Monday, 6:00AM - 6:30AM

■ VM85-1

Virtual Room 85

Technology Showcase: Medical Resource Optimization with SAS

Technology Showcase

1 - Medical Resource Optimization with SAS

Subramanian Pazhani, SAS Institute, Inc., Cary, NC, United States, Natalia Summerville

This technology showcase demonstrates a new medical resource optimization solution. SAS and Cleveland Clinic have collaborated to develop this solution to help medical organizations effectively manage their resources during the COVID-19 pandemic. After pausing non-emergency visits and elective procedures during the pandemic's initial peak, Cleveland Clinic needed to decide how best to reopen their facilities and services. This solution generates a reopening plan that balances hospital economics, efficient use of resources, and patient access to quality clinical care across multiple locations and numerous medical services. The plan also accounts for the constraints imposed by ongoing COVID-19 testing requirements and test availability.

Monday, 6:00AM - 7:30AM

■ VMA01

Virtual Room 01

Advances in Data Analytics for Operations Management and Decision Making

Sponsored: Data Mining

Sponsored Session

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

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

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

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

2 - Cancelled - Interpretable Control with Synthetic Models

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

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

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

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

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

4 - Data Driven Feature-Based Newsvendor: A Distributionally Robust Approach

Xiaobo Li, National University of Singapore, Singapore, 129790, Singapore

We propose a distributionally robust optimization approach for the newsvendor model with historical demand observations and demand covariates. The new class of distribution ambiguity set based on the reference distribution, which can be obtain from machine learning tools, admits a close-form optimal inventory level. We provide the finite-sample performance guarantee and conduct numerical experiments with both synthetic and real data.

5 - Joint Pricing and Inventory Decision with Risk Hedging

Jin Yao, University of Hong Kong, Hong Kong, China, Liao Wang

We develop and solve a general model integrating pricing, inventory, and financial hedging decisions for a newsvendor. The hedging strategy is found in closed form and risk-return efficient frontier is completely characterized. We show that in presence of risk hedging, the optimal price will be lower than that without hedging. The model is implemented with real data of U.S. automakers.

■ VMA02

Virtual Room 02

Advances in Health Informatics

Sponsored: Data Mining

Sponsored Session

Chair: Haifeng Wang, Mississippi State University, Starkville, MS, 39762-9542, United States

1 - Metastable Epileptic Networks: Investigating the State Transition in Synchronization Patterns

Miaolin Fan, Boston, MA, 02115, United States

Previous studies suggested fractal, heterogeneous synchronization patterns with possible co-existence of opposite neural dynamics in epilepsy. We built a network-based machine learning model by applying recurrence plot-based techniques to intracranial EEG data for describing the nonlinear dynamics by an evolving network. The state transition in epileptic networks during seizure generation, propagation and termination can be characterized using the local and global state transitions within and outside of seizure onset zone.

2 - Deep Learning Architecture Optimization For Medical Image Analysis

Haifeng Wang, Mississippi State University, Starkville, MS, 39762-9542, United States

Deep neural network demonstrates remarkable generalization performance in many machine learning tasks. However, there is still no such a universal model that can always obtain the best performance for all problems, a.k.a., no free lunch theorem. Deep neural architecture design is a time-consuming and challenging task, which is even challenging for medical image analysis due to the limited data size and higher variation of scanning modalities. This talk discusses an adaptive deep learning model for disease classification in 3D medical image analysis. A novel objective function is proposed to optimize both the model convergence trend and the accuracy in the learning process. The experimental results are conducted to validate the performance of the proposed model and demonstrated better performance over many existing approaches.

3 - Detecting Epileptic Seizures Via Non-Uniform Multivariate Embedding Of EEG Signals

Haidong Gu, Northeastern University, Boston, MA, United States, Chun-An Chou

Efficient real-time detection of epileptic seizures remains a challenging task in clinical practice. In this study, we introduce a new thresholding method to monitor brain activities via a non-uniform multivariate (NUM) embedding of multi-channel EEG signals. Specifically, we present a NUM embedding optimization problem to identify the best embedding parameters. We originate one feature, named non-uniform multivariate multiscale entropy (NUMME), which is extracted from the NUM embedded EEG data. Finally, the extracted feature, compared to an individualized threshold, is used for monitoring and detecting seizure onsets. Experimental results show that our approach achieves a comparable performance to the state-of-art methods. Moreover, it is important to note that we accomplish this without using any sophisticated machine learning algorithms.

4 - Functional Regression Based Quantification Of Interruptive Effects For Resuscitation Events In Hospital Emergency Departments

Xiaochen Xian, University of Florida, Gainesville, FL, 53719-2450, United States

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

5 - Apply And Evaluate An Instance-specific Causal Machine Learning Framework For Identifying The Causative Genomic Variants Of Cardiovascular Diseases

Jinling Liu, Missouri University of Science and Technology, Rolla, MO, United States, Md Asad Rahman

The Trans-omics for Precision Medicine (TOPMed) project, led by NHLBI, has recently released huge amounts of whole genome sequencing data accompanied by rich phenotypic data to help advance the understanding of genomic causes for heart, lung, blood and sleep disorders. Previous efforts in identifying genomic variants associated with cardiovascular diseases were mostly via population-based genome-wide association studies (GWAS). We implemented and evaluated an instance-specific causal inference (ICI) framework that is capable of discovering causative genomic variants in a given patient. The ICI framework has a great potential to derive rich information from the TOPMed data for guiding precision medicine in cardiovascular diseases.

6 - Optimal Intervention Portfolio To Improve Health Equity Response In The Coronavirus Pandemic

Yueran Zhuo

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

■ VMA03

Virtual Room 03

Data Analytics for Cyber-Physical Systems

Sponsored: Data Mining

Sponsored Session

Chair: Dan Li, Georgia Institute of Technology, Atlanta, GA, 30309-4360, United States

1 - A Framework for Real-time Traffic Trajectory Tracking, Speed Estimation, and Driver Behavior Calibration at Urban Intersections Using Virtual Traffic Lanes

Abdelhalim Awad, Virginia Tech, Blacksburg, VA, United States

In previous work, we presented VT-Lane, a three-step framework for real-time vehicle detection, tracking, and turn movement classification at urban intersections. Our framework has been proven efficient in trajectory tracking and reconstruction after effectively handling identity switches. We present a case study incorporating the highly accurate trajectories obtained via VT-Lane for the purpose of speed estimation and driver behavior calibration for traffic at urban intersections. First, we use a highly instrumented vehicle to verify the estimated speeds obtained from video inference. We conclude with a value proposition of utilizing the estimated speeds from video inference to calibrate the parameters of a driver behavior model for the vehicles, which can lead to substantial improvements in traffic modeling via microscopic simulation.

2 - Automated Adversary Emulation For Cyber-physical Systems Via Reinforcement Learning

Arnab Bhattacharya, Pacific Northwest National Laboratory, Richland, WA, 99354, United States

Adversary emulation is an offensive exercise that provides a comprehensive assessment of a system's resiliency against cyber attacks. However, adversary emulation is typically a manual process, making it costly and hard to deploy in cyber-physical systems (CPS) with complex dynamics, vulnerabilities, and operational uncertainties. We present an automated, domain-aware approach to adversary emulation for CPS. We formulate a Markov Decision Process (MDP) model to determine an optimal attack sequence over a hybrid attack graph with cyber (discrete) and physical (continuous) components. State-of-the-art reinforcement learning algorithms are used to solve this MDP model in a tractable fashion. We present our findings through a numerical study on sensor-deception attacks in buildings to compare the performance and solution quality of our proposed algorithms.

3 - Secure And Private Market-based Coordination Of Grid Edge Iot Devices

Vineet Jagadeesan Nair, PhD Student, Massachusetts Institute of Technology, Cambridge, MA, United States, Venkatesh Venkataramanan, Anuradha Annaswamy

We propose a suite of hierarchical market structures at the sub-transmission, primary, and secondary feeder levels, in order to effectively use Distributed Energy Resources (DERs) and other IoT devices to increase grid efficiency and resilience. At the grid edge, market operators use decentralized optimization and bilateral contracts to securely aggregate assets. At the upper levels, we use privacy-preserving distributed optimization. Multiple levels of aggregation and disaggregation allow for better differentiation of real-time prices to correctly compensate customers and improve social welfare. We also incorporate additional security cost terms in our objective functions to improve reliability guarantees.

4 - Vertical Federated Learning for Anomaly Detection in Multi Component Cyber Physical Systems

Paritosh Ramanan, Georgia Institute of Technology, Atlanta, GA, 30305-4240, United States

Federated Learning (FL) is a distributed machine learning paradigm that accomplishes large scale learning tasks among multiple user devices with full data privacy. However, classical FL schemes assume homogeneity of features as well as labels across all user devices. In case of large scale multi component systems, classical FL might be infeasible owing to a heterogenous feature set that is scattered across all components/devices. In this talk we present a Vertical Federated Learning framework that eliminates the need to move data for multicomponent systems. Instead, our VFL based approach uses a combination of local and global embeddings to capture interdependencies in the performance at the component level. We demonstrate our results using anomaly detection for a large scale multi component system with a heterogenous feature set at the component level.

■ VMA04

Virtual Room 04

Deep Learning for Image & Video Analysis

Sponsored: Data Mining

Sponsored Session

Chair: Seoung Bum Kim, Korea University, Korea, Republic of

1 - Multi-task Deep Learning For Pallet Image Classification

Chunghyup Mok, Korea University, Seoul, Korea, Republic of, Yoon Sang Cho, Insung Baek, Seoung Bum Kim

The automated-guide forklift with a vision sensor has been recently used for an efficient logistics system. The forklift reaches the target pallet and inserts its forks into the pallet's two holes for pallet transport. However, if the target pallet is tilted left or right, then inserting the forks in the forward direction can cause toppling. This study proposes a multi-task deep learning model that predicts distance and angle classes to guide the forklift to the correct location. The pallet images collected by the vision sensor were used to predict two classes at once. We demonstrate the effectiveness of our method in real-world pallet images.

2 - Deep Learning Model For Obscured Enemy Information Prediction In Starcraft II

Insung Baek, Korea University, Seoul, Korea, Republic of, Jinsoo Bae, Keewon Jeong, Young Jae Lee, Uk Jo, Jaehoon Kim, Seoung Bum Kim

Predicting enemy information is essential in real-time strategy game such as StarCraft II because the gamer make strategies to win considering enemy conditions. However, it is difficult to accurately predict enemy information because the enemy situation is obscured by the fog of war. In addition, real-time strategy games are challenging to predict the enemy information because the information changes over time and various strategies are used. In this study, we propose a deep learning model that can predict the obscured enemy information. We confirm that the effectiveness of the proposed method by demonstrating comparing the predicted enemy information with the hidden enemy information.

3 - Self-supervised Representation Learning For Visual Anomaly Detection And Segmentation

Yongwon Jo, Korea University, Seoul, Korea, Republic of, Seoung Bum Kim

Visual anomaly detection and segmentation are important tasks in computer vision. Many studies have applied a convolutional autoencoder (CAE) to reconstruct abnormal-free images. However, the CAE has a limitation that they can generalize even for abnormal images. Recently, self-supervised representation learning (SSL) has been developed to learn visual features for many unlabeled data. In this study, we propose SSL-based CAE to learn features from abundant abnormal-free images only. Our method detects the abnormal at image-level and pixel-level in terms of out-of-distribution detection. We demonstrate that our method is competitive with the existing CAE method.

