate SSS by using an integrated Analytical Hierarchy Process (AHP) and TOPSIS techniques.

3 - Analytic Hierarchy Process/Analytic Network Process Applications In Big Data Enabled Supply Chain Management

Birsen Karpak, Youngstown State University, Youngstown, OH, 44555-0001, United States, Ilker Topcu, Fusun Ulengin

We will be reviewing and classifying the application of Big data Business Analytics (BDBA) in supply chain management which we will call Big Data Supply Chain Analytics (BDSCA). We emphasize the need for managers to understand Big Data Business Analytics (BDBA) and Supply Chain Analytics (SCA) as strategic assets that should be integrated across business activities to enable integrated enterprise business analytics. We will also review Analytic Hierarchy Process (AHP)/Analytic Network Process (ANP) and combined applications in bigdata enabled supply chains and will identify new research directions, primary research opportunities.

4 - Selection of a 3PL Service Provider for an Aerospace Company: Analytic Network Process (ANP) Approach

Ozden Bayazit, Central Washington University, Lynnwood, WA, 98036, United States, Birsen Karpak

Third-party logistics (3PL) service providers are becoming important orchestrators of the supply chain. Several criteria are part of the decision-making process, such as price, reliability, service quality, sound financial background, trustworthiness, IT capability, range of services, flexibility, reputation, special expertise, speed of service, and global capabilities. We find out the overall priority of manageable list alternatives as well as the importance of criteria using Analytic Network Process (ANP) since there is dependence among certain criteria.

■ VSD51

Virtual Room 51

Service Science Best Cluster Paper Competition (III)

Sponsored: Service Science

Sponsored Session

Chair: Weiwei Chen, Rutgers University, Piscataway, NJ, 08854-8081, United States

Co-Chair: Robin Qiu, Pennsylvania State University, Malvern, PA, 19355-1488, United States

1 - 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.

2 - 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.

3 - Delay Information in Virtual Queues: A Large-Scale Field Experiment on a Ride-Sharing Platform

Qiuping Yu, Scheller College of Business, Georgia Tech, Atlanta, GA, 30308-1149, United States

We study how the wait time information (WTI) - both its initial magnitude and its subsequent progress - impacts customers' abandonment behavior by conducting a large-scale randomized field experiment on a major ridesharing platform: 1/3 received a neutral WTI, 1/3 received an optimistic WTI (hence less frequent updates), and 1/3 received a pessimistic WTI (hence more frequent updates). We find that both the magnitude of the initial WTI and the update frequency of the WTI have a significant impact on customer abandonment. When adjusting the initial WTI by 1 minute, it did not make a difference. When adjusting the WTI by more than 1 minute, the magnitude effect dominates.

4 - Calibrating Sales Forecast in a Pandemic Using Competitive Online Non-Parametric Regression

Ruihao Zhu, Massachusetts Institute of Technology, Chicago, IL, 60654, United States

Motivated by our collaboration with AB InBev, we consider the problem of forecasting beer sales volumes under the COVID-19 pandemic. Our approach combines non-parametric regression, game theory, and pandemic modeling to develop a competitive online non-parametric regression method. Specifically, the method takes the estimated future COVID-19 cases as an input, and outputs the level of calibration for AB InBev's baseline sales forecast. Experiments with AB InBev's three top markets show that our method is capable of reducing the forecasting error in terms of WMAPE and MSE by more than 40%.

■ VSD52

Virtual Room 52

Service Science IBM Best Student Paper Competition (III)

Sponsored: Service Science

Sponsored Session

Chair: Guiping Hu, Iowa State University, Ames, IA, 50011, United States

Co-Chair: Meng Li, University of Houston, Houston, TX, 77204, United States

1 - COVID-19: A Multipeak SIR Based Model for Learning Waves

Leann Thayaparan, Massachusetts Institute of Technology, Somerville, MA, 02144-1805, United States

The COVID-19 pandemic has been marked by several waves. Traditional epidemiology models are not equipped to handle them. We propose a novel multiwave SIR model, which can dynamically detect and model the waves of a disease by pairing the SIR model's compartmental structure with a change-point detection martingale process. We show analytically this process is expected to detect COVID-19 waves in under a week. We find the multiwave model improves MAPEs by 15%-25% over the original SIR for state-level predictions in the USA. Our model outperforms most of the CDC models in long-term predictions.

2 - Right to Repair: Pricing, Profit, Welfare and Environmental Implications

Cungen Zhu, National University of Singapore, Singapore, 117418, Singapore

The Right to Repair (RTR) movement calls for government legislation asking firms to offer repair information facilitating consumers' self-repair. Repair advocates argue that such legislation can break firms' monopoly on repair markets, benefit consumers, and reduce the environmental impact by reducing e-waste. Yet, the RTR legislation may trigger a price adjustment in product markets in response to the profit loss. Using an analytical model, we study the pricing, welfare, and environmental implications of RTR. We find that as the self-repair cost decreases due to RTR, firms may cut the new product price first and then raise it, which may hurt consumer surplus, social welfare, and the environment.

3 - On Customer (Dis)honesty in Priority Queueing Systems: The Role of Lying Aversion

Arturo Estrada, University College London, London, United Kingdom

We study a two-priority $M/G/1$ queueing system where customers make strategic claims about their true priorities, and where the manager based on those claims, decides on the static scheduling policy to minimize the total expected delay cost. Customers are both delay sensitive and incur psychological costs when they are untruthful. We find that the equilibrium proportion of customers who are untruthful is bounded away from 1, independently of the waiting times in the system. We also find that the optimal scheduling policy deviates from the celebrated $c\mu$ rule. To substantiate our theoretical analysis, we run controlled online queueing experiments where we validate our theoretical insights.

4 - Fast Algorithms For Matching Markets Beyond Stability

Xuan Zhang, Columbia University, New York, NY, 10025-7952, United States

Two-sided matching markets is a flexible model used in many applications (e.g., school choice). In the basic model by Gale and Shapley, the goal is to find a matching between students and schools, who rank each other in strict order, that satisfies a fairness condition known as stability. In this talk, we present structural and algorithmic results for extensions of the original model that aim to regain the efficiency loss due to stability constraints (i.e., to improve the welfare of students): legal assignments and efficiency adjusted deferred acceptance mechanism. Joint work with Yuri Faenza.

5 - Share or Solo? Individual and Social Choices in Ride-Hailing
Hengda Wen, University of Toronto, Toronto, ON, Canada, Ming Hu, Jianfu Wang

Ride-hailing platforms offer riders pooling service to share rides with other riders. The introduction of shared rides mitigates the driver shortage and reduces rider wait times, especially in rush hours, but it may compromise riders' privacy, space, and security. We study a queueing model that accommodates solo and shared rides together, and riders are strategic in choosing which ride to participate: shared or solo. We analyze and compare the strategies of decentralized riders and the centralized social planner on arrival rates and sharing probabilities, under First-In-First-Out (FIFO) and Priority-For-Sharing-Groups (PFSG) principles. We discover that, under the FIFO principle, riders in equilibrium always under-share, compared to the socially optimal fraction of share rides. This leads to under-join due to thinner effective system capacity compared to that under the socially optimal sharing probability. In contrast, under the PFSG principle, riders may over-share to gain priority over solo riders, despite the incurred negative sharing externality. Nonetheless, in equilibrium, the social planner can induce decentralized riders to choose the socially optimal arrival rate by adjusting service prices, and to choose the socially optimal sharing probability by proper social, monetary, or priority schemes. Furthermore, we conduct a numerical study with the ride-hailing data of Chicago, and discover that though riders under-share (resp. over-share) in residential areas (resp. downtown) during morning rush hours and in downtown (resp. residential areas) during evening rush hours, the observed sharing fractions are near the socially optimal ones.

■ VSD53

Virtual Room 53

High Impact Paper Award in Social Media Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Michel Ballings, University of Tennessee, Knoxville, TN, 37996, United States

■ VSD54

Virtual Room 54

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

Committee Choice: Public Sector OR

Committee Choice Session

Chair: Gabriela Gongora-Svartzman, Carnegie Mellon University, Pittsburgh, PA, 15213-3725, United States

Co-Chair: Michael P Johnson, 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.

2 - Challenges Faced By Black Applicants To Graduate Programs In Computing
Ezinne Nwankwo, University of California-Berkeley, Berkeley, CA, United States

While AI has revolutionized many sectors in society, Black people remain underrepresented within the field. In this talk, we describe the Black in AI Academic Program, a program that supports black researchers as they apply to graduate programs, navigate graduate school, and enter the postgraduate job market. We support our applicants with online information sessions, resource documents, and mentorship. We examine the impact of mentorship and the challenges that the 2019-2020 cohort in the program encountered during the application process. Overall 56% of the program participants were successfully admitted, but the lack of information, financial constraints, and unclear academic systems remain the prominent challenges that black people face in applying for AI graduate programs. We discuss the implications and offer recommendations to alleviate these challenges.