■ VMA05

Virtual Room 05

Probabilistic Modeling in Predictive Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Burak Cankaya, Embry Riddle Aeronautical University, Lake Mary, FL, 32746, United States

1 - Realistic Couple Scenes: Modeling Joint Multi-site Extreme Events Distribution For Storm Surge

Priscilla Avegliano, Researcher, IBM Research, Sao Paulo, Brazil, Carlos Raoni Mendes, Emilio Vital Brazil

Climate change is raising essential alterations in the dynamics of weather variables. Risk assessment and resilience planning cannot rely solely on past observations and must incorporate techniques to detect drifts in weather variables behavior rapidly. Moreover, they should efficiently generate a large set of geographical and temporal coherent scenarios. In this work, we introduce a solution to propagate the output of a surge model to multiple locations, sparing several executions of simulations. We tailored the solution for extreme events that will become more frequent with climate change.

2 - Probabilistic Shortest Electric Vehicle Paths: Balancing Efficiency And Reliability

Ridvan Aksu, University of Alabama, Tuscaloosa, AL, United States, Mesut Yavuz

Sustainability efforts and the recent developments in battery technologies are driving the popularity and the market share of Electric Vehicles (EVs) higher than ever. The main obstacles before conquering the market are limited driving autonomy and long charge times. With the state-of-the-art battery technology, we investigated pre-determining a route that minimizes the total waiting and charging costs and employing recourse to update the path in case of severe waiting times. Our analysis includes finding an initial shortest path that allows low expected waiting times and improved worst case times.

3 - Allocating Shelf Space For Fresh Produce Under A Probabilistic Waste Bound

Belleh Fontem, Assistant Professor, University of Massachusetts Lowell, Lowell, MA, United States, Cuibing Wu

We examine a supplier duopoly serving a risk-averse retailer who faces compound Poisson demand for (initially) fresh produce that deteriorates exponentially over time. Each supplier sells a unique food item to the retailer, and upon arrival, a customer elects to purchase at most one item. Moreover, a customer's expected demand quantity is proportional to the amount of remaining fresh stock. The retailer's quest is a profit-maximizing allocation of shelf space subject to a probabilistic upper bound on the total space inadvertently wasted on stale inventory. We determine the retailer's optimal allocation, and characterize the Nash equilibria arising from the suppliers' pricing rivalry.

■ VMA06

Virtual Room 06

Mining Big Data in Energy Systems

Sponsored: Data Mining

Sponsored Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

1 - Big Data Analysis of Synchrophasor Data: Experience from the U.S.

Nanpeng Yu, University of California-Riverside, Riverside, CA, 92521, United States, Feng Qiu

This talk covers the findings from mining terabytes of Phasor Measurement Unit data in the U.S. We will share our experience of analyzing the large-scale PMU data and developing useful tools and algorithms. The discussions and findings will help shape future development and application of faster grid analytics and modeling; better grid asset management; and sub-second automatic control actions that will help system operators avoid grid outages, improve operations, and reduce costs.

2 - A Spatio-temporal Analysis for Power Grid Resilience to Extreme Weather

Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

In recent years, extreme weather events frequently cause large-scale power outages, affecting millions of customers for extended duration. Resilience, the capability of withstanding, adapting to, and recovering from a large-scale disruption, has become a top priority for power sector, in addition to economics and sustainability. However, a good understanding on the power grid resilience, as in many other critical infrastructure resilience study, is still lacking, as most approaches still either stay on the conceptual level, yielding no measurable/actionable results, or focus on a particular technical issue, revealing little insights on the system level.In this study, we take a quantitative approach to understanding power system resilience by directly exploring real power outage data. We first give a qualitative analysis on power system resilience and large-scale power outage process, identifying key elements and developing conceptual models to describe grid resilience. Then we propose a spatio-temporal random process model, with parameters representing the identified resilience capabilities and interdependence between service areas. We perform analyses using our model on a set of large-scale customer-level quarter-hourly historical power outage data and corresponding weather records from three major service territories on the east-coast of the United States under normal daily operations and three major extreme weather events.

3 - Minimizing Power Outage For Energy And Utility Industry With Deep Learning

Levente Klein, IBM, Yorktown Heights, NY, United States, Wang Zhou, Harini Srinivasan, Steve Meliksetian

To minimize power outages many utility companies, trim the vegetation around their power lines on a fixed time cycle. Weekly updates of satellite images enable detection of trees, changes in tree growth, tree health and tree removal. Using the massive volume of satellite and aerial imagery in combination with deep learning tools, utility companies can gain insight into hazardous trees and tree species around their assets that require spot-wise trimming or removal. Operationalizing satellite-based tree detection and hazard calculation, we present a framework that enable prioritization of vegetation-based hazard removal considering cost, crew size, and the volume of wood that needs to be removed.

4 - Wake Effect Calibration In Wind Power Systems With Adaptive And Stratified Sampling Based Optimization

Pranav Jain, PhD student, North Carolina State University, Raleigh, NC, United States

The calibration of the wake effect in wind turbines is computationally expensive. Wake represents the energy loss in downstream turbines and characterizing it is essential in designing wind farm layout. With large data, calibrating the wake parameters is a derivative-free optimization that can be computationally expensive. But with Adaptive Sampling variants of stochastic optimization combined with variance reduction, we can handle the large data and reach robust solutions by harnessing the uncertainty through two sampling mechanisms: the sample size and the sample choices. We do the former by generating a varying number of samples and the latter by the variance-reduced methods of sampling.

1 - Distributed Agent-based Demand Response For Grid Support

Juliette Ugirumurera, Computational Scientist, National Renewable Energy Laboratory, Golden, CO, United States, Devon Sigler

We present a framework for distributed demand response using energy agents, such as electric vehicles, buildings, and battery-storage. We designed this framework using the Scalable Integration Infrastructure Planning modeling framework (SIIP), which provides high-fidelity simulations of power grid operations. We run SIIP production cost models coordinated with demand response agents, where the grid exchange signals with agents to enable distributed load adjustments. The resulting loads are fed back into the production cost models. This process is run once or iteratively, and enables to explore the benefits of distributed agent-based demand response on grid efficiency and resilience.

■ VMA07

Virtual Room 07

Confluence of Data Mining and Business Analysis

Sponsored: Data Mining

Sponsored Session

Chair: Arif Ansari, University of Southern California, University of Southern California, Los Angeles, CA, 90089-0809, United States

1 - Visual Programming: Teachingfor Business Analytics Best Practices

Dursun Delen, Professor & Research Director, Oklahoma State University, Tulsa, OK, United States

A proven way to make learning of the foundational concepts and best practices more intuitive for students is to utilize a visual modeling and workflow-driven analytics platform. The goal is to reduce the syntactic nature of data science so that more time and mental capacity can be spent on concepts. KNIME Analytics Platform (a free and open-source software environment) is an excellent candidate for such an intuitive teaching, learning, and practicing tool. The current presentation will provide evidence and a short tutorial to illustrate the ease use of the KNIME Analytics Platform.

2 - Data Mining and Business Analysis for Efficient Search Engine Marketing
Arif Ansari, University of Southern California, Los Angeles, CA, 90089-0809, United States

In this presentation, we will provide a novel approach to find Search Engine Marketing keywords using multiple datamining methods, like clustering, text explorer, Tree Maps, Probabilistic Simulation, Estimation of Customer Acquisition Cost etc., This presentation will show the confluence of Business Analysis, Analytics and Data Mining to get Competitive Edge.

■ VMA08

Virtual Room 08

Data Analytics and Machine Learning in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Brittany Green, University of Louisville, Cincinnati, OH, 45221, United States

1 - Using Machine Learning to Investigate Brain Changes from Subconcussive Head Impacts in Sports
Brittany Green, University of Louisville, Cincinnati, OH, 45221, United States

Repetitive sub-concussive impacts—those that do not result in symptoms—may have a cumulative, damaging effect to the brain. Traditional approaches to monitor sub-concussive impacts use wearable sensor technology, but these sensors have been shown to overestimate impacts. We propose an alternative predictive modeling approach to increase head impact detection accuracy. Then after classifying impacts, we investigate longitudinal white matter changes to the brain using tensor response regression

2 - Data Mining Attachments to Understand Kidney Utilization
Andrew Placona, UNOS, United States

While the association between structured clinical data and kidney utilization is understood, the association between information from attachments (i.e. PDF forms and photos) and kidney utilization is not well understood. We will describe our efforts to build data mining pipelines for these data. These data mining efforts may inform and shape future technology developments within the organ evaluation process.

3 - Prediction Of Inpatient Disaggregate Length Of Stay For Heterogeneous Demand Using Machine Learning Algorithms And Survival Analysis
Jorge Andrés Acuña, University of South Florida, Tampa, FL, United States, Jose L. Zayas-Castro, Weimar Ardila

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

■ VMA09

Virtual Room 09

Interface between Healthcare and Criminal Justice

Sponsored: Health Applications Society

Sponsored Session

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

1 - Causal Inference with Selectively Deconfounded Data
Kyra Gan, Carnegie Mellon University, Pittsburgh, PA, 15205, United States, Andrew Li, Zachary Lipton, Sridhar R. Tayur

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

2 - Learning Across A Network Of Bandits In High Dimension
Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States, Kan Xu

In applications ranging from healthcare to criminal justice, decision-makers often face multiple bandit decision-making problems. We leverage the network structure across bandit problem instances to efficiently and simultaneously learn across many bandit instances in high dimension. We propose a novel estimator based on robust statistics and LASSO for the static (supervised learning) setting, and embed it within a dynamic bandit algorithm. We prove that our approach yields favorable regret guarantees and we also demonstrate strong empirical performance.

3 - Prioritizing Substance Abuse Treatment In Community Corrections Centers.
Iman Attari, Indiana University, Bloomington, IN, United States, Pengyi Shi, Jonathan Eugene Helm, Nicole Adams

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

■ VMA10

Virtual Room 10

Learning in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: John M Silberholz, University of Michigan Ross School of Business, Ann Arbor, MI, 48103-2380, United States

1 - Evidence Synthesis For Health Technology Assessments: Primer For Operations Researchers.
Thomas Trikalinos, Brown University, Providence, RI, 02912, United States

I will provide an introductory technical overview of evidence synthesis using examples from my work on important and costly decision- and policy-making problems in health. I will enumerate and motivate open problems in health technology assessment methods and applications that are amenable to operational research approaches.

2 - From Data To Prescriptions: An Optimization Framework For Treatment Personalization
Holly Mika Wiberg, Massachusetts Institute of Technology, Cambridge, MA, 02144-2603, United States, Dimitris Bertsimas

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

3 - Do Regulators Adequately Control For The Control Arm? An Empirical Analysis Of Drug Approvals
Xiaoyu Wu, Duke University, Durham, NC, United States, John M. Silberholz, Shourya Verma

For some diseases like cancer, Phase III clinical trials typically compare a new treatment against an active control, which is a standard of care treatment for the disease. Diseases often have multiple standard of care therapies, some of which may yield better or worse outcomes. Therefore, the therapy selected as the active control may make it easier or harder to prove the efficacy of the new therapy. Using a large-scale database of cancer clinical trials, we explore whether Phase III trials selecting weaker therapies for the control arm get an advantage in the drug approval process, using the statistical technique of network meta-analysis to compare the qualities of different standard therapies.