3 - Diversity and Inequality in Social Networks
Ana-Andreea Stoica, Columbia University, New York, NY, United States

Online social networks often mirror inequality in real-world networks. Such disparities are often amplified by algorithms that leverage social data to provide recommendations, share information or form groups. I review explanations for algorithmic bias in social networks, addressing information diffusion, grouping, and general definitions of inequality. I use network models that reproduce inequality seen in online networks to characterize the relationship between pre-existing bias and algorithms in creating inequality, discussing different algorithmic solutions for mitigating bias. I address challenges in bridging theory and practice in studying bias and inequality.

4 - Centering Racial Equity In Research And Data Practice
Alex Jackson, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

Creating equitable data practices produces meaningful insights across racial groups while avoiding the common pitfalls that result in harmful data work. Legacies of discrimination can show up in data, and research practices themselves can be exploitative. Centering racial equity is not about avoiding data bias or difficult research questions but focuses on acknowledging that these challenges exist and how to create solutions for tackling them. This talk will cover some of the ways to practice racially aware data collection, analysis, and research. I will highlight high-level considerations that extend to data work with underserved communities broadly and offer resources for further development of equitable data practices.

■ VSD55

Virtual Room 55

Community-engaged Operations Research

Sponsored: Public Sector OR

Sponsored Session

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

1 - Community Based or (CBOR) and its Role in Building Smart Cities
Tayo Fabusuyi, University of Michigan, Ann Arbor, MI, 15206, United States

Much ado has been made about smart cities but what, in a functional sense, constitutes city smartness? Despite the proliferation of technological applications, sensors, and services in the urban space, only incremental improvements in performance have been documented. I examine why this is the case and make the argument that the ill-structured and multidimensional nature of the issues at stake and obscure goals emanating from a multitude of stakeholders are key contributing factors. I subsequently make the case for a community based OR (COR) framework that broadens and enriches conventional design principles to capture the subtleties inherent in most complex challenges in the urban domain.

2 - Use Of CBOR To Understand Housing Priorities of Slum Dwellers In India
Namesh Killemsetty, University of Massachusetts Boston, Milton, MA, 02186, United States

Majority of Government of India's housing programs have only been partially successful in addressing the housing needs and preferences of slum-dwellers, largely because of a lack of a systematic understanding of such needs, and an indifference to their participation during the policy design and implementation process. Taking the case study of four slum communities in the Indian state of Odisha, this paper assesses the slum dwellers' housing preferences by documenting and analysing their decisions. The paper uses Community Based Operations Research (CBOR) to highlight the voices of vulnerable populations such as slum dwellers, and identify solutions to optimize their efficiency and social equity. The findings provide support to the greater need of including community voices and participation in the design and implementation of welfare policies for the urban poor.

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.

4 - Interactions Between Mission-oriented And Profit-oriented Organizations In Community Welfare Programs: A Case Study On Childcare Subsidy Vouchers

Gulten Busra Karkili, University of Massachusetts Amherst, Amherst, MA, 01003, United States, Priyank Arora, Senay Solak

Motivated by examples of child care and housing subsidy voucher programs, we study interactions between profit-oriented and mission-oriented organizations with the goal of improving social impact of such community programs. Our model interrelates operational decisions of a state agency (budget allocation) and different types of service providers (capacity allocation) with quality-adjusted volume of beneficiaries served. Our analysis helps understand how various contextual parameters impact the optimal decisions and payoffs of each entity as well as the generated social impact.

5 - Decisions in Complex Scenarios with Application to Urban Mobility Planning

Tristan Stull, University of Massachusetts-Boston, Boston, MA, 02125, United States

Complex real-world problems often involve many decision-makers, multiple objectives and unknown factors and interactions. Despite the complexities, the observation of an ordered solution space suggests the potential for a rationalist approach emerging from effective information syntheses. We explore complex problems as problems in analytics, with particular application to the design of the 21st century Urban Mobility System. The assumption of a rationalist basis drives the quest for effective decision support based on an epistemologically appropriate representation of the decision context. A correct decision model addresses who actually decides the form of the system, how they do and what kinds of information do they need. The decision model drives an information model, which in turn drives a data handling approach. A series of design-science experiments combines elements of multi-objective optimization, agent-based microsimulation and data mining into exploratory design paths that address the various facets of the complex problem: values divergence, irreducible complexity and uncertainty. A decision support framework in this context will seek the forms of sociotechnically optimal solutions.

■ VSD56

Virtual Room 56

OR/MS in Industry Practice - II

Informs Special Session: Informs Section on Practice

Informs Special Session Session

Chair: Sebastian Souyris, University of Illinois Urbana-Champaign, Champaign, IL, 61820, United States

1 - Efficient Algorithms For The Joint Replenishment Problem With Minimum Order Quantities

Michael Prokle, University of Massachusetts Amherst, Boston, MA, United States, Ana Muriel, Tammana Chugh

Suppliers often impose a minimum order quantity to ensure economically viable production runs and shipping quantities. Additional economies of scale may arise as various items share high joint costs and require coordination of replenishment policies. The buyer needs to find the joint ordering interval and replenishment policies for each of the items to minimize the system-wide ordering and inventory costs. We focus on the case of constant demand without backlogging. We characterize the optimal inventory ordering strategy for each item (showing the sub-optimality of ZIO policies) and derive a closed-form expression for the optimal average inventory costs per period. An extensive computational study shows the total inventory and setup cost reduction, the impact of various parameters on cost and policy performance, and the loss associated with discretizing time.

2 - On-line Control Optimization Of Material Handling Systems

Richard Schrade, President, Automation Intelligence, Atlanta, GA, 30308, United States

Material handling systems must make complex decisions quickly and often. By improving the decision quality, the client presented in this application observed a 7% throughput gain by upgrading only the control logic; no equipment upgrades required. Our patented solution enhances the sophistication of the package assignment system using mixed-integer programs which update the decision strategy every 200ms. As every millisecond counts, we use modern solver features like warm start and max solve time to reliably cycle new, high-quality decisions. This replaces static heuristic logic which comes standard from the equipment manufacturer. Using a scale, physics based digital twin, we are able to test and virtually commission our changes so for a smooth, bug-free migration to the physical system.

3 - Forecasting TV Audience and Programming Ads

Josué Salinas, University of Chile, Santiago, Chile, Sebastian Souyris, Jaime Miranda, Ingasi Neira

The hyper-competitive live and video entertainment industry offers consumers an array of high-quality products. At the same time, content providers must make decisions carefully to maintain a profitable position. Decision-makers must decide what shows to create and acquire at a tactical level to maximize the medium-term ratings. Schedulers must program shows and ads at an operational level to maximize the short-term target demographic viewership and ads revenue. To make the best decisions, data science can take advantage of the recent advances in data management, applied math, and fast algorithms to gain a deep understanding of audience behavior and the competitive landscape. In this talk, we describe what the main challenges are in forecasting TV audiences and programming ads.

■ VSD57

Virtual Room 57

AAS Best Student Presentation Competition (3)

Sponsored: Aviation Applications

Sponsored Session

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

1 - Competitive Integrated Airline Schedule Design and Fleet Assignment

Yifan Xu, Beihang University, Beijing, 100191, China

In this research, we develop an integrated optimization model to derive a comprehensive flight schedule, fleet assignment and average airfares. A hybrid algorithm is developed accordingly based on column generation and large neighborhood search which can achieve two orders of magnitude speedup compared to the branch-and-bound method. The model is incoporated in a Bertrand game with other transport operators through market share model. The game-theoretic framework is applied to a case study of Chinese aviation market with insights for the potential of low-cost service.

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 - Planning Structured Route Network For Drone Delivery In Urban Environments With Efficiency And Fairness

Xinyu He, City University of Hong Kong, Hong Kong, Hong Kong

The rapid development of unmanned aircraft system (UAS) operations in urban environments is emerging worldwide recently. Airspace management is a key issue to enable such UAS operations and spatially separated tubes are feasible solutions. However, there is a lack of efficient algorithm to design such tubes. We develop a distributed multi-path planning method to design such tubes. For individual routes, the methodology formulates conflicts as congestion cost and develops a dynamic update strategy to solve conflicts. It can converge to conflict-free routes. Also, the methodology enables fair competition among individual routes to select the executor for conflict resolution.

4 - 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.

■ VSD58

Virtual Room 58

From Digital to Cyber-Physical Twin: Testbeds, Methods and Applications

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Anike Murrenhoff, Fraunhofer IML, Germany

Co-Chair: Michael Schmidt, Fraunhofer IML, Germany

Co-Chair: Christopher Reining, TU Dortmund University, Germany

1 - A Testbed For The Development Of Cyber-Physical Twins

Moritz Roidl, TU Dortmund University, Germany

A development environment for cyber-physical twins consists of a physical space and its virtual representation. During development of cyber-physical twins, it is important that hardware and software go through rapid development cycles together. We show the setup of a testbed that enables this kind of co-development, including the close connection of reality to virtuality via a motion capturing system and the visualization of virtual objects via a laser projection system. We present a swarm of drones, developed as a cyber-physical twin within the testbed, and show a derived system for sorting packages - the Loadrunner. We briefly address the challenge of replacing the testbed infrastructure with production systems for use in the real world.

2 - Leveraging Human Avatars For Activity Recognition

Christopher Santiago Reining, TU Dortmund University, Dortmund, Germany

"Data is the new gold"'. This remark is particularly true when it comes to human activity recognition in industrial processes using body-worn sensors. Manual activities need to be quantitatively determinable and thus assessable to allow for their enhancement. A classifier for automated activity recognition requires training data.But due to sensor-environment interactions as well as legal and ethical aspects, its creation in real-world facilities poses a challenging task. Thus, methods of augmenting sparse recordings of real humans using a cyber-physical twin offer an appealing solution. This presentation explores how to mine the gold of synthetic motion patterns of human avatars that do justice to the non-deterministic nature of human motion. Their resemblance to reality needs to be sufficient to allow for activity recognition in physical reality.

3 - Deep Reinforcement Learning For Multi-robot Navigation Scenarios

Christian Jestel, Fraunhofer Institute for Material Flow and Logistics, Germany

Multi-robot-navigation is one of the main challenges in mobile robotics. Multiple robots must be coordinated simultaneously to finish their task and have to navigate through a complex dynamic environment without causing collisions. We apply deep reinforcement learning to learn a decentralized end-to-end policy which maps raw sensor data to command velocities of a robot. The policy is trained in an efficient simulation in different environments with multiple robots simultaneously. It is then tested and evaluated in common multi-robot scenarios. We transfer the trained policy from the simulation to a real robot. Despite the reality gap the policy can navigate through unseen real-world environments and reacts to dynamic objects properly.

4 - Towards Re-identification For Warehousing Entities

Jérôme Rutinowski, TU Dortmund University, Germany

Re-Identification is the process of not only detecting but identifying a previously recorded subject over a network of cameras. So far, Re-Identification methods have most commonly been applied to pedestrians, while other entities are rarely the subject of research, possibly due to the developmental infancy that the field still finds itself in. Nonetheless, a plethora of research fields and industries, for instance the warehousing industry and its warehousing entities, could profit from the application of Re-Identification methods. This presentation will therefore discuss the application of such methods to warehousing entities and the benefits that can be derived from their application. In particular, a novel dataset, namely for the Re-Identification of Euro-pallets, along with a Re-Identification algorithm and a corresponding use case will be presented.

5 - Decision Infrastructures For Recurrent Decision-making In Logistics

Anne Meyer, TU Dortmund University, Dortmund, Germany, Katharina Glock, Martin Pouls, Alexandru Rinciog

Decision-making in logistics operations is often recurrent with decision horizons spanning several days down to milliseconds. Varied optimization paradigms exist for decision automation. These paradigms range from myopic heuristics through stochastic or robust optimization to learning-based approaches, e.g. reinforcement learning. The best possible paradigm depends, on the one hand, on the objective and the decision space and, on the other hand, on the available data. Furthermore, different optimization paradigms require different data analysis and preparation steps and often comprehensive training and evaluation simulations. In this talk, we derive requirements for a recurrent decision automation infrastructure, which enables the selection, synthesis, and application of the best decision pipeline possible for operational logistics tasks.

6 - Cyber-Physical Twins In A Silicon Economy

Anike Murrenhoff, Fraunhofer IML, Dortmund, Germany

Digital twins enable physical system states to be mapped into virtuality. They constitute the building blocks of the Silicon Economy - a new kind of inter-connected and self-orchestrated logistics ecosystem. In this new paradigm, all decision-making processes will be based on real-time data streams. As such, the handling of information between a shopfloor and its virtualized counterpart plays a crucial role. Classical approaches for Digital twins use an inadequate centralized, monolithic system architecture. There is a need for a class of digital twins which enables a decentralized, modular architecture and whose integration enables highly scalable, complex systems: cyber-physical twins.

■ VSD59

Virtual Room 59

Tackling Emerging Logistics Challenges With Large-scale Analytics

Sponsored: TSL/Freight Transportation

Sponsored Session

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

1 - 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.

2 - 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.

3 - 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.

4 - 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.

■ VSD60

Virtual Room 60

Countering the Insider Threat

Sponsored: Military and Security

Sponsored Session

Chair: Shaun Doheney, Amazon Web Services (AWS), Stafford, VA, 22554-6548, United States

Co-Chair: Jonathan W. Roginski, United States Military Academy, West Point, NY, 10953-9800, United States

1 - Presenter

Nicholas Ashby, United States Military Academy, West Point, NY, 10996, United States

2 - Presenter

Jungin Lee, United States Military Academy, West Point, NY, 10996, United States

3 - Using Neural Hidden Markov Models To Identify Insider Threat Behavior

David Elkind

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.

4 - Presenter

Jonathan W. Roginski, United States Military Academy, Mountainville, NY, 10953-9800, United States

■ VSD62

Virtual Room 62

Managing Complex Projects

Informs Special Session: Scheduling and Project Management

Informs Special Session Session

Chair: Theodore D Klastorin, University of Washington, ISOM Department, Box 353226, Foster School of Busi, Seattle, WA, 98195-3226, United States

1 - Coordinating Electric Vehicle Charging Station Installation between the Government and Automakers

Musen Kingsley Li, Shanghai University, Shanghai, China, Christopher S. Tang, Joey Yu

Recognizing that accessibility of Electric Vehicle charging stations is an important factor for EV adoption, many governments are contemplating with the ideas of constructing extra EV charging stations directly or offering subsidy to entice automakers to construct more EV charging stations so that a certain EV adoption target is achieved. To do so, governments need to coordinate with automakers to ensure the total number of charging stations is planned optimally. In this paper, we examine this coordination problem and our results can be served as guidelines for the government when contemplating with the idea of coordinating the construction so as to improve EV adoption and the consumer welfare.

2 - Using Bootstrapping and Validating with Regression to Identify the Factors Affecting Construction Projects in India

Goutam Dutta, Indian Institute of Management, Ahmedabad, 380015, India, Sagar Tilwani, Jyoti Trivedi

This study identified 51 attributes responsible for schedule overruns in projects in India(having overrun from 1 to 252 months). We carried out the study through a non-parametric resampling technique called Bootstrap Bias Corrected and Accelerated (BCA) for the determination of critical factors. We developed an improvised Earned Schedule (Corrected Factor) or (ESCF) in order to understand the extent of contribution of critical factors to project schedule performance. The ESCF derived in this paper depicted better performance of the project than the Schedule Performance Index (SPI) in the Earned Value Method (EVM) of project monitoring in three real life projects in city of Ahmedabad, India

3 - 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.

4 - The Impact of Rating Systems on Workforce Performance

Morvarid Rahmani, Georgia Institute of Technology, Atlanta, GA, 30319, United States, Christopher Green

We study the impact that rating systems can have on workforce performance. We compare the performance of a Relative rating system where workers compete with each other for a constrained number of high ratings and an Absolute rating system where workers are awarded high ratings by performing above a known threshold. We characterize the conditions by which workers and firms prefer one system over the other.

■ VSD63

Virtual Room 63

Julia Packages for the Modeling and Solution of Optimization Problems

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Victor M. Zavala, Argonne, IL, 60439, United States

Co-Chair: Joshua Pulsipher, University of Wisconsin-Madison, Madison, WI, United States

1 - 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).

2 - Graph-based Modeling And Optimization Using Plasmo.jl

Jordan Jalving, Sandia National Laboratories, Albuquerque, NM, United States, Sungho Shin, Victor M. Zavala

This talk presents recent advances with Plasmo.jl, a Julia package that performs graph-based modeling to construct and solve complex optimization problems. Plasmo.jl harnesses an abstraction we call the optigraph to express complex problems and reveal innate optimization structures. From a user-standpoint, we show how Plasmo.jl combines modular modeling, graph analysis, and diverse partitioning functions to communicate such structures to solvers. From an algorithm standpoint, we show how the optigraph permits new solver development by discussing its implementation for overlapping schwarz decomposition. We lastly discuss key design elements of Plasmo.jl and how it integrates with the JuMP and MathOptInterface ecosystem.

3 - Reduced-space Optimization Of Data-driven Hybrid Models In EAGO.jl

Matthew E. Wilhelm, PhD Candidate, University of Connecticut, Storrs, CT, United States, Matthew D. Stuber

We discuss several recent advancements added to EAGO.jl relevant to the optimization of hybrid data-driven models. These naturally integrate with EAGO's native approach to generating composite relaxations of nonlinear terms via a reduced-space McCormick relaxations approach. EAGO's flexible design, coupled with a novel modular directed acyclic multigraph backend, allows for direct support of hybrid formulations. We outline several theoretical contributions and detail their implementation in EAGO.jl to illustrate the platform's extensibility. Further, utilize several literature examples to highlight existing capabilities, gaps, and future work relevant to EAGO.jl.