4 - Automating Biomedical Evidence Synthesis Via Nlp: Recent Progress And Current Challenges

Byron Wallace, Northeastern University

Rigorously synthesizing biomedical evidence relevant to a given question entails identifying all available relevant studies, manually extracting from these the data elements necessary for synthesis, and aggregating these to produce a synopsis. This process remains largely manual, and so imposes substantial burden on physicians and other domain experts trying to make sense of the evidence.

In this talk I will discuss work on designing tasks, corpora, and models that aim to realize natural language technologies that can extract key attributes of clinical trials from articles describing them, and infer the reported findings regarding these. I will discuss current technologies, what works well at present, and areas where we will need better machine learning methods to realize more useful models and tools.

■ VMA11

Virtual Room 11

Data-driven Approaches for Combating Healthcare Challenges

Sponsored: Health Applications Society

Sponsored Session

Chair: Ebru Korular Bish, University of Alabama, Tuscaloosa, AL, 24061-2000, United States

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

1 - Optimal Unlabeled Set Partitioning With Application To Risk-based Quarantine Policies

Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States, Jiayi Lin, Su Li, Hadi El-Amine

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

2 - Risk Reduction And Prevention Of Epithelial Ovarian Cancers

Michael J. Hintlian, PhD Student, University of Southern California, Los Angeles, CA, United States, Julia L Higle

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

3 - Heuristic Policies For Spatiotemporal Vaccine Allocation Based On A Compartmental Model With Behavioral Feedback

Julius Barth, University of Texas at Austin, Austin, TX, United States, Diwakar Gupta

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

4 - Explaining Zambia's Childhood Vaccination Success

Francisco Castillo-Zunino, ISyE Georgia Tech, Atlanta, GA, United States, Pinar Keskinocak, Dima Nazzal, Matthew C Freeman

Since year 2000, Zambia has excelled in improving and maintaining high vaccination coverage among low- and lower-middle-income countries; reaching above 90% DTP3 coverage in recent years. Our goal is to understand what factors better explain Zambia's success. We use statistical, matching and classification methods to rank factors by importance so we can better inform policy makers on what factors to prioritize. We use Zambia's Demographic and Health Surveys as primary data sources as they offer household, mother, and child-level granularity with hundreds of samples..

5 - A Quantitative Examination Of The Impact Of A Screening Protocol In Healthcare Delivery

Olga Bountali, University of Toronto, Toronto, ON, Canada, Sila Cetinkaya, Farnaz Nourbakhsh

We consider a patient profile that is subject to 'screen, reject & revisit' loops due to a screening protocol which results in severe hospital congestion and poor patient outcomes. We explore and analyze two alternative proposals: one that modifies the existing protocol considering available capacity, and one that schedules the future revisits in order to regulate patient flow.

■ VMA12

Virtual Room 12

Predictive Analytics towards Improved Health Outcomes

Sponsored: Health Applications Society

Sponsored Session

Chair: Maryam Alimohammadi, University of Arkansas, Fayetteville, AR, 72701, United States

Co-Chair: Maryam Kheirandish, University of Arkansas, Fayetteville, AR, United States

1 - Using Simple Optimization Methods To Enhance The Development Of Stratified Models For Infectious Disease

Anthony C Nguyen, PhD Student, University of Southern California, Los Angeles, CA, 92886-9014, United States, Sze-chuan Suen

Infectious disease models are powerful tools for assessing health policy benefits. It is critical to stratify these models by demographic characteristics, such as race/ethnicity and age, if prevalence, incidence, transmission, or treatment vary across these factors. However, this may be challenging as limited subpopulation-specific data may be available. We use simple optimization techniques to parameterize a race- and age-stratified model of HIV in Los Angeles given limited data from publicly available surveillance reports. Given these straightforward formulations, we hope these formulations can be widely adopted among modelers in public health and epidemiological disciplines.

2 - Social Determinants Of Health Status Trajectories In Older Adults

Ying Lin, University of Houston, Houston, TX, 77204, United States, Jagadeswara R. Earla, Rajender R. Aparasu

There is growing attention for the social determinants of health (SDOH) and associated health inequalities among older adults. But quantitative evaluation of SDOH associated health status changes over time among older adults in the United States is limited. This study conducted secondary analyses if longitudinal panel data of older adults using a Mixture Hidden Markov Model to evaluate latent health state changes over time, clusters in health trajectory, and their associations with demographic, SDOH and chronic health conditions. This study revealed that there are distinct health trajectories in older adults. Both SDOH and comorbidities influence the health status changes over time. Concerted policy efforts are needed targeting SODH to reduce inequities in the health trajectories of older adults.

3 - Feature Engineering For Opioid Overdose Prediction

Shengfan Zhang, University of Arkansas, Fayetteville, AR, 72701, United States, Ryan Sanders, Maryam Alimohammadi

We develop an efficient methodology for extracting features from time-dependent variables in transaction data. Transaction data is collected at varying time intervals making feature extraction more difficult. Unsupervised representational learning techniques are investigated, and the results compared with those from other feature engineering techniques. This methodology is then applied to insurance claims data in order to find features to predict whether a patient is at risk of opioid overdose. Features created are input to recurrent neural networks with long short-term memory cells. Hyperparameters are found through Bayesian optimization. Validation data features are reduced using weights from the best model and compared against those found using unsupervised learning techniques in other classifiers.

■ VMA13

Virtual Room 13

Health Care I

Contributed Session

Chair: Motahareh Tavakolikashi, SUNY at Binghamton, Portland, ME, 04102-3420, United States

1 - Telehealth During The Covid-19 Pandemic: The Impact On The Care Of Patients With Chronic Conditions

Mina Ostovari, Lead Research Investigator, Christiana Care, Wilmington, DE, United States, Vishal Patel, Zugui Zhang

The study population included patients with a diagnosis of diabetes, heart failure, hypertension, and/or chronic obstructive pulmonary disease (COPD). The outcome of interest was the type of visit after March 2020 (office, phone, video). The predictors were the patient's age, gender, ethnicity, race, primary insurance coverage, marital status, Charlson score, diabetes flag, hypertension flag, heart failure flag, and COPD flag. We used generalized estimating equations (GEE) to model the relation between the predictors and the outcome. The GEE model identified all predictors significant except for ethnicity, marital status, and diabetes flag.

2 - Detection Of Blood Clots Within Pulmonary Microcirculation Following E-cigarette Exposure In Mice

Reza Iranzad, University of Arkansas, Fayetteville, AR, United States, Xiao Liu, Margaret Bennewitz, Hunter Snoderly

Edge detection of medical imaging data plays a vital role that helps radiologists, pathologists and improves diagnostic accuracy. In this context, an algorithm is demonstrated through the edge detection of imaging data collected during a medical experiment on mice lungs when exposed to E-cigarette. The edge detection algorithm uses feature engineering coupled with a tree-based ensemble model for medical imaging data. The process helps extract features from raw images and utilizes these features to improve edge detection performance.

3 - An Overview Of Synergistic Organizational Resources In Algorithm-enabled Virtual Patient Care

Amrita George, Marquette University, Milwaukee, WI, United States, Lillian Campbell, Shion Guha

The Covid-19 pandemic has brought the rapid expansion of virtual services and automated patient care. While there is a growing body of research on how organizations can leverage algorithm-enabled systems to make patient decisions, attention to the synergistic combination of organizational resources surrounding the use of these systems in providing virtual patient care has been limited. More importantly, the enablement of new avenues for value-creation has been overlooked. This presentation report how health practitioners within virtual contexts successfully use algorithm-enabled patients care systems based on interviews with health professionals working in a Virtual Intensive Care Unit.

4 - Identifying High Quality Narrative Feedback For Residents In A Teaching Hospital: Application Of Natural Language Processing

Motahareh Tavakolikashi, PhD Student, SUNY at Binghamton, Binghamton, NY, United States, Melissa Zelaya-Floyd, Yong Wang, Mohammad T. Khasawneh

Receiving high quality feedback from attending physician during the residency program is essential for learners in order to develop required competencies. Literature suggests that narrative feedback could be more effective than traditional Likert-type scales and high quality feedback must include particular types of comments such as specific, actionable, reinforcing, corrective, etc. The traditional content analysis method (manual coding) is highly labor and time intensive. In this study we implement Natural Language Processing techniques to automate the process. The developed model has a satisfactory performance level in term of accuracy and significantly decreases the process time.

■ VMA14

Virtual Room 14

New Directions in Revenue Optimization

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Georgia Perakis, Massachusetts Institute of Technology, Belmont, MA, 02478-1706, United States

1 - Motem: Method For Optimizing Over Tree Ensemble Models

Kiran V Panchamgam, Oracle America Inc., Burlington, MA, 01803, United States, Leann Thayaparan, Setareh Borjian Boroujeni, Georgia Perakis

Machine learning tools have become core to forecasting but the most sophisticated models are not easily optimized over. When tree-based models, such as Random Forest or XGBoost, are used in optimization formulations they then require an exponential number of binary decision variables. These formulations do not scale well and result in intractable formulations. In this work, we propose a scalable approximation of the revenue optimization formulation that can optimize over ensemble tree models in linear time while still capturing over 90% of optimality on a variety of datasets. MOTEM (Method for Optimizing over Tree Ensemble Models) is an algorithm for optimizing an objective function that is determined by an ensemble tree model.

2 - Addressing High Dimensional Prediction Challenges in RM Applications

Ioannis Spantidakis, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Tamar Cohen-Hillel, Georgia Perakis, Leann Thayaparan

High dimensional data is a blessing and a curse, often necessary for the most interesting machine learning problems but bringing with it feature-correlation, noise, and long runtimes. This is especially true in retail, where a large amount of information is needed to make optimal decisions. In this research, we develop a new dimensionality reduction algorithm called Supervised Approach for Feature Engineering (SAFE), which is an alternative to Principal Component Analysis (PCA). SAFE finds uncorrelated, lower dimensional features that best explain differences in the dependent variable (e.g., sales) facilitating the prediction task.

3 - XSTrees: Extended Sampled Tree Ensembles For Classification And Regression

Omar Skali Lami, MIT, Cambridge, MA, 2139, United States, Georgia Perakis, Divya Singhvi

Extended Sampled Trees (XSTrees), is a novel tree ensemble method for classification and regression. Instead of learning a single decision tree like CART, or an independent collection of trees like Random Forests, XSTrees learns the entire probability distribution over the tree space. This approach results in good theoretical guarantees and a significant edge over other methods in terms of performance. Analytically, we prove that XSTrees converge to the true underlying tree model with rate O(log(n)/n), where n is the number of observations. Experimentally, we show on publicly available datasets, synthetic data and two real-world case studies that XSTrees are very competitive with the state-of-the-art predictive models, with an average accuracy between 2.5% and 50% higher than competitors for classification, and an average R2 between 2% and 85% higher for regression.

4 - Supply Chain Of Illegal Logging: A Market-based Analysis

Jean-Baptiste Seby, MIT, Cambridge, MA, United States, Saurabh Amin

We present a market-based analysis to study the flow of illegally logged timber in the global supply of wood products. Our network model captures the strategic behavior of exporters of wood who can acquire both legally and illegally harvested timber from loggers in countries that are rich in forest resources. We use this model to study the incentives to inject and mix illegally acquired wood in the global supply chain. We also present insights on targeted monitoring at logging regions (e.g., using remote sensing) and inspection of traded products at import points (e.g., using computer vision).

■ VMA15

Virtual Room 15

Innovative Applications in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ovunc Yilmaz, University of Colorado Boulder, Denver, CO, 80202, United States

1 - On The Timing Of Auctions

Hayri Alper Arslan, University of Texas at San Antonio, San Antonio, TX, United States, Alex P. Arsenault-Morin, Matthew Gentry

This paper structurally estimates the complementarities between heterogeneous contracts in a setting where these contracts are awarded by separate first-price auctions. We establish an identification framework for a structural auction model that incorporates sequential and simultaneous bidding phenomena. We develop an estimation strategy that incorporates firms' entry behaviors following our identification steps and apply it to data on auctions for roof-maintenance projects for public schools in Montreal. We show that complementarities can account for as high as 15 percent of the total size of a contract combination. Motivated by these differences and the size of the complementarities, we develop an algorithm to search a schedule of auctions that decreases the total cost of procurement and show that procurement cost can be reduced by more than 21.5 percent.

2 - Strategic Behavior In A Dual Newsvendor Setting
Nicole Perez Becker, University of Luxembourg, Luxembourg, Benny Mantin, Joachim Jacob Arts

We consider the interaction between a seller and a buyer over two periods. The buyer serves a population of end consumers with uncertain demand. Whereas he can replenish at the beginning of each period, the seller serving the buyer has only one ordering opportunity at the beginning of the horizon. Hence, both agents bear the risk of demand uncertainty and have an incentive to limit this risk (e.g. by rationing). We study this inventory game and the effect that different degrees of strategic behavior have on the profits of the seller in a constant pricing setting. We find that the seller makes as much as, or more, profit when facing a forward-looking buyer than a benchmark myopic buyer. We then consider a sophisticated buyer who additionally accounts for potential stock-outs at the seller. We find that the seller is better off facing a forward-looking buyer over a sophisticated buyer.

■ VMA16

Virtual Room 16

Data Markets

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Azarakhsh Malekian, University of Toronto, Toronto, ON, Canada 02143-2434

1 - The Economics Of Data Externalities
Shota Ichihashi, Bank of Canada, Ottawa, ON, Canada

A firm buys data from consumers to learn about some uncertain state of the world. There are data externalities, whereby data of some consumers reveal information about other consumers' data. I characterize data externalities that maximize or minimize consumer surplus and the firm's profit. I use the result to solve an information design problem in which the firm chooses what information to buy from consumers, balancing the value and price of information. The firm collects no less information than the efficient amount. In some cases we can solve the firm's data collection problem with a two-step concavification method.

2 - Estimation, Data Generators And The Optimal Contract
Tan Gan, Yale University, New Haven, CT, United States,

This paper considers the problem of using monetary transfers to incentivize data generation in data markets. A principal who collects multiple agents' (data generators') data to estimate the unknown state by a fixed estimator attempts to use a data-dependent transfer to incentivize high-quality data generation. I propose a contract using subsample estimation to discipline agents' behavior that can implement the first-best actions under mild conditions, for example, if the principal uses a linear unbiased estimator. The implementation result is robust even if the principal has no knowledge about agents' belief structures and worries about strategic uncertainty. The informational robustness makes it possible to apply the result in the joint design problem, where the estimator is endogenously chosen, under a Bayesian or minimax objective.

3 - Synthetic Interventions
Anish Agarwal

Consider a setting where there are N heterogeneous units (e.g., individuals, sub-populations) and D interventions (e.g., socio-economic policies). Our goal is to learn the potential outcome associated with every intervention on every unit (i.e., N x D causal parameters). Towards this, we present a causal framework, synthetic interventions (SI), to infer these N x D causal parameters while only observing each of the N units under at most two interventions, independent of D. This can be significant as the number of interventions, i.e, level of personalization, grows. Importantly, our estimator also allows for latent confounders that determine how interventions are assigned. Theoretically, under a novel tensor factor model across units, measurements, and interventions, we formally establish an identification result for each of these N x D causal parameters, and establish finite-sample consistency and asymptotic normality of our estimator. Empirically, we validate our framework through both experimental and observational case studies; namely, a large-scale A/B test performed on an e-commerce platform, a phase 3 clinical trial data from a pharmaceutical company, and an evaluation of mobility-restricting policies on COVID-19. We believe this has important implications for program evaluation and the design of data-efficient RCTs with heterogeneous units and multiple interventions.

4 - A Model Of Behavioral Manipulation
Ali Makhdoumi, Duke University, Durham, NC, 27708-9972, United States

The default position among AI researchers is that the vast amounts of data collected by online platforms ultimately benefit users by providing them with more informative advertising, better-targeted products, and more personalized services. This talk raises and explores the possibility that this informational advantage may also enable platforms to engage in behavioral manipulation, which we define as the ability of platforms to modify the behavior of users in a way that is beneficial for the platform and costly for users.

■ VMA17

Virtual Room 17

Data-Driven/Empirical Research

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: So Yeon Chun, INSEAD, Fontainebleau, 77300, France

Co-Chair: Freddy Lim, INSEAD, Fontainebleau, 77300, France

1 - The Impact Of Co-branded Credit Cards On Customer Loyalty
Nan Zhao, Washington University in St.Louis, Saint Louis, MO, United States, Arun Gopalakrishnan, Chakravarthi Narasimhan

We study how adopting co-branded credit cards affects customers' behavioral loyalty with the brand in the context of the airline industry. Leveraging a comprehensive longitudinal dataset from a major North American airline firm, we carefully estimate treatment effects for co-branded credit card adopters by using a combination of propensity score matching and difference-in-differences methods to account for selection effects. Using pre-post data from adopters and our matched control group, we find card adoption increased the frequency of flying, amount spent, and miles earned and redeemed with the focal airline. Further, card adoption decreased customer attrition. We find the effects of the cards persist over time for business travelers, whereas they are short lived for leisure travelers.

2 - Scalable Data-driven Forecasting And Revenue Management With Asymmetric Formation Of Reference Prices
Opher Baron, University of Toronto, Toronto, ON, M5S 3E6, Canada, Dang Cheng, Simai He, Hongsong Yuan

We use e-retail data to consider scalable forecasting and revenue management (RM) for thousands of items. We use forecasts that depend on the novel concept of asymmetric formation of reference prices. We show that such forecasts are accurate and lead to better RM decisions for thousands of items.

3 - Ancillary Services in Targeted Advertising: From Prediction to Prescription
Jiong Wei Lua, Massachusetts Institute of Technology, Cambridge, MA, United States, Alison Borenstein, Georgia Perakis, Divya Singhvi, Omar Skali Lami

The market of online retail has reached $1.5 trillions in the United States alone. Online retailers provide recommendations of ancillary services when a customer is making a purchase. The impact of personalization and display optimization cannot be overstated. We discuss a framework for predicting the Net Present Value (NPV) of these services, estimate the probability of a customer subscribing to each of them depending on what services are offered to them and ultimately prescribe the optimal personalized service recommendation that maximizes the expected long-term revenue. This is joint work with industry collaborator Wayfair.

4 - Monetization Of Loyalty Digital Currency: Mental Accounting And Income Effects On Spending
Freddy Lim, INSEAD, Singapore, Singapore, So Yeon Chun, Ville Satopaa

Many companies have loyalty programs that reward loyalty points for consumers' purchases with the firm, and consumers can use these points to pay for additional purchases. Recently, many loyalty programs have monetized points further by allowing consumers to also earn points via different sources and of different types. We analyze a proprietary dataset from an airline loyalty program to study how consumers decide whether to spend money or points for a purchase and whether consumers' points earning methods affect their payment choices and points spending behaviors. We develop a structural model to describe their decision making process and estimate it with a hierarchical Bayesian setup. We find that different earning methods affect the shapes of their mental accounting functions and perceived values of points differently, leading to different redemption behaviors.

■ VMA18

Virtual Room 18

Recommender Systems and Personalization Techniques

Sponsored: Information Systems

Sponsored Session

Chair: Jingjing Zhang, Indiana University, Bloomington, IN, 47405-1701, United States

1 - Presenter

Meizi Zhou, University of Minnesota, Minneapolis, MN, United States

To regulate companies' usage of consumers' personal data, California Consumer Privacy Act (CCPA) provides consumers in California the "Request to Delete" right. This right requires a business to comply with a consumer's request to delete their personal information that was collected. The new regulation increases the users' control over their privacy; at the same time, it may influence the quality of some services that heavily rely on users' personal data, such as recommender systems. Complying with the Act, companies implement the data deletion practices that are most suitable for their business. In this work, we study how different data deletion practices influence the performance of recommender systems using the simulation-based approach that leverages data collected from a major e-commerce company.

2 - When Variety-seeking Meets Unexpectedness: Incorporating Variety-seeking Behavior Into Design Of Unexpected Recommender Systems

Pan Li, New York University, Stern School of Business, New York, NY, United States, Alexander Tuzhilin

Variety seekers represent those customers who prefer new and fresh content to expand their horizons. Despite its prevalence, the variety-seeking behavior has hardly been studied in the context of recommender systems. In this paper, we propose a two-stage recommendation framework, where we first utilize a novel deep-learning-based model to automatically identify variety-seekers from the consumer group based on consumption records and then provide targeted unexpected recommendations for the identified variety-seekers. We show that the proposed model significantly increases various business performance metrics, as demonstrated through a large-scale online controlled experiment. In particular, we show that it is beneficial to provide more unexpected recommendations for variety-seekers and less unexpected recommendations to non-variety-seeking consumers.

3 - Know Thy Context: Parsing Contextual Information From User Reviews For Recommendation Purposes

Konstantin Bauman, Fox School of Business, Temple University, Philadelphia, PA, 19122-6012, United States

We study an important problem of parsing contextual information from user reviews for recommendation purposes. We study the ways contextual information is expressed in user reviews, and relying on the obtained insights, we design a novel Context Parsing method for systematic extraction of contextual information from user-generated reviews. We apply the proposed method to three different Yelp applications and demonstrate that it works well and systematically extracts more comprehensive sets of relevant contextual variables and corresponding phrases than the baselines. Our analysis also shows the importance of the newly discovered contextual information for recommendation purposes. The obtained results and the proposed method can help to get more comprehensive knowledge about contextual variables in a given application that leads to better recommendations.

4 - Personalization And The Decoy Effect

Nasim Mousavi, Emory University, Marietta, GA, 30062-2088, United States, Jesse Bockstedt, Panagiotis Adamopoulos

In this paper, we study how the decoy effect, a well-studied context effect, impacts the effectiveness of personalization systems. By conducting a controlled experiment and using a real-world movie recommendation system, we find that the decoy effect negatively impacts the effectiveness of the personalized recommendations.