4 - Juniper: An Open-source Nonlinear Branch-and-bound Solver In Julia

Carleton Coffrin, Los Alamos National Laboratory, Los Alamos, NM, United States

Nonconvex mixed-integer nonlinear programs (MINLPs) represent a challenging class of optimization problems that often arise in engineering and scientific applications. Nonlinear branch-and-bound has recently been shown to be an effective heuristic for quickly finding high-quality solutions to large-scale nonconvex MINLPs, such as those arising in infrastructure network optimization. This work proposes Juniper, a Julia-based open-source solver for nonlinear branch-and-bound. Leveraging the high-level Julia programming language makes it easy to modify Juniper's algorithm and explore extensions, such as branching heuristics, feasibility pumps, and parallelization. Juniper provides a strong foundation for further exploration in utilizing nonlinear branch-and-bound algorithms as heuristics for nonconvex MINLPs.

5 - Stochasticprograms.jl: Efficient Stochastic Programming In Julia

Martin Biel, KTH Royal Institute of Technology, Stockholm, Sweden, Mikael Johansson

We present StochasticPrograms.jl, a user-friendly and powerful open-source framework for stochastic programming written in the Julia language. The framework includes both modeling tools and structure-exploiting optimization algorithms. Stochastic programs can be efficiently formulated using expressive syntax and can then be instantiated, inspected, and analyzed interactively. The framework scales seamlessly to distributed environments. Large instances are distributed in a memory-efficient way onto supercomputers or clouds and solved using parallel optimization algorithms. The structure-exploiting solvers are based on the classical L-shaped, progressive-hedging, and quasi-gradient algorithms. We highlight software innovations related to the implementation of the framework and algorithmic innovations related to the structured solvers.

6 - Why SDDP.jUMP?

Oscar Dowson

SDDP.JUMP is a generic open-source solver for multistage stochastic programming problems. However, multistage stochastic programming is a small niche. In this talk we show how SDDP.jl is really just a structured heuristic for finding good control policies for systems with a mix of continuous and integer decisions in the presence of uncertainty.

■ VSD64

Virtual Room 64

Algorithmic Foundations of Reinforcement Learning

Sponsored: OPT/Global Optimization

Sponsored Session

Chair: Yuxin Chen, Princeton University, Princeton, NJ, 08544, United States

1 - Doubly Robust Off-Policy Reinforcement Learning: Convergence and Optimality

Yingbin Liang, Ohio State University, Columbus, OH, United States, Tengyu Xu, Zhuoran Yang, Zhaoran Wang

Designing off-policy reinforcement learning algorithms is a challenging task, because a desirable iteration often involves an expectation over an on-policy distribution. In this work, we develop a doubly robust off-policy AC (DR-Off-PAC) for discounted MDPs, which can take advantage of learned nuisance functions to reduce estimation errors. Moreover, DR-Off-PAC adopts a single timescale structure, and is thus more sample efficient than prior two timescale or nested-loop algorithms. We characterize the sample complexity for DR-Off-PAC to attain an optimal policy with a target accuracy. We also show that the overall convergence of DR-Off-PAC is doubly robust to the approximation errors that depend only on the expressive power of approximation functions. Our study establishes the first overall sample complexity for a single timescale off-policy AC algorithm.

2 - A Model Free Approach To Safely Learning A Safe Policy

Lei Ying, The University of Michigan, Ann Arbor, MI, 48109-2122, United States, Honghao Wei, Xin Liu

Traditional reinforcement learning aims at maximizing the expected cumulative reward, but in practice, many applications need to be operated under a variety of operational constraints. This talk introduces a model-free approach for constrained reinforcement learning, which ensures operational constraints, such as safety and fairness, during both learning and decision making.

3 - Softmax Policy Gradient Methods Can Take Exponential Time to Converge

Yuxin Chen, Princeton University, Princeton, NJ, 08544, United States

The softmax policy gradient (PG) method is arguably one of the de facto implementations of policy optimization in modern reinforcement learning. For discounted infinite-horizon tabular Markov decision processes, remarkable progress has recently been achieved towards establishing global convergence of softmax PG methods in finding a near-optimal policy. However, prior results fall short of delineating clear dependencies of convergence rates on salient parameters such as the cardinality of the state space and the effective horizon, both of which could be excessively large. In this work, we deliver a pessimistic message regarding the iteration complexity of softmax PG methods. We demonstrate that softmax PG methods can take exponential time to converge, even in the presence of a benign policy initialization and an initial state distribution amenable to exploration.

4 - Is Q-Learning Minimax Optimal?
Yuejie Chi, Carnegie Mellon University, United States

Q-learning lies at the heart of reinforcement learning. When it comes to the synchronous setting, for a -discounted infinite-horizon MDP with state space S and action space A: to yield an entrywise -accurate estimate of the optimal Q-function, state-of-the-art theory for Q-learning, however, fails to match with the existing minimax lower bound. This gives rise to natural questions: what is the sharp sample complexity of Q-learning? Is Q-learning provably sub-optimal? In this work, we settle these questions by (1) demonstrating that the sample complexity of Q-learning is at most on the order of |S||A|/((1−)4 2) (up to some log factor) for any 0 < < 1, and (2) developing a matching lower bound to confirm its sharpness. Our findings unveil the sample complexity of Q-learning is in fact considerably higher than the minimax lower bound for problems with long effective horizon.

5 - Bridging Offline Reinforcement Learning and Imitation Learning: A Tale of Pessimism
Cong Ma, University of Chicago, Chicago, IL, 08540, United States

In this talk, we consider offline reinforcement learning (RL), which seeks to learn an optimal policy from a fixed dataset without active data collection. First, we propose a new offline RL framework based on a weak version of the concentrability coefficient that measures the deviation from the behavior policy to the expert policy alone. This allows us to smoothly interpolate between the two extremes of data composition encountered in practice, namely the expert dataset and the uniform coverage dataset. We then investigate a lower confidence bound (LCB) algorithm developed based on pessimism in the face of uncertainty and show that LCB is adaptively optimal for offline contextual bandits, whose optimal rate interpolates between 1/N and 1/sqrt(N) depending on the unknown dataset composition. Here N is the sample size. Bandits and MDPs will also be discussed.

6 - Multi-agent Reinforcement Learning In Networked Systems: Scalability And Role Of Information
Guannan Qu, Massachusetts Institute of Technology, Cambridge, MA, 02138-2933, United States

We study a multi-agent RL setting where each agent is associated with a local state, local action, and the local states evolve according to a networked dependence structure. This problem suffers a scalability issue as the state and action space size scales exponentially with the number of agents. In this talk, we discuss ways to tackle such a curse of dimensionality by exploiting the interaction structure. In doing so, we will also characterize the role of information, i.e. how much we gain if we allow more observations in each agent's decision policy.

■ VSD65

Virtual Room 65

Radiotherapy and Optimization

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Oylum eker, University of Toronto, Toronto, ON, Canada

1 - Predicting Radiation-induced Lymphopenia Risk In Esophageal Patients Treated By Proton And Photon Therapy
Gino J. Lim, University of Houston, Houston, TX, 77204, United States, Saba Ebrahimi, Radhe Mohan, Wenhua Cao

Lymphocytes have a significant role in the body's anticancer immune response. Recent studies showed that the absolute lymphocyte count (ALC) is very sensitive to radiation exposure and the quality of treatment outcome can be variable for different radiation modalities. In this study, we aim to evaluate the relationship between severe lymphopenia and poor treatment outcomes, and compare the potential post-treatment ALC in esophageal cancer patients for three treatment modalities: intensity-modulated radiation therapy (IMRT), passive scattering proton therapy (PSPT) and intensity-modulated proton therapy (IMPT). We proposed two models based on the dose distributions to estimate post-treatment ALC for each patient.

2 - A Sequential Convex Programming Algorithm For Vmat Including Aperture Complexity And Delivery Efficiency
Pinar Dursun, Memorial Sloan Kettering Cancer Center, New York, NY, United States, Joseph O. Deasy, Gourav Jhanwar, Masoud Zarepisheh

Volumetric modulated arc therapy (VMAT) results in a complex and highly non-convex optimization problem and existing algorithms suffer from local optimality. We propose a sequential convex programming (SCP) algorithm that directly optimizes aperture shapes and promotes delivery efficiency and global optimality. The algorithm is equipped with local and global search strategies to promote global optimality and ensure plan quality. Highly complex apertures are excluded using appropriate convex constraints and delivery efficiency is further promoted via convex objective function. The performance of algorithm is tested on three different diseases sites.

3 - An Open Source Analysis Of Optimization Models In Knowledge-based Radiotherapy Treatment Planning
Aaron Babier, University of Toronto, Toronto, ON, M5T0A9, Canada, Binghao Zhang, Rafid Mahmood, Kevin L. Moore, Thomas G. Purdie, Andrea McNiven, Timothy Chan

Knowledge-based planning (KBP) is a two-stage predict and optimization pipeline that generates radiotherapy treatment plans without human intervention. We perform the first open source analysis of KBP and provide the first dataset tailored specifically for testing new KBP optimization models. We show that optimization can eliminate significant differences between high-quality dose prediction methods in a KBP pipeline. This project will enable researchers to improve KBP optimization in an open source setting.

4 - A Multiobjective Approach For Sector Duration Optimization In Stereotactic Radiosurgery Treatment Planning
Oylum Seker, University of Toronto, Toronto, ON, Canada, Mucahit Cevik, Merve Bodur, Young Lee-Bartlett, Mark Ruschin

We present a multiobjective linear programming model for sector duration optimization arising in stereotactic radiosurgery with Gamma Knife delivery systems to generate a diverse collection of solutions so that one that best suits patient-specific needs can be chosen by clinicians. We develop a generic two-phase solution strategy based on the epsilon-constraint method for solving multiobjective optimization models with the aim of systematically increasing the number of high-quality solutions obtained, instead of conducting a traditional uniform search. We also propose an alternative version of it, which makes use of machine learning tools to devote the computational effort rather to solving epsilon-constraint models that are predicted to yield clinically desirable solutions. We test the proposed strategies on eight previously treated real test cases.

■ VSD66

Virtual Room 66

Discrete and Global Optimization for Energy Systems

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Can Li, Carnegie Mellon University, Pittsburgh, PA, United States

1 - Dual Decomposition Of Distributionally Robust Optimization For Distribution System
Kibaek Kim, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

This talk considers the operation model of electric distribution system, where rooftop photovoltaic generators produce uncertain amount of electricity. A distributionally robust optimization (DRO) problem is formulated to model the distribution system operations under uncertain generation. The dual decomposition is applied to the DRO problem, leading to a scalable algorithm. Numerical results demonstrate the computational performance of the dual decomposition algorithm and the implication of using distributional robustness to the model.

2 - Capacity Planning With Uncertain Endogenous Technology Learning
Tushar Rathi, University of Minnesota-Twin Cities, Minneapolis, MN, United States, Qi Zhang

The reduction in the cost of a technology with cumulative installed capacity, aka the endogenous technology learning, is key to capacity planning for renewable technologies that can promptly cease the ongoing adverse climatic changes. However, the rate of cost decline is often difficult to estimate. We propose a stochastic programming (SP) framework that accounts for uncertainty in the learning rate. Next, we propose a branch-and-price decomposition strategy to tackle the intractability due to a large number of binary variables and non-anticipativity constraints. The effectiveness of the proposed framework is demonstrated in a case study involving an integrated energy/technology network.

3 - Optimization Workflows to Quantify the Resource-grid Interactions in Wholesale Energy Markets
Xian Gao, University of Notre Dame, United States

Large-scale penetration of renewable energy into the grid requires new multiscale modeling capabilities to ensure reliable grid operations while mitigating non-dispatchable uncertainty. In this talk, we present a multiscale simulation framework that integrates process- [1-3] and grid-centric [4] modeling paradigms to better understand resource-grid interactions in wholesale energy markets. With the framework, we quantify the impact of strategic bidding from 1 generator on the grid [5]. We show that though there is little impact on the grid-level statistics, such as total generation costs and renewable penetration rate, the profit distribution of the generators has been greatly shifted. We argue analysis of emerging flexible energy systems with dynamic operation must consider interactions with the grid to accurately capture economic impacts and rewards.

4 - Mixed-integer Linear Programming Models And Algorithms For Generation And Transmission Expansion Planning Of

Power Systems

Can Li, Carnegie Mellon University, Pittsburgh, PA, United States, Antonio J. Conejo, Peng Liu, Benjamin Omell, John Siirola, Ignacio E. Grossmann

We propose a mixed-integer linear programming formulation for the generation and transmission expansion planning problem. Three different formulations, i.e., a big-M formulation, a hull formulation, and an alternative big-M formulation, are reported for transmission expansion. We theoretically compare the tightness of the LP relaxations of the three formulations. The proposed MILP GTEP model typically involves millions or tens of millions of variables, which makes the model not directly solvable by the commercial solvers. To address this computational challenge, we propose a nested Benders decomposition algorithm and a tailored Benders decomposition algorithm that exploit the structure of the GTEP problem.

■ VSD67

Virtual Room 67

Methods for Solving Nonlinear and Stochastic Optimization Problems

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Raghu Bollapragada, The University of Texas at Austin, Evanston, IL, 60208-0834, United States

1 - 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.

2 - Retrospective Approximation With Random Restarts Nesterov PGM

Daniel Vasquez, Purdue, West Lafayette, IN, 47906, United States, Raghu Pasupathy, Yi Chu, Yongjia Song

We consider stochastic convex optimization in some specialized contexts, e.g., root-finding, zero-sum matrix games, and overparameterized least squares, where the optimal value is known. We first characterize the complexity results of projected gradient descent (PGD) and Nesterov's PGM when executed with strategic restarts, as a function of the smoothness and sharpness of the objective. We then embed the restarted PGD/PGM in a retrospective approximation framework to arrive at a practical algorithm that automatically adjusts to the smoothness level of the underlying stochastic optimization problem, while retrieving the canonical work complexity.

3 - Newton-MR Algorithms With Complexity Guarantees For Non-convex Optimization

Fred Roosta, University of Queensland and ICSI, St Lucia, 4067, Australia

Classically, the conjugate gradient (CG) method has been the dominant solver in most inexact Newton-type methods for unconstrained optimization. In this talk, we consider replacing CG with the minimum residual method (MINRES), which is often used for symmetric but possibly indefinite linear systems. We show that MINRES has an inherent ability to detect negative-curvature directions. Equipped with this, we discuss line-search and trust-region variants of Newton-MR, which can be used for optimization of general non-convex objectives, and that come with favorable complexity guarantees.

4 - NonOpt: Nonlinear/Nonconvex/Nonsmooth Optimizer

Frank E. Curtis, Lehigh University, Bethlehem, PA, 18015-1518, United States

I will present NonOpt, a C++ software package for solving nonlinear, nonconvex, and nonsmooth optimization problems. The software requires function and (sub)gradient evaluations of the problem functions and employs self-correcting quasi-Newton strategies to improve performance. Bundle and gradient sampling methods are included. The results of numerical experiments on a set of test problems demonstrate the reliability and efficiency of the implementations.

5 - Accelerated And Inexact Proximal-gradient Methods

Daniel Robinson, Lehigh University, Department of Industrial and Systems Engineer, Bethlehem, PA, 18015, United States, Frank E. Curtis

In this talk I present recent work on inexact-proximal gradient methods that use implementable termination conditions within the subproblem solver. These ideas serve as the basis for a stand-a-alone first-order algorithm, but they can also be used within a subspace-accelerated framework that achieves state-of-the-art performance. Numerical results validating our approach will be provided.

■ VSD68

Virtual Room 68

Algorithms for Hierarchical and Distributed Optimization

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Harshal D Kaushik, Oklahoma State University, Stillwater, OK, 74075-4509, United States

Co-Chair: Farzad Yousefian, Oklahoma State University, Stillwater, OK, 74074, United States

1 - Distributed Optimization Problems With Variational Inequality Constraints: Algorithms, Complexity Analysis, And Applications

Harshal D. Kaushik, Oklahoma State University, Stillwater, OK, 74075-4509, United States, Farzad Yousefian

We consider a class of optimization problems with variational inequality (VI) constraints. This formulation captures a wide range of problems, e.g., when the constraint set is complicated by an inner-level optimization problem, equilibrium constraints, or complementarity constraints. First, we assume that the objective function is globally known. We develop a randomized block iteratively regularized gradient scheme and derive non-asymptotic rates for suitably defined suboptimality and infeasibility error metrics. In distributed regimes where the objective function and the mapping of the VI are locally known, we develop an iteratively regularized incremental gradient scheme and derive agent-specific complexity guarantees. The numerical performance is validated on a multi-agent traffic network problem, a Cournot competition model, and a distributed SVM.

2 - A Smoothing-enabled Implicit Zeroth-order Method For Stochastic Mpecs

Shisheng Cui, Pennsylvania State University, University Park, PA, 16801, United States, Uday Shanbhag, Farzad Yousefian

Stochastic MPECs have found increasing relevance for modeling a broad range of settings. Yet, there seem to be no efficient first/zeroth-order schemes equipped with non-asymptotic rate guarantees. We consider MPECs where the lower-level equilibrium problem is given by a deterministic/stochastic VI problem whose mapping is strongly monotone, uniformly in upper-level decisions. We develop a zeroth-order implicit algorithmic framework for three sets of settings: (i) Convex settings. The implicit problem is convex and the lower-level decision is obtainable by inexactly solving a strongly monotone stochastic VI; (ii) Exact oracles and accelerated schemes. The lower-level problem can be resolved exactly; (iii) Nonconvex regimes. The implicit problem is not necessarily convex and the lower-level problem can be inexactly resolved via stochastic approximation.