■ VMA19

Virtual Room 19

Stochastic Scheduling for Multi-server Systems

Sponsored: Applied Probability Society

Sponsored Session

Chair: Mor Harchol-Balter, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States

1 - Overview of Multi-server Queueing Problems Inspired by today's Data Centers

Mor Harchol-Balter, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States

Today's computer systems are all multi-server or multi-core. This session examines scheduling problems related to these settings. The first talk will introduce the different models and how they fit into data center computing today. In particular, we cover the "multiserver job" model, where a single job occupies multiple servers for a given amount of time, and the "parallelizable job" model, where a job receives depreciating benefit from each additional core on which it is run. We also report findings from empirical studies of workloads in today's data centers.

2 - Multiserver-job Systems Under Heavy Traffic

Isaac Grosof, Carnegie Mellon University, Pittsburgh, PA, United States

Multiserver-job systems, where jobs require concurrent service at many servers, occur widely in practice. Little is known about these systems in the heavy-traffic regime, where load approaches capacity and queues become long. In this paper, we derive the asymptotic growth rate of response time in the FCFS multiserver-job system. Our result gives a multiplicatively-tight characterization of response time in a FCFS multiserver-job system with any number of servers and any number of classes of jobs. This is the first heavy-traffic response time result in any FCFS multiserver-job system with more than two servers. Our work crucially leverages the idea of a "saturated" system, in which an unlimited number of jobs are always available.

3 - Sharp Zero-queueing Bounds For Multiserver-job Systems

Yige Hong, Carnegie Mellon University, Pittsburgh, PA, United States

Multiserver jobs, which are jobs that occupy multiple servers simultaneously during service, are prevalent in today's computing clusters. But little is known about the delay performance of systems with multiserver jobs. In this paper, we consider queueing models for multiserver jobs in a scaling regime where the number of servers in the system becomes large. Prior work has derived upper bounds on the queueing probability in this scaling regime. But without proper lower bounds, the results cannot be used to differentiate between policies. We focus on the mean queueing time of multiserver jobs, and establish both upper and lower bounds under various scheduling policies. Our results show that a Priority policy achieves order optimality for minimizing mean queueing time, and the Priority policy is strictly better than the First-Come-First-Serve policy.

4 - Optimal Scheduling Of Elastic And Inelastic Jobs

Benjamin Berg, Carnegie Mellon, Pittsburgh, PA, 15201, United States

Modern data centers are tasked with processing heterogeneous workloads consisting of various classes of jobs. These classes differ in their arrival rates, size distributions, and job parallelizability. Some jobs are elastic, meaning they can parallelize perfectly across any number of servers. Other jobs are inelastic, meaning they can only run on a single server. Given these heterogeneous workloads, one must decide how many servers to allocate to each job at every moment in time. We design and analyze scheduling policies which aim to minimize the mean response time across jobs -- the time from when a job arrives until it completes. We show that, in the common case where elastic jobs are larger on average than inelastic jobs, the optimal allocation policy is Inelastic-First, giving inelastic jobs preemptive priority over elastic jobs.

5 - The Case For Phase-Aware Scheduling Of Parallelizable Jobs

Justin Whitehouse, Carnegie Mellon University, PA, United States

Modern computational workloads are characterized by highly parallelizable jobs. While these jobs are often modeled as a single task having a speedup curve, many jobs actually consist of multiple phases of varying parallelizability. Some phases are elastic, or highly parallelizable, and others are inelastic, or fully sequential. Until recently, it was unknown how to schedule these multi-phase jobs in order to minimize mean response time. We show, under some assumptions, a policy called inelastic first, which prioritizes inelastic phases, minimizes mean response time. Additionally, we empirically demonstrate that even when the assumptions are not satisfied, inelastic first outperforms state of the art scheduling policies.

■ VMA20

Virtual Room 20

APS - Reinforcement Learning

Sponsored: Applied Probability Society

Sponsored Session

Chair: Qiaomin Xie, Cornell University, Ithaca, NY, 14850, United States

1 - Randomized Experimental Design In The Face Of Additive Heterogeneous Network Interference

Christina Lee Yu, Cornell University, Ithaca, NY, 14853, United States

Consider the task of estimating causal effects using randomized experiments in the presence of network interference, when an individual's outcome may depend on the treatment of his/her neighbors. Existing solutions either impose restrictive assumptions on the potential outcome models, propose estimators that are too computationally expensive, or use randomization strategies that are challenging to implement for non-trivial network structures. We consider a class of models for potential outcomes that allows for heterogeneous additive network interference effects, and assumes access to historical baseline measurements. We characterize the bias and variance for linear weighted estimators for several causal effects of interest, under a range of classical and modern randomization strategies.

2 - Is Pessimism Provably Efficient for Offline RL?

Zhuoran Yang, Princeton University, Princeton, NJ, 8544, United States

We study offline reinforcement learning (RL), which aims to learn an optimal policy based on a dataset collected a priori. Due to the lack of further interactions with the environment, offline RL suffers from the insufficient coverage of the dataset, which eludes most existing theoretical analysis. In this paper, we propose a pessimistic variant of the value iteration algorithm (PEVI), which incorporates an uncertainty quantifier as the penalty function. Such a penalty function simply flips the sign of the bonus function for promoting exploration in online RL, which makes it easily implementable and compatible with general function approximators.Without assuming the sufficient coverage of the dataset, we establish a data-dependent upper bound on the suboptimality of PEVI for general Markov decision processes (MDPs). When specialized to linear MDPs, it matches the information-theoretic lower bound up to multiplicative factors of the dimension and horizon. In other words, pessimism is not only provably efficient but also minimax optimal. In particular, given the dataset, the learned policy serves as the "best effort" among all policies, as no other policies can do better. Our theoretical analysis identifies the critical role of pessimism in eliminating a notion of spurious correlation, which emerges from the "irrelevant" trajectories that are less covered by the dataset and not informative for the optimal policy.

3 - Decentralized Q-learning In Zero-sum Stochastic Games

Kaiqing Zhang, MIT, Cambridge, MA, 61801-2307, United States

We study reinforcement learning (RL) in infinite-horizon zero-sum stochastic games. We focus on the practical while challenging setting of decentralized multi-agent RL, where the agents are not coordinated by any central controller, and neither the actions nor the payoffs of the opponent agent can be observed. Each agent might be even oblivious to the presence of the opponent. Unlike many existing MARL algorithms, we aim to develop algorithms that are both rational and convergent - the learning dynamics are natural to each agent, converging to the opponent's best-response when the opponent converges to a stationary policy; while the iterates converge to the Nash equilibrium when both agents adopt the learning dynamics. We develop a decentralized Q-learning, with provable convergence guarantees to the Nash equilibrium of the game.

4 - Learning With Side Information: Online Resource Allocation For O-ran 5g Networks

Carlee Joe-Wong, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, Xiaoxi Zhang, Jinhang Zuo, Zhe Huang

Resource allocation in networked systems generally occurs at fine temporal granularities compared to the timescale at which operators can ask users to adjust their demands, e.g., by sending control signals or prices that depend on the amounts of available resources. Finding the right signals to specify, however, is challenging as different users may react differently to these signals. We propose a novel hierarchical online learning framework for operators to leverage "side information" on user demands for resources at a fine temporal granularity in order to learn which control signals they should offer at a coarser time granularity, so as to maximize the collective social welfare. We show this framework accelerates the learning task compared to prior work, and that it can be used to send control signals in emerging 5G wireless network architectures.

■ VMA23

Virtual Room 23

Deep Learning for Quality Assurance In Manufacturing Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

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

Co-Chair: Wenbo Sun, University of Michigan, Ann Arbor, MI, 48104-4951, United States

1 - Deviation-aware Segmentation And Active Landmarks Selection For 3d Printing

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

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

2 - Presenter

Prahalad Rao, University of Nebraska-Lincoln, Lincoln, NE, 68506, United States

Abstract not available at this time

3 - WOOD: Wasserstein-based Out-of-Distribution Detection

Yinan Wang, Virginia Tech, Blacksburg, VA, United States, Wenbo Sun, Jionghua Jin, Xiaowei Yue

The training and testing data in machine learning (ML) is supposed to be sampled from the same distribution, however, this assumption does not always hold when the out-of-distribution (OOD) samples appear because of cyber-attacks. OOD detection is very important when applying the ML model in the real manufacturing system because it directly influences the reliability of the model performance (fooled by OOD samples) and the security of the real system (false alarm caused by cyber-attack). In this work, we propose a general framework to adapt the Wasserstein distance to the machine learning model to detect OOD samples in the image classification task. The proposed framework is compatible with most of the popular image classification models (DenseNet, ResNet, etc.) and outperforms other OOD detection methods.

4 - In-situ Monitoring Of Optical Emission Spectra For Microscopic Pores In Metal Additive Manufacturing

Wenbo Sun, University of Michigan, Ann Arbor, MI, 48104-4951, United States, Zhenhao Zhang, Wenjing Ren, Jyoti Mazumder, Judy Jin

Quality assurance techniques are increasingly demanded in additive manufacturing. Going beyond most of the existing research that focuses on the melt pool temperature monitoring, we develop a new method that monitors the in-situ optical emission spectra signals. Optical emission spectra signals have been showing a potential capability of detecting microscopic pores. The concept is to extract features from the optical emission spectra via deep auto-encoders, and then cluster the features into two quality groups to consider both unlabelled and labelled samples in a semi-supervised manner. The method is integrated with multitask learning to make it adaptable for the samples collected from multiple processes. Both a simulation example and a case study are performed to demonstrate the effectiveness of the proposed method.

■ VMA24

Virtual Room 24

Advanced Maintenance Models

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yisha Xiang, Texas Tech University, Lubbock, TX, 79409, United States

Co-Chair: Ying Liao, Texas Tech University, Lubbock, TX, 79415-5119, United States

1 - Prognosis Analysis Of Breast Cancer Based On Dirichlet Process Mixture Models

Ying Liao, Texas Tech University, Lubbock, TX, 79415-5119, United States, Yisha Xiang, Di Ai, Ning Dong

Breast cancer patients in a particular subgroup often have common disease progression pattern that leads to similar survival outcomes. It is of great importance to identify such subgroups because effective treatments can be developed for the patients based on their corresponding prognostic information. In clinical practices, the number of subgroups is generally unknown and it is also challenging to model the relationships between the group labels and various prognostic factors, such as age at diagnosis, estrogen and progesterone receptors status. In this work, we propose a novel clustering framework to probabilistically label the patients based on the Dirichlet process mixture models. Given the labels, we identify significant prognostic factors using advanced machine learning algorithms and provide some insights for clinical practitioners.

2 - Optimal Condition-based Maintenance For Assets Dispersed On A Graph

Shadi Sanoubar, University of Pittsburgh, Pittsburgh, PA, 15207-1176, United States, Bram de Jonge, Lisa M. Maillart, Oleg A. Prokopyev

This talk is concerned with providing condition-based maintenance via a single maintenance resource to a set of geographically distributed assets. We use graph representation to model possible geographical locations, including idling and asset locations and the links between them. We formulate a Markov Decision Process to dynamically obtain the optimal positioning of the maintenance resource and the optimal timing of the interventions that the resource performs. We explore how the underlying graph structure impacts the maintenance thresholds and the locations most used for idling under the optimal policy, as well as the performance metrics such as resource utilization and asset downtime.