3 - Distributed Optimization Algorithms For Wasserstein Barycenters

Pavel Dvurechensky, Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany, Darina Dvinskikh, Alexander Gasnikov, Cesar A. A. Uribe, Angelia Nedi

We study the decentralized distributed computation of discrete approximations for the regularized Wasserstein barycenter (WB) of a finite set of continuous probability measures distributedly stored over a network. We assume there is a network of agents/machines/computers, and each agent holds a private continuous probability measure and seeks to compute the barycenter of all the measures in the network by getting samples from its local measure and exchanging information with its neighbors. To solve this problem, we develop, and analyze, an accelerated primal-dual stochastic gradient method for general stochastic convex optimization problems with linear equality constraints and apply this method to the WB problem. Moreover, we show explicit non-asymptotic complexity for the proposed algorithm.

4 - Distributed Randomized Block Stochastic Gradient Tracking Methods

Jayesh Yevale, Oklahoma State University, Stillwater, OK, 74075, United States, Farzad Yousefian, Harshal D. Kaushik

We consider distributed optimization over networks where each agent is associated with a smooth and strongly convex local objective function. We consider stochastic regimes where agents only have access to unbiased estimators of the gradient of their objective functions. Motivated by big data applications, we develop a randomized block coordinate variant of the recently developed distributed stochastic gradient tracking method. We derive non-asymptotic convergence rates in terms of an optimality metric and a consensus violation metric. Importantly, the proposed algorithm appears to be the first randomized block coordinate gradient tracking method that is equipped with the aforementioned convergence rate statements. We validate the performance of the proposed algorithm on the MNIST and a synthetic dataset under different settings.

■ VSD69

Virtual Room 69

Robust and Stochastic Decision-making Under Uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Meng Qi, University of California-Berkeley, Berkeley, CA, 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 a subset 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 best objective, 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 - 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.

3 - 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.

■ VSD70

Virtual Room 70

Decision-making under Multistage uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored 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 - Optimality Criteria Of Constant And Affine Policies In Adjustable Robust Optimization

Peter Zhang, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States, Ningji Wei

We provide general conditions under which constant (a.k.a. static) policies and affine policies (a.k.a., linear decision rules) are optimal for adjustable robust optimization. Our results provide a unifying framework to reinterpret and extend several existing results in the robust optimization literature and provide new geometric insights to understand this class of problems.

3 - A Globalized Perspective to Distributionally Robust Optimization

Shuming Wang, University of Chinese Academy of Sciences, Beijing, China, Feng Liu, Zhi Chen

We consider a globalized distributionally robust optimization (GDRO) counterpart for an inequality involved with expectation of a general random loss function, using Wasserstein metric. The GDRO counterpart not only protects the distributional robustness within a core ambiguity region, but also controls the distributional robustness when the true distribution goes beyond the core ambiguity region. It naturally extends the globalized robust optimization (GRO) to the situation of distributional ambiguity. We show under several conditions, the GDRO counterpart preserves the tractability and some interesting insights can be drawn from the dual reformulations.

4 - A Robust Integration Of EV Charging Load Into Smart Grid's Capacity Expansion Planning

Sajad Aliakbari Sani, HEC Montreal, Montreal, QC, Canada, Erick Delage, Olivier Bahn

With increasing share of electric vehicles (EV) in the transportation systems, battery charging of a fleet of EV is becoming an important load in smart grids. Charging behavior influences not only the expansion and operational plan of the smart grid, but also the total marginal price of electricity production. In this paper, we exploit a Mean-Field-Game (MFG) approach to model how electricity prices affect the charging behavior of a large number of EV users connected to a smart grid. This in turn, allows us to use this information to characterize demand response uncertainty in a conservative approximation of a robust multi-period capacity expansion problem, and iterate until an equilibrium is reached.

5 - 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.

■ VSD71

Virtual Room 71

Integer Programming

Contributed Session

Chair: Munwon Lim, Hanyang University, United States

1 - 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.

2 - ODH|CPLEX - An Optimizer For Hard MIPs

Robert Ashford, Optimization Direct Inc., Harrington Park, NJ, 07640, United States, Alkis Vazacopoulos

Mixed Integer Programming Models (MIPs) commonly solved are becoming larger and more complex in response to much more readily available data and cheaper computer resources. ODH|CPLEX handles large models by co-running a set of heuristics within a traditional branch-and-cut optimizer so as to find good, usable solutions to problems that would otherwise be intractable. We outline the structural decomposition technology used and demonstrate its effectiveness on many user instances as well as its ability to find solutions to standard test models to which no solution has been previously known.

3 - Neighborhood Pricing For Column Generation: A New Matheuristic

Andrew J. Mason, University of Auckland, Auckland, New Zealand, Isaac Cleland, Michael O'Sullivan

Neighborhood pricing is a new general approach for solving large IPs that extends columnwise neighborhood search to column generation by modifying the column generation sub-problem to return columns within some neighborhood of an existing fractional LP or integer solution. We explore generator-friendly neighborhoods for staff rostering, and show that this approach dramatically outperforms standard approaches such a branch and bound dive. We observe that neighborhood pricing can quickly generate dozens of high quality integer solutions, suggesting that the neighborhood structure improves the integrality of the problem.

4 - Fault Diagnosis For Manufacturing Equipment Via 2d Spatio-temporal Process

Munwon Lim, Hanyang University, Seoul, Korea, Republic of, Suk Joo Bae

In manufacturing industries, the production tends to degrade along with the operation time. The deterioration of the machines can lead to decrease the quality of products and the yield of manufacturing processes. Recently, image-based production maintenance based on images has been conducted. In this paper, we suggest 2D stochastic process-based condition monitoring scheme for manufacturing equipment. Based on the stochastic process, the degradation of images with respect to space and time domain is modeled by parametrizing spatial and temporal correlation structures of observations. The application result of automobile production images provides the abnormal detection for the processes.

■ VSD73

Virtual Room 73

Defense & Security Applications

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Einstina Wang, Oxford Academy

1 - Augmenting Military Wargaming With Artificial Intelligence

Christina Rinaudo, USACE Engineer Research and Development Center, Vicksburg, MS, United States, William Leonard, Kayla Houte, Christopher Morey, Phillip L. Bond, Jonathan K. Alt

Advancements in deep reinforcement learning, a sub-field of machine learning, provide the opportunity to develop intelligent systems capable of credibly competing with human experts in military wargame settings. This presentation provides a summary of proof of concept efforts to apply these recent advancements to a military wargaming scenario and discusses challenges and opportunities presented by this emerging field.

2 - Road Detection And Segmentation In Aerial Imagery Using U-Net Architecture

Hyeong Suk Na, South Dakota School of Mines and Technology, Rapid City, SD, United States

In the aftermath of natural disasters such as hurricanes, blizzard or snowstorms, roads are often flooded or swept away, making them treacherous for emergency management agencies or even evacuees. Accordingly, road detection and segmentation from remote sensing images is of great significance to risk assessment and emergency management. In this study, we propose a road detection and segmentation model using U-Net architecture for emergency management. To validate the applicability of our model, the comparative experiments using various remote sensing images are performed, showing that our model can improve on accuracy rates for road detection and segmentation in large-scale datasets.

3 - Allocation Of Resources Between Offense And Defense: The Role Of Espionage

Aniruddha Bagchi, Kennesaw State University, Kennesaw, GA, United States

I examine a game between two countries (Home and Foreign) to determine the choice between offense and defense. The foreign country wants to attack the home country and expends effort in developing a viable plan of attack. The outcome of this effort is uncertain and the home country spends resources to find out the outcome of this development effort. I allow for both missed and false alarm. Based on the intelligence input, the home country first decides whether to undertake a pre-emptive strike. If not, then in the next period, the home country can choose to fortify itself, while the foreign country decides whether to attack. I examine the tradeoff between reducing the missed alarm rate vs. the false alarm rate.

4 - A Closer Look Into Digital Forensics Use In Federal Criminal Courts

Ryan Aponte, University of Florida, Gainesville, FL, United States, Christie Nelson, Fred Roberts, Dennis Egan

We examine criminal court case text data from Thomson Reuters Westlaw and use keyword searches to gain insight into the use of digital forensics in the federal criminal court system. We take steps to provide a more accurate understanding of the prevalence of digital forensics use with the method of keyword searches. Additionally, we search for trends in digital forensics use over time. With this novel understanding, the Federal Law Enforcement Training Centers and the Department of Homeland Security will be able to provide more relevant training to law enforcement.

5 - 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.

■ VSD74

Virtual Room 74

Decision Analysis in Public Policy

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Katharina Ley Best, The RAND Corporation, Pittsburgh, PA, 15217-1452, United States

1 - 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.

2 - Modeling Trades Across Military Readiness & Modernization
Katharina Ley Best, The RAND Corporation, Pittsburgh, PA, 15217-1452, United States

Military force planners must consider competing priorities in any planning environment. For example, they must balance the investment of resources across readiness, capability, modernization, and force size. This talk will describe optimization- and simulation-based capabilities related to analytically describing this high-level decision-space, providing quantitative decision-support and "what-if" analyses. These modeling capabilities examine the effects of tradeoff decisions about readiness policies, force size and mix, modernization investment, force posture, and capability priorities.

3 - City-Heat Equity Adaptation Tool (City-HEAT): A Multi-objective, Uncertainty-based Decision Support Tool for Urban Heat Adaptation
Rui Shi, Johns Hopkins University, Baltimore, MD, 21218-2608, United States, Benjamin Hobbs, Julianne Quinn, Debra Knopman, Robert Lempert

Rising global temperatures and associated intensification of urban heat island effects amplify heat-related health risks to urban residents. Adaptation planning could lessen these risks, but equitable adaptation will need to account for past discriminatory urban planning practices. To fill this need, we propose a health-oriented and equity-based decision framework: City-Heat Equity Adaptation Tool (City-HEAT). City-HEAT generates Pareto-efficient heat adaptation plans that balance multiple objectives and adapt actions in response to observations, enabling robustness to possible future scenarios. The plans consist of region-specific decision rules on the location, timing, and magnitude of different adaptation actions to take to maximize mortality reduction, carbon sequestration, and equity at the lowest cost. In applying City-HEAT to Baltimore, MD, we find an increasing marginal cost of mortality reduction and identify an effectiveness-efficiency-equity trade-off. City-HEAT can be flexibly applied to any city to design adaptation plans that protect human health and enhance social equity.

■ VSD75

Virtual Room 75

Last Mile Science at Amazon

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Liron Yedidsion, Amazon, Redmond, WA, 98052, United States

1 - Package Delivery For Nearest Neighbors
Rohit Malshe, PhD, Amazon, Seattle, WA, United States, Jin Ye, Liron Yedidsion, Dipal Gupta, Abhilasha Katariya, Chinmoy Mohapatra, Natarajan Gautam

Knowing the nearest neighbors of customers is valuable to synchronize deliveries among neighbors. This increases delivery coincidence, reduces vehicle stops, achieves higher efficiency and reduces carbon emissions. We develop a static address aggregation system based on a combination of "Address Management hierarchy" and historical drivers' consolidation of stops on the road. The system forms logical groups in a hierarchical manner starting from the granularity level of two specific addresses that are nearest neighbors to a granularity level as wide as an entire apartment community.

2 - Road Network Aware Zone Design Using Barrier Constrained Voronoi Methods
Dipal Gupta, Amazon, Issaquah, WA, United States, Rohit Malshe, Jin Ye, Chinmoy Mohapatra, Abhilasha Katariya, Liron Yedidsion

We consider the problem of dividing a metropolitan area into smaller geographical units with a constraint that these geographic units must avoid crossing major highways and natural barriers such as rivers, mountains, and forests. We develop an approach that consists of utilizing three barrier-constrained voronoi methods - network voronoi, line voronoi, and raster voronoi - to design barrier-respecting geographic units and ensuring a high degree of road network connectivity within each geographic unit. The geographic units can be used to allocate workload and divide a city into logical blocks according to a chosen metric such as population density.

3 - Solving The Super Rural And Super Dense Delivery With Asset-light Programs
Jin Ye, Senior Research Scientist, Amazon, Bellevue, WA, 98033, United States, Rohit Malshe, Dipal Gupta, Liron Yedidsion, Natarajan Gautam, Chinmoy Mohapatra, Abhilasha Katariya

The low density and wide geographical spread of rural customers makes it financially infeasible to invest in centralized facilities. The high real estate cost within the urban area and a capped labor pool also constrain the service scaling. Amazon's last mile network will need to evolve to include lower cost nodes that enable cost-effective delivery in these extreme geographies. We develop innovative approaches that leverage upon methods based on risk pooling as well as resource sharing to effectively use resources.

4 - 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.

5 - OR-assisted Machine Learning
Abhilasha Katariya, Amazon, Bellevue, WA, 98029, United States, Natarajan Gautam, Rohit Malshe, Jin Ye, Chinmoy Mohapatra, Dipal Gupta, Liron Yedidsion

Although machine learning techniques are frequently used to predict metrics in a future time-frame, a significant limitation is when the feature set used to predict is far outside the historically observed range. For example, the demand could be much higher next year than what has ever been recorded. To assist in such an extrapolation, we consider analytical models and show their effectiveness while using machine learning to perform the heavy lifting.

■ VSD77

Virtual Room 77

Closing the Analytics Talent Gap

Informs Special Session: INFORMS

Chair: Jennifer Priestley, Kennesaw State University, Kennesaw, GA, 30144, 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, 1000 Chastain Road, 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.

■ VSD78

Virtual Room 78

COVID-19 Response and Disparate Impact

Committee Choice: Committee's Choice

Committee Choice Session

Chair: David Morton, Northwestern University, Evanston, IL, 60208-0834, United States

1 - Structural Racism And Covid-19 Response: Higher Risk Of Exposure Drives Disparate Covid-19 Deaths Among Black And Hispanic/Latinx Residents Of Illinois, USA
Jaline Gerardin, Northwestern University, Chicago, IL, United States

In 2020, Black and Latinx communities across the United States, including in Illinois, experienced disproportionately high rates of COVID-19 cases and deaths. Public health officials implemented targeted programs to increase intervention access and reduce disparities. Data on SARS-CoV-2 diagnostic tests, COVID-19 cases, and COVID-19 deaths were used to quantify the evolution of disparities in Illinois. 79.3% and 86.7% of disparities in deaths among Black and Latinx populations respectively were attributable to differences in incidence compared to White populations rather than differences in case fatality ratios. Relative lack of access to health care, crowded living conditions, and high-risk occupations are the result of structural racism, which placed Black and Latinx populations at higher risk of exposure to SARS-CoV-2 and higher COVID-19 mortality.

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.

■ VSD79

Virtual Room 79

AgriTech for Operational Value Chain

Informs Special Session: Agriculture

Informs Special Session Session

Chair: Junmin Shi,

1 - 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.

2 - Blockchain Adoption For Agricultural Supply Chain

Junmin Shi, New Jersey Institute of Technology, Tuchman School of Management, Newark, NJ, 07102, United States

This study investigates the impact of blockchain technology (BCT) on agricultural Supply Chain Management (SCM) and studies the fundamentally inherent design and adoption issues. We consider a stochastically dynamic programming model, where a firm seeks to maximize the total expected discounted profit, by jointly managing (i) blockchain design, (ii) production and ordering decisions, and (iii) dynamic pricing and selling. We first show that the deployment of BCT can assist firms in reducing order quantities, lowering selling prices and reducing target-inventory levels. It is also shown that volatility of either supply or demand lowers the expected profit. The analysis is robust with some major extensions, such as lost-sales of demand and random capacity.

3 - Dynamic Irrigation Management Under Temporal And Spatial Variability

Erkut Sonmez, University of Nebraska Lincoln, Lincoln, NE, 68588-1201, United States, Baris Ata, Derek Heeren

Recent studies report that agricultural productivity must improve significantly in the near future to meet the increase in demand due to rapid growth of the world population. One way to improve agricultural productivity is to increase irrigation. However, fresh water scarcity, increasing production costs, and the climate change necessitate sustainable and efficient methods for irrigation. This paper studies dynamic irrigation management under uncertainty taking into account temporal variability and spatial soil heterogeneity of the field. Our results reveal that proposed (s, S)-type irrigation policies can improve farmers' expected net benefit and water savings significantly over the commonly used irrigation policies in practice.

4 - Blockchain as a Two-sided Platform for Supply Chains

Mahtab Kouhizadeh, University of Rhode Island, Kingston, RI, United States, Sara Saberi, Sang Hoo Bae, Joseph Sarkis

Blockchain platform adoption for supply chains can be modeled as a two-sided market. In this situation, demand markets and suppliers interact with each other and are necessary for effective platform operation. Network economics, supply chain principles and blockchain capabilities inform an economic game theoretic model. The model determines a price structure for a given market seeking to maximize utility for network participants in a two-sided market.

■ VSD80

Virtual Room 80

INFORMS TutORial - Discrete Choice Models and Applications in Operations Management

Tutorial Session

Chair: Douglas R. Shier, Clemson University, Pittsboro, NC, 27312-8612, United States

1 - Discrete Choice Models and Applications in Operations Management

Ruxian Wang, Johns Hopkins University, Carey Business School, Kensington, MD, 20895, United States

Modeling decision behavior among multiple choices has been an active research area for several decades. In this tutorial, we review the classic discrete choice models that are widely used in studying purchase behavior for consumers faced with multiple substitutable products. In addition, many other choice models have also been proposed to capture new features that arise in choice process, such as network effects, consideration set, sequential choice and bounded rationality. We provide an overview for a variety of operations management problems under discrete choice models. Pricing is a widely-used marketing strategy to attract consumers and win market competition. In pricing problems, firms determine prices for all their products to maximize the aggregate expected revenue or profit. We characterize the structure of the optimal prices under various choice models. Assortment management is viewed as another effective retailing strategy. In the assortment problems, sellers are not allowed to change retail prices; for example, some product must be sold at the manufacturer suggested retail price. However, a seller can decide which products should be carried in its store or presented to the arriving consumers. We find the optimal solution to the assortment optimization problems under mild conditions for some discrete choice models, and present efficient approximation algorithms for other problems that are NP-hard. To implement the discrete choice models in practice, a critical step is to calibrate the models using real data. We provide the general estimation procedure for discrete choice models using sales data of different structure, and discuss how to develop algorithms to deal with the issues on choice modeling or data availability.