3 - Risk And Resilience-based Optimal Post-disruption Repair For Critical Infrastructures Under Uncertainty

Haitao Liao, University of Arkansas, Fayetteville, AR, 72703-9301, United States, Basem Alkhaleel, Kelly Sullivan

Post-disruption restoration of critical infrastructures (CIs) often faces uncertainties associated with the required repair tasks and the related transportation network. In this paper, two-stage risk-averse and risk-neutral stochastic optimization models are proposed to schedule repair activities for a disrupted CI network with the objective of maximizing system resilience. Both models are developed based on a scenario-based optimization technique that accounts for the uncertainties of the repair time and the travel time spent on the underlying transportation network. An improved fast forward algorithm based on a wait-and-see solution methodology is provided to reduce the number of chosen scenarios. To assess the risks associated with post-disruption scheduling plans, a conditional value-at-risk metric is incorporated into the optimization models.

4 - Maintenance Optimization of an Offshore Wind Turbine Subject to Weather Conditions

Morteza Soltani, Clemson University, Clemson, SC, United States, Jeffrey P. Kharoufeh, Amin Khademi

We consider the maintenance optimization of an offshore wind turbine, where the feasibility of performing maintenance depends on the weather condition. The turbine's degradation evolves as a Markov chain, and the objective is to minimize the sum of the expected total setup, replacement and downtime costs over a finite horizon. We devise a Markov decision process model and establish the existence of a threshold policy, as well as monotonicity of the value function and optimal policy. A novel approach for theoretical sensitivity analyses of key model parameters is also presented.

■ VMA26

Virtual Room 26

Drug Development and Distribution under Uncertainty

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Christopher S Tang, University of California-Los Angeles, Los Angeles, CA, 90095-1481, United States

Co-Chair: Tugce Martagan, Eindhoven University of Technology, Eindhoven University of Technology, Eindhoven, 5611AZ, Netherlands

1 - Outcome-based Reimbursement: The Solution To High Drug Spending?

Liang Xu, University of Nebraska - Lincoln, Lincoln, NE, United States, Hongmin Li, Hui Zhao

The continuously soaring prices of new drugs and their uncertain effectiveness in clinical practices have put substantial risks on insurers/payers. To induce coverage of their drugs, manufacturers propose an innovative outcome-based reimbursement (OBR) scheme, under which manufacturers will refund insurers (and possibly patients) if the drugs does not achieve treatment target. We investigate the optimal design of OBR and its impact on insurer spending, manufacturer profit and patient health benefit. Using data on 14 drugs treating a common disease, hyperlipidemia, we estimate through a Multinomial Logit (MNL) model the demand of the 14 drugs and conduct counterfactual analyses on the impact of OBR.

2 - The Value Of Transparency And Commitment In Pharmaceutical Strategic Partnerships With Contract Research Organizations

Lidia Betcheva, Cambridge Judge Business School, Cambridge, CB2 8BT, United Kingdom, Feryal Erhun, Nektarios Oraiopoulos

Recently, there has been a push to move relationships between pharmaceutical companies and contract research organizations (CROs) from simple arm's length outsourcing transactions to strategic partnerships. Although information sharing and visibility characterize such partnerships, it has been suggested that CROs are given limited insight into their clients' pipelines. We employ game theory to evaluate the role of transparency and commitment in reducing clinical trial durations. Our results carry valuable managerial implications as clinical trial overruns have substantial consequences, financial and otherwise.

3 - Improving Access To Rare Disease Treatments: Subsidy, Pricing, And Payment Schemes

Wendy Olsder, Eindhoven University of Technology, Netherlands, Tugce Martagan, Christopher S. Tang

We consider subsidy programs and pricing mechanisms to improve patient access to rare disease treatments. We present a multi-stage game theoretic mode to capture the interactions among the government, manufacturer, and patients. We consider different pricing and payment schemes, and characterize the optimal R&D effort and the unit selling price for rare disease treatments.

4 - Incentive Programs To Coordinate Research And Development Effort And Capacity Investment For A New Pandemic Vaccine

Mehrnaz Azimi, University College London, London, United Kingdom, Kenan Arifoglu

Developing a pandemic vaccine (e.g., for Covid-19) and building the capacity in advance to bring this vaccine to the market in a timely fashion is very challenging because a vaccine manufacturer, a priori, does not know whether its vaccine will be approved or not. Therefore, the social planner (e.g., a government) must be involved to ensure that the manufacturer has the necessary incentives to develop the vaccine and makes enough capacity investment to make the vaccine available on time. We study different contractual arrangements between a vaccine manufacturer and the government to ensure socially optimal research and development effort and capacity investment.

■ VMA27

Virtual Room 27

Manufacturing II

Contributed Session

Chair: John Meluso, University of Vermont, Burlington, VT, 05403, United States

1 - Double Tolerance Design For A Product Family
Di Liu, Clemson University, Clemson, SC, United States

We consider a production process with multiple types of products that are inspected on the same quality characteristic with target values are different for each product type. We use double tolerance sets to determine which products require reworking. The nonconforming products with measurements that are between two adjacent target values are separated by a shared outer tolerance. This outer tolerance is used to determine into which product type these products should be reworked. We develop a non-linear optimization model to identify the optimal locations of the shared outer tolerances to maximize profit given the trade-off among selling prices, processing costs and quality loss costs.

2 - Strategical Remanufacturing With Upgrading
Mengyun Zhang, Texas A&M University, College Station, TX, United States, Harry Neil Geismar, James Duane Abbey

A product's value decays over time, so upgrading to the current technology is necessary to increase its value. Upgrading can also be incorporated into remanufacturing to improve profitability. We model how to determine whether a remanufacturer should restore a recovered item to its original configuration or should upgrade it to the current technology. In particular, we model the remanufacturing decision in three scenarios, which correspond to three stages during a product's lifetime when there are few, limited, and sufficient recovered items. The results provide guidance and managerial insights on upgraded remanufacturing.

3 - A Review & Framework For Modeling Complex Engineered System Development Processes
John Meluso, University of Vermont, Burlington, VT, United States, Jesse Austin-Breneman, James Bagrow, Laurent Hébert-Dufresne

Experts have expressed great interest in filling the gap in theory about how complex engineered systems (CES) develop. This talk begins to address that gap first by reviewing the numerous definitions of CES and their development processes. Then, it proposes the ComplEx System Integrated Utilities Model (CESIUM), a novel framework for exploring how system and development process characteristics affect the performance of CES by simulating representations of a system architecture, the corresponding engineering organization, and the new product development process. This talk describes the model, sensitivity analysis, validation, and suggests directions for future study.

■ VMA28

Virtual Room 28

Healthcare: Incentives and Operations

Sponsored: MSOM/Healthcare

Sponsored Session

Chair: Kraig Delana, University of Oregon, Eugene, OR, 97403, United States

1 - A Deep Learning Approach To Improve Access To Specialist Care In Referral Networks
Amin Mahmoudian Dehkordi, PhD student, Wilfrid Laurier University, Waterloo, ON, Canada, Michael Pavlin, Salar Ghamat

Access of patients to specialized healthcare services has become a major challenge in most countries in recent years. Patients gain access to specialized services through referral networks. While centralized referral networks increase access of the referrers (general practitioners) to specialists, they tend to balkanize and isolate from neighboring networks. In this paper, we study the application of collaboration between adjacent referral networks and its value to the health system. Using a Deep Learning algorithm, we introduce intelligent routers that are capable of finding optimal referral and internetwork transfer policies in stochastic environments.

2 - Scheduling Smarter: Scheduling Decision Impact On Nurse-Aide Turnover
Kevin Mayo, Indiana University, Bloomington, IN, 47408, United States, Eric Michael Webb, George Ball, Kurt M. Bretthauer

High turnover rates in long-term nursing facilities exacerbates the current and worsening shortage of caregivers. Part-time Certified Nursing Assistants (CNAs) provide a significant amount of patient care in these facilities and have high turnover rates, potentially harming health outcomes and increasing cost of care. We empirically analyze the effect of scheduling decisions on part-time CNA turnover. Using novel data for 6,221 part-time CNAs at 157 facilities over a 26-month period, we identify three scheduling levers that can reduce turnover: reducing co-worker variability, reducing variation in weekly scheduling and increasing hours worked which follows a nuanced non-linear relationship. These findings suggest that smart managers will benefit from identifying quality workers and assigning them more consistent schedules as part of a team.

3 - Religious Ownership, Physician Leadership And Operational Strategies: Empirical Study In German Hospitals
Sandra Sülz, Erasmus University, Rotterdam, 3062 PA, Netherlands, Ludwig M. Kuntz, Michael Wittland

Hospitals are under pressure to improve their business models and have engaged in strategies aiming to increase patient volume or emphasizing certain services and treatment fields. Previous research showed that Catholic hospitals more likely follow a strategy of horizontal diversification and maximation of the number of patients treated, whereas Protestant hospitals follow a strategy of horizontal specialization and focus on vertical differentiation. However, there is no empirical evidence pertaining to the mechanism. We argue that physician leadership mediates the relationship between ownership and operational strategies and conduct an empirical study in the German setting.

4 - On The Trade-off Between Efficiency And Fairness: Evidence From An Emergency Department
Basak Bebitoglu, London Business School, London, W2 6NE, United Kingdom, Nicos Savva, Tolga Tezcan

We look at how healthcare providers in an emergency department make a trade-off between fairness and efficiency in setting patient priorities. A fair policy in our context corresponds to a first-come-first-served type of policy, while an efficient policy corresponds to a policy that can treat more number of patients in a shorter amount of time, which in return can improve delays in treatment. With these definitions at hand, we hypothesize that healthcare providers in an emergency department setting give importance to both fairness and efficiency, but as the system gets busier, efficiency gains more importance against fairness. Our analysis reveals a more fundamental phenomenon in service systems where humans are involved: the queueing policy can be endogenous to system's state unlike what the majority of the operations management literature assumes.

■ VMA29

Virtual Room 29

Mitigating Climate Risk in the Energy Sector - Emerging Business Models and Regulatory Interventions

Sponsored: MSOM/iForm

Sponsored Session

Chair: Siddharth Prakash Singh, University College London, London, E14 5AA, United Kingdom

1 - Uncertainty in Carbon Tax Policy and Its Effect on Investment in Renewable Electricity Generating Capacity
Thomas Palley, Indiana University, Bloomington, IN, United States, Asa Palley, Owen Wu

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

2 - Investment Decisions For A Microgrid Price Dependent And Independent Demand Cases

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

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

3 - Performance-Based Contracts For Energy Efficiency Projects

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

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

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

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

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

5 - Community Solar Value Generation and Distribution

Siddharth Prakash Singh, UCL School of Management, London, United Kingdom, Owen Wu

Fueled by policy efforts to decarbonize the electricity grid, intermediate scale solar projects are gaining traction through community solar, an innovative business model in which residential customers pay a local solar project developer (via an ongoing subscription fee or an upfront investment) for a share of solar capacity. These customers are compensated for the generation of their share by the utility, at a bill credit rate set by the regulator. We study how the community solar business model generates value and how this value is distributed among all the players, using a model that endogenizes the adoption decisions of heterogeneous customers and the solar developer's pricing decisions in response to the bill credit rate. Our analysis provides guidance on regulating community solar programs to achieve both high value generation and equitable value distribution.