■ VSD81

Virtual Room 81

Multi-modal Transit Network Design

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Samitha Samaranayake, Cornell University, Ithaca, NY, 14853, United States

Co-Chair: Pascal Van Hentenryck, ISyE Georgia Tech, Atlanta, GA, 30318, 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, 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.

3 - The Value of Choice: A Utility Maximization Model for "Mobility as a Service"

Damon Wischik, Computer Laboratory, University College London, Cambridge, WC1E 6BT, United Kingdom

In transport planning, two steps are (1) modelling the mode choice of travellers, and (2) modelling the routes taken. With on-demandmobility services such as Uber, these steps are coupled: travellersmight choose between bus or Uber based on price; empty vehicles arerouted to where there is demand; and price is set based on supply anddemand. I will describe how the entire system can be modelled as asingle utility maximization problem, combining discrete choicemodelling with flow optimization. The solution lets us read off howmuch of the price of on-demand travel is attributable to the cost ofrunning the system, and how much is profit-making.

■ VSD82

Virtual Room 82

On-Demand Logistics

Sponsored: TSL/Facility Logistics

Sponsored Session

Chair: Alp Arslan, TU DELFT, Singapore, 178902, Singapore

1 - Steering Problem In On-demand Meal Delivery Services

Alp Arslan, TU DELFT, Delft, 178902, Netherlands, Martin W. P. Savelsbergh, Shadi Sharif Azadeh, Yousef Maknoon

One of the main challenges of on-demand meal delivery platforms is to provide an on-time fulfillment service while using limited delivery resources. If the platform has a predetermined courier capacity, the dynamic capacity resizing strategies throughout the day is not possible. In this study, we investigate the impact of courier and demand steering, in which couriers can be repositioned with respect to demand hot-spots or displayed delivery time of some restaurants will be extended. In particular, we propose a mechanism that governs the dispatching decisions through the steering actions. We test our approach in Berlin, Germany using historical data of our industry partner. The results reveal that the supply and demand steering framework increases on-time meal deliveries and decreases the mean order-to-delivery time.

2 - Public Transport-based Crowd-shipping With Backup Transfers

Baris Yildiz, Koc University, Sariyer, 34450, Turkey

With the rising urbanization and booming e-commerce, traditional last-mile delivery systems fail to keep up with the exploding demand and to satisfy the need for faster, cheaper, and more environmentally friendly deliveries. Several new approaches are put forward as an alternative to classical delivery systems in this regard, yet none of them offers the same level of flexibility, capacity, reliability, and managerial control by itself. We propose a new last-mile delivery model that combines several new approaches and technologies to address this issue. The design problem for the envisioned system is formulated as a two-stage stochastic program, and a branch-and-price (BP) algorithm is devised to solve it. Taking advantage of the nearly decomposable structure, we present the first example of using decomposition branching in a BP framework.

3 - On-demand Store Fulfillment Employing In-store Customers And Collaborative Robots

Joyjit Bhowmick, Rensselaer Polytechnic Institute, Troy, NY, United States, Iman Dayarian, Jennifer A. Pazour

Operational designs have traditionally viewed the presence of in-store shoppers as a constraint. This research takes a different approach, viewing a shared facility - with both in-store shoppers and e-commerce orders - as an advantage. We identify, optimize, and evaluate new operational policies that creatively combine in-store customers, collaborative robots, and store employees to support store fulfillment operations in buy-online pick-up-from-store and home delivery services.

4 - Parameterized Cost-function Approximations For Instant-delivery Platforms

Albert Schrotenboer, Assistant Professor, Eindhoven University of Technology, Eindhoven, 5613 SE, Netherlands, Michiel uit het Broek, Paul Buijs, Marlin Wolf Ulmer

Instant-delivery platforms offer local stores the services and support required to fulfill their online sales. Crucial for their success is to maintain high delivery-service quality at any time. However, this is very challenging as the delivery platform faces a complex dynamic, stochastic pickup-and-delivery problem. In that context, the platform needs to balance the urgency of the orders currently known with future consolidation opportunities due to presently unknown future demand. This study introduces a parameterized cost-function approximation (CFA) that can balance urgency and future consolidation. Besides, it accommodates advanced MIP optimization methods to solve the complex routing problem. The CFA consists of only two parameters, is interpretable, and is easy to optimize. Experiments show the efficiency of our method.

■ VSD83

Virtual Room 83

Advances in Connected And Autonomous Vehicles

Sponsored: TSL/Intelligent Transportation Systems

Sponsored Session

Chair: Yangjiao Chen, Marietta, GA, 30067, United States

1 - Proactive Longitudinal Control Of Connected And Autonomous Vehicles With Lane-change Assistance For Human-Driven Vehicles

Yongyang Liu, Georgia institute of Technology, Atlanta, GA, United States, Srinivas Peeta

Connected and autonomous vehicles (CAVs) can enhance traffic safety and alleviate traffic oscillations through cooperative platooning control. However, mixed-flow traffic introduces challenges for CAV operations in terms of lane-change maneuvers of human-driven vehicles (HDVs) in adjacent lanes, which can generate oscillations, jeopardizing the performance of platoon control. This study proposes a proactive longitudinal control strategy for CAVs to assist HDV lane changes and minimize adverse impacts on the smooth operation of a mixed platoon. Further, the generalizability of the proposed control strategy for different HDV driver types is demonstrated.

2 - Sustainability Considerations For Autonomous Vehicles Exclusive Lanes Deployment

Mohammadhosein Pourgholamali, Research Assistant, Purdue University, West Lafayette, IN, United States, Mohammad Miralinaghi, Sania Esmaeilzadeh Seilabi, Samuel Labi

Traffic congestion is a major concern in urban networks. Autonomous vehicles (AVs) introduce benefits of reducing traffic congestion and vehicular emissions, especially with homogeneous AV fleet on dedicated lanes (AVL). In this research, a bi-level optimization framework is proposed to deploy AVL by considering the sustainability pillars including (i) social, (ii) environmental and (iii) equity aspects. This problem is formulated as bi-level multi-objective optimization and solved by Genetic algorithm. Our results show that the proposed framework results in AVL deployment plans that can achieve the system-level goals without imposing excessive travel times on human-driven vehicles.

3 - 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.

4 - Modeling And Analyzing Malicious Information Impacts In A Connected Traffic Environment

Yangjiao Chen, Georgia Institute of Technology, Atlanta, GA, United States, Jian Wang, Kyriakos Vamvoudakis, Srinivas Peeta

Connected vehicles can exchange information with each other to enhance situational awareness and assist the decision-making process. However, cyberattacks can create malicious information to mislead vehicles' perception of the surrounding traffic states and influence their driving strategies. This study seeks to model the impacts of malicious information caused by cyberattacks on traffic flow in a connected environment. Numerical experiments analyze the impacts on traffic performance.

■ VSD84

Virtual Room 84

Nicholson Student Paper Competition: II

Award Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, Pittsburgh, PA, 15217-1420, United States

Co-Chair: Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States

1 - Branch-and-Bound Solves Random Binary IPs in Polytime

Yatharth Dubey, Georgia Institute of Technology, Atlanta, GA, 30318, United States

In this paper our goal is to theoretically analyze the performance of the standard variable branching based branch-and-bound algorithm. In order to avoid the exponential worst-case lower bounds, we follow the common idea of considering random instances. Our main result is that with good probability branch-and-bound with variable branching explores only a polynomial number of nodes to solve these instances, for a fixed number of constraints. To the best of our knowledge this is the first known such result for a standard version of branch-and-bound.

2 - Data-Driven Newsvendor: How Big Should Your Data Really Be?

Omar Mouchtaki, Columbia University, New York, NY, 10027, United States

We study the classical newsvendor problem in which the decision-maker decides inventory without knowledge of the underlying distribution driving uncertainty but only with access to past data drawn from the distribution. 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. We provide the first finite sample exact analysis of the classical Sample Average Approximation algorithm for this class of problems across all data sizes and further derive an optimal algorithm and its performance.

3 - Fast Global Convergence of Natural Policy Gradient Methods with Entropy Regularization

Shicong Cen, Carnegie Mellon University, Pittsburgh, PA, United States, Chen Cheng

Natural policy gradient (NPG) methods, equipped with entropy regularization to encourage exploration, are prevalent in contemporary reinforcement learning, however the theoretical underpinnings remain severely limited. Focusing on tabular discounted Markov decision processes, this work demonstrates that entropy-regularized NPG converges linearly at an astonishing rate that is independent of the size of the state-action space, and is provably stable vis-à-vis inexactness of policy evaluation. This result highlights the role of preconditioning and regularization in enabling fast convergence.