■ VMA30

Virtual Room 30

Laurens' Session

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Laurens G. Debo,
Dartmouth College, Hanover, NH, 03755-9000, United States

1 - Sourcing Innovation And Production

Cuihong Li, University of Connecticut, School Of Bus, Storrs, CT, 06269-1041, United States, Xiaoshuai FAN, Ersin Korpeoglu

We consider a firm sources the design and production of an innovative product from two risk-neutral suppliers. The value of the design depends on the supplier's effort and buyer's subjective taste, while the production cost is private information of suppliers. Through comparing non-commitment, joint-sourcing, and separate-sourcing mechanisms, we find that 1) when the marginal innovation cost is large and the efficiency loss, which occurs when a supplier produces the design provided by another supplier, is small, non-commitment mechanism generates the highest profit for the buyer; 2) when the marginal innovation cost is small, and the efficiency loss is large, the separate mechanism dominates others; otherwise, the joint mechanism is the best. The above results are derived by the tradeoff between allocation efficiency and effort incentives provided to suppliers.

2 - Order Ahead For Pickup: Promise Or Peril?

Luyi Yang, University of California-Berkeley, Berkeley, CA, 94002, United States, Yunan Liu

Recent years have seen growing adoption of order-ahead among quick-service restaurants. Ordering ahead enables customers to place orders on demand remotely and then travel to the service facility for pickup. It is widely believed that order-ahead reduces delay and therefore attracts more orders than if customers must order on-site. We build queuing-game theoretic models to study the implications of order-ahead for delay announcement and system throughput.

3 - To Tip Or Not To Tip: An Analytical Study

Laurens G. Debo, Dartmouth College, Hanover, NH, 03755-9000, United States, Ran Snitkovsky

We develop and analyze a model in which customers leave a tip in a service setting to express their gratitude for the service, while at the same time, they feel pressured by a social norm, which emerges endogenously over time. We discuss why it is difficult in an industry to break such norm.

■ VMA31

Virtual Room 31

Empirical Research in Operations Management

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Ashish Kabra, University of Maryland-College Park, College Park, MD, 20740-3119, United States

1 - Reading Between The Stars: Understanding The Effects Of Online Customer Reviews On Product Demand

Hallie Cho, Vanderbilt, Nashville, TN, 37203, United States, Manuel Sosa, Sameer Hasija

Consumer perceptions of product quality—and how they are shared via customer reviews—are of extreme relevance to the firm, but we still do not understand how the quantitative and qualitative aspects of customer reviews affect product demand. Our paper seeks to fill this critical gap in the literature by analyzing star ratings, the sentiment of customer reviews, and their interaction. Using the US automobile market data, we find robust empirical evidence that 1) review sentiment and star ratings both have a decreasingly positive effect on product demand and 2) the effect (on demand) of their interaction suggests that the two components of reviews are complements. Positive sentiments in text reviews increase the positive effect of ratings when the effect of ratings is decidedly positive and they compensate for the tendency of consumers to discount extremely high star ratings.

2 - Value Of Promotions With Delayed Incentives

Bharadwaj Kadiyala, University of Utah, Salt Lake City, UT, 84112-8939, United States, A. Serdar Simsek, Ozalp Ozer

A gift card promotion provides customers an incentive to spend more than an expenditure level on regularly priced (as opposed to discounted) products, by rewarding customers with a gift card to be redeemed against a future purchase. Using a regression discontinuity design, we empirically test and quantify the causal effects of gift card promotion on the retailers' revenue and the mechanisms through which it impacts customers' purchase behavior. We find that about 18.50% to 38.14% of the retailer's total online channel revenue during promotion days can be attributed to gift card promotion. Further, customers who redeem their earned gift cards increase their expenditures (beyond the face value of the gift card) by 23.3%, on average.

3 - Exploring The Trilateral Productivity In Surgery Teams: Do Agents, Pairs, And Teams Affect Each Other?

Jaeyoung Kim, PhD Candidate, Clemson University, Clemson, SC, United States, Lawrence Fredendall, Ahmet Colak, Robert Allen

We study the effect of micro-level foundations of surgical teams on team productivity: interactions among individuals (agents), dyads (pairs), and teams. Using six datasets containing the micro-level characteristics of surgical teams (e.g., patient, operation, staff, procedure, scheduling, and surgeons) obtained from a large south-eastern hospital, we show that surgical teams have trilateral relationships where the micro-level team characteristics affect each other: while individuals and dyads affect the macro-level team performance, the rest of the team also affect the micro-level individual and dyad performance. Our study adds to the prior literature by showing the different effects of learning on individuals and dyads, which enhances the micro-level organizational design of hospitals.

4 - Time Allocation In Sequential Experiences: Model And Application To Museums

Abhishek Deshmane, PhD Candidate, IESE Business School, Barcelona, Spain, Ali Aouad, Victor Martinez de Albeniz

Visitor experience at museums depends on the assortment of the artworks and the artwork-display program. In this paper, we seek to develop a framework to inform the curatorial decisions by considering heterogeneous preferences of the visitors. We make use of a detailed log of visitor movement across one of the world's most-visited museums. We develop a Markov Chain model to establish

the relationship between the artwork-display program, the order in which the visitors choose to view the artworks and their overall time budget for the visit. We build a DP model for visitor-time allocation for the viewing of each artwork with imperfect information about what is to come next. This is simplified to a full-information state to get a reduced form expression that is used to simulate the visitor utility for different artwork assortments and display programs to compare it with NPS scores.

■ VMA33

Virtual Room 33

Applied Research in Supply Chains

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Christina Imdahl, Kuhne Logistics University, Hamburg, 20535, Germany

1 - Inventory As A Financial Instrument: Evidence From China'S Metal Industries

Jing Wu, Chinese University of Hong Kong, Decision Sciences and Managerial Economics, Hong Kong, Hong Kong, Vernon Hsu

Classical inventory theory suggests that inventory plays a vital role in matching demand and supply. This paper provides both macro and micro evidence that inventory can be used as a financial instrument to take advantage of arbitrage opportunities in financial markets with limited capital mobility. Using data from China's country-level metal commodity imports and firm-level inventory from metal processing industries (with metal commodities as primary inputs), we show that firms can utilize the inventory of an imported product to carry lower-cost capital into a country with strict capital controls and thus gain higher financial returns. We also utilize a unique regulatory policy shock as a natural experiment to establish causality in our empirical analysis.

2 - Planogram Design In The Presence Of Store Brands And Shelf Display Fees

Yasin Alan, Vanderbilt University - Owen Graduate School of Management, Nashville, TN, 37203-2405, United States, Mumin Kurtulus, Alper Nakkas

We examine how store brands (SBs) and display fees, which manufacturers pay retailers for prime shelf space, affect retailers' planogram decisions (i.e., placement of products on shelves). We consider a game-theoretic model with one retailer and two national brand (NB) manufacturers. The NB manufacturers determine their wholesale prices and how much they are willing to pay for the prime shelf space, while the retailer makes assortment and planogram decisions and sets retail prices. Our study generates three insights. First, the common practice of giving the prime shelf space to a high sales volume product can be suboptimal for the retailer. Second, the retailer can carry the SB in its assortment to increase its display revenue. Third, display fees can increase the NB manufacturers' profits.

3 - Sourcing Under Supply Disruption And Responsibility Violation Risks: A Behavioral Investigation

Vincent (Junhao) Yu, University of Minnesota, Minneapolis, MN, 55455-0438, United States, Karen L Donohue, Karthik Natarajan

We combine modeling and experimental methods to investigate how managers make sourcing decisions between a high-cost supplier with no risk and a low-cost supplier with potential risks. We focus on two types of risk: (1) supply disruption risk that influences the flow of product supply, and (2) responsibility violation risk that influences the flow of customer demand. To better understand the differences between these two risk types, we propose a framework to disentangle their differing dimensions and introduce new risk types to serve as references for comparison. Through a series of behavioral experiments, we demonstrate how elements of different risk types can shape buyers' ordering decisions through cognitive processing and affective reactions.

4 - The Impact Of Trade Credit Provision On Retail Inventory: An Empirical Investigation Using Synthetic Controls

Nitish Jain, London Business School, London, NW1 4SA, United Kingdom

This paper identifies the causal impact of trade credit on inventory decisions at the retailer level. We use an empirical strategy that leverages: (i) an exogenous shock imparted by the French government's intervention to impose a ceiling on trade credit repayment; (ii) a triple difference-in-differences identification strategy; and (iii) Synthetic Controls. We find that, in retail sectors affected by the French regulation, the decrease in trade credit led to both an economically and statistically significant decline in firms' inventory levels.

5 - Targeted Automation Of Order Decisions Using Machine Learning

Christina Imdahl, Kuehne Logistics University, Hamburg, 20535, Germany, Kai Hoberg, William Schmidt

In many practical settings, human decision makers can review the recommendations that a decision support model generates and either approve or override the recommendation. We develop a set of ML models in conjunction with our research partner, a large materials handling equipment manufacturer, and employ the models using our partner's procurement ordering process. Using only features that are available at the time a system makes a recommendation, our proposed set of ML models predict (1) whether or not the decision maker will modify the recommendation and (2) whether such a modification will improve or impair the performance of the system. We identify a material portion of the order recommendations that can be automated with little, or even a positive, impact on performance.

■ VMA34

Virtual Room 34

Energy, Carbon, and Climate Change

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Karthik Murali, Oregon State University, Corvallis, OR, 97331, United States

1 - Investment In Wind Energy: The Role Of Subsidy Policies

Safak Yucel, Georgetown University, Washington, DC, 20057, United States, Saed Alizamir, Foad Iravani

Motivated by an ongoing debate among policymakers, we investigate how the government should offer investment and production subsidies to promote wind energy investment. We find that the government should offer the two subsidies simultaneously only if the societal benefit from wind energy is sufficiently high. Otherwise, the government should offer only the investment subsidy, but not the production subsidy. This finding suggests that the government's current practice of offering only the production subsidy is suboptimal.

2 - Scaling Up Battery Swapping Services In Cities

Wei Qi, McGill University, Montreal, QC, Canada, Yuli Zhang, Ningwei Zhang

Battery swapping for electric vehicle refueling is reviving and thriving in our cities. Some cities are embracing an emerging infrastructure network in which decentralized swapping stations replenish their inventory of charged batteries from centralized charging stations that are colocated with grids of sufficient capacity. In this paper, we model this new infrastructure network to understand its cost and environmental implications. In a broader sense, this work deepens our understanding about how mobility and energy are coupled in future smart cities.

3 - Carbon Offsetting With Eco-conscious Consumers

Fei Gao, Indiana University, Bloomington, IN, United States, Gilvan Souza

We study how a firm should voluntarily reduce its carbon footprint by purchasing offsets for both its controllable and uncontrollable emissions in the supply chain, in the presence of a segment of eco-conscious consumers. We also provide insights into how NGOs may set their offset prices to achieve maximum carbon footprint reduction at the product level.

■ VMA35

Virtual Room 35

Power System Expansion Planning Considering New Technologies

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Enzo Sauma, Pontificia Universidad Catolica de Chile, Santiago, Chile

1 - Co-optimized Transmission And Distribution System Expansion Planning

Javier Contreras, University of Castilla-La Mancha, Spain, Gregorio Muñoz-Delgado, José M. Arroyo, Agustín Sánchez de la Nieta, Madeleine Gibescu

The increased deployment of distributed generation calls for the coordination and interaction between the transmission and distribution levels. We address the integrated expansion planning problem of transmission and distribution systems where investments in network and generation assets are jointly considered. Uncertainty is characterized through a set of scenarios that explicitly capture the correlation between the uncertain parameters. The resulting stochastic program is driven by the minimization of the expected total cost, which comprises the costs related to investment decisions and system operation. The associated scenario-based deterministic equivalent is formulated as a mixed-integer linear program for which finite convergence to optimality is guaranteed. Numerical results show the effective performance of the proposed approach.

2 - Second-best Transmission Planning Under Different Carbon Regulation Regimes

Yinong Sun, Johns Hopkins University, Baltimore, MD, 80215, United States, Benjamin Field Hobbs

Deregulation in the electricity sector calls for a proactive approach in transmission planning to fully consider market interactions between generation companies and policy impacts. In this study, we model transmission planning as a Stackelberg game using a bi-level optimization model to investigate how transmission expansion plan would change with different carbon policy schemes. Specifically, we aim to answer two questions: 1) how transmission planning would be different under multiple carbon regulation regimes, and what are the corresponding welfare implications? 2) given regional carbon policies, whether and how second-best transmission planning can help reduce carbon emissions?

3 - Expansion Planning Effects Of Battery And Pump-hydro Energy Storage Systems

Enzo E. Sauma, Pontificia Universidad Catolica de Chile, Santiago, 00001, Chile, Martin Larsen

In this work, we assess the long-term expansion planning effects of Energy Storage Systems (ESS), using a two-stage generation, transmission, and storage expansion planning model. The effects of including an adaptive planning step, where investments can be adjusted to long-term demand trends, and those of including ramp and reserve constraints are analyzed. The methodology is illustrated using a 45-bus representation of the Chilean power system. Our results show that ESS help reducing total system costs, albeit slightly increasing CO2 emissions. Likewise, including the adaptive (two-step) approach significantly changes the generation and transmission expansion mix, as well as the emission levels.

■ VMA36

Virtual Room 36

Progress in Harnessing the Potential of Energy Storage

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Miguel Anjos, University of Edinburgh, United Kingdom

1 - How Quebec Can Support The Energy Transition Of Northeastern North America

Viviane Aubin, Analyst, Hydro-Québec, Montréal, QC, Canada, Marko Blais, Miguel F. Anjos

Northeastern North America is transitioning rapidly from fossil fuel generation to variable renewable energy (VRE) sources. Their integration into electricity grids poses challenges in terms of matching supply with demand. Once VRE represent a large share of installed capacity, intermittency and variability of production will become an issue. Hydro-Québec, the public electric utility in the Canadian province of Québec, has a large hydropower generation fleet. Its storage capacity enables adjusting hydro production to support VRE integration. Potential impacts of VRE growth within neighbouring grids are simulated through operational production management models. The results show that Hydro-Québec has the potential to facilitate this energy transition but that the current electricity market structure does not provide incentives for an optimal contribution.

2 - Market Integration Of Behind-the-meter Residential Energy Storage

Bárbara Rodrigues, University of Edinburgh, Edinburgh, United Kingdom, Miguel F. Anjos, Valérie Provost

A new business opportunity beckons with the emergence of prosumers. We propose an innovative business model to harness the potential of aggregating behind-the-meter residential storage in which the aggregator compensates participants for using their storage system. A bilevel optimization model is developed to evaluate the potential of this business model and determine the optimal compensation scheme for the participants. A realistic Texas case study confirms the year-round profitability of the model, showing that participants could earn on average nearly $1500 per year, and the aggregator could make an average profit of nearly $2000 per participant annually. The case study shows that this business model has potential, and that the main driver for a successful implementation is a suitable setting of the compensation paid to participants for using their storage system.

3 - Optimal Control Of Multiple Electric Energy Storage Units For Arbitrage With Market Impact

Albert Solà Vilalta, University of Edinburgh, Edinburgh, United Kingdom

Energy storage and demand-side response will play an increasingly important role in the future electricity system. How should one optimally manage a fleet of electric energy storage units with market impact to maximize profit from arbitrage by buying electricity when it is cheap and selling it when it is expensive? We compare two different approaches for this problem, one based on Dynamic Programming and the other on Alternating Direction Method of Multipliers (ADMM). Our focus is on the practical implications of having multiple storage units, extending previous results for a single storage unit.

■ VMA37

Virtual Room 37

Energy Infrastructure Resilience and Economic Impacts

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Mohamad Darayi, The Pennsylvania State University, Malvern, PA, United States

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

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

Mohamad Darayi, The Pennsylvania State University, Malvern, PA,United States

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

2 - A Review On Energy Infrastructure Resilience: Modeling, Metrics And Data Analytics

Harsh Anand, Pennsylvania State University, Malvern, PA, United States, Mohamad Darayi

In recent years, energy infrastructure, one of the critical infrastructure sectors (CIs), has experienced revolutionary shifts in multiple aspects. These infrastructures are highly interconnected within themselves and other CIs to run the overall economy. In this study, we have reviewed the literature related to energy infrastructure resilience in two broad domains - systems modeling and analytics, to understand the challenges and the open problems faced by the research community. The study is conducted for the readers to understand (1) analytical approaches to solve the critical challenges in energy infrastructure resilience and (2) different modeling techniques used to reach the objectives.

3 - A Multiple-drones-multiple-trucks Routing Problem For Disruption Assessment

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

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

4 - RI-Based Control Systems for Networked Power Infrastructures

Namrata Saha, Florida International University, Miami, FL, United States, Shabnam Rezapour, Mohammadhadi Amini

Coordination in today's large power systems is critical to satisfy demand fluctuations and reduce the required generation capacity. In this paper, we employ Reinforcement Learning (RL) techniques to design a control system to enhance coordination among facilities and minimize the power production cost. The controlling agent of the RL observes the the system's state (e.g., demand volumes), perform actions (e.g., production volumes), and get rewards or punishments as the effect of their actions. Therefore, agent gets trained in the environment, find an optimal policy towards the system's goal, and establish a smart energy system.

■ VMA38

Virtual Room 38

Water and Energy Modeling

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Nathalie Voisin, Pacific Northwest National Lab., Seattle, WA, 98109, United States

1 - Hydropower Scheduling Toolchains In Norway, Brazil And United States

Albert C. G. Melo, Associate Professor, UERJ - Rio de Janeiro State University, Rio de Janeiro, Brazil

Hydropower resources in Norway, Brazil and United States are substantial, relying on large watersheds with complex reservoir systems that need to be coordinated on both the water and the electricity sides. We review the toolchains for generation scheduling in those three countries. We focus on how the market structures, diversity in stakeholders and their objectives, and other regulations, motivate the differences in toolchains despite the same underlying operational objective. This also leads to different uses of the scheduling models and information flow between them. We further discuss the need to improve the current toolchains under energy sector transition scenarios.

2 - A Weekly Hydropower Representation In Power System Models For Continental Scale Power Grid Studies

Nathalie Voisin, Pacific Northwest National Lab., Seattle, WA, 98109, United States, Konstantinos Oikonomou, Sean Turner

Data scarcity and computational tradeoffs lead to simplified representations of hydropower in continental scale power grid studies with mixed generation portfolio. Using a hydrology model, reservoir operation scheme, and statistical tools, we develop datasets of plant-specific weekly hydropower generation potential and flexibility capabilities. These datasets are adopted in an industry-standard, hourly unit commitment - economic dispatch model of the Western US Interconnect. To evaluate the new data, we compare simulations results to existing practice for multiple years with varying water conditions.

3 - Valuing Pumped Storage Hydropower

Vladimir Koritarov, Argonne National Laboratory, Lemont, IL, United States, Patrick Balducci

The U.S. Department of Energy has sponsored a study to develop a comprehensive and transparent valuation guidance for pumped storage hydropower (PSH) projects. The objective was to develop a detailed step-by-step valuation guidance that PSH developers, plant owners and operators, and other stakeholders can use to assess the value of existing or potential new PSH plants and their services. Vladimir Koritarov and Patrick Balducci will present an overview of the project and the PSH Valuation Guidebook that was developed by the project team. The project team is currently developing an online PSH valuation tool that will help the users navigate through the valuation process.

4 - Exploring Multidimentional Spatial-temporal Hydropower Operational Flexibilities By Modeling And Optimizing Water-constrained Cascading Hydroelectric Systems

Yikui Liu, Stevens Institute of Technology, Hoboken, NJ, United States, Jiarong Xia, Neng Fan, Zhechong Zhao, Lei Wu

The power industry such as Portland General Electric (PGE) continues to evolve their operation strategies for cascading hydroelectric systems (CHS) to provide enhanced values to the grid. However, existing heuristic operation practices predate the integration of renewables, which could prohibit effective utilization of their inherent flexibilities in delivering maximum financial benefits and valuable grid services. This talk discusses our DOE project with PGE to develop machine-learning based water inflows forecast models and data-driven optimization approaches, which would leverage unique characteristics of CHSs to promote their multidimensional operational flexibilities.

5 - Optimization of Pumped-hydro-storage Project Costs

Tiago Andrade, PSR-inc, Rio de Janeiro, Brazil, Joaquim Garcia, Raphael Sampaio

Production of renewable sources, such as wind and solar power, is key to decarbonization. Their short-term production variability needs to be compensated by flexible resources of power for a reliable supply of power. This has motivated the assessment of energy storage systems in recent years, such as Pump Hydro Storage (PHS). PHS has appealing attributes, such as fast response time, larger storage capacity and comparatively lower cost. Because PHS projects are highly site-specific, we have developed a mixed-integer programming problem for the siting and sizing of PHS. The approach selects cells from a Digital Elevation Model to be part of future reservoirs of PHS to meet energy storage requirements. The objective function is to minimize construction costs, which includes dams, water conveyance system, and the connection of the PHS to the power grid.

■ VMA39

Virtual Room 39

Improving Distributed Energy Generation and Resilient Microgrid Modeling

Sponsored: ENRE/Environment and Sustainability

Sponsored Session

Chair: Ahmed Abdulla, Carleton University, Ottawa, ON, K1X 0C3, Canada

1 - Characterizing Wind Power Curtailment In Ercot

Kristen Schell, Assistant Professor, Ottawa, ON, 12180-3522, Canada

Curtailment of renewable energy occurs when the power system cannot accept the power available from the renewable generator, so this power is "spilled", or not used. Curtailment can happen in a power system for many reasons - market and dispatch decision, transmission constraints, errors in forecasting - as the power grid is constantly balancing supply and demand. Using data from the power system operator of Texas, ERCOT, two models are developed to: 1) characterize the extent of wind power curtailment and 2) quantify the opportunity cost of past curtailment practices.

2 - Simulating Hydrogen Transition Pathways In The Canadian Maritimes Using An Integrated Energy System

Ahmed Abdulla, Carleton University, Ottawa, ON, K1X 0C3, Canada, Ian Maynard

Multiple Canadian provinces are exploring the role that hydrogen might play in achieving net-zero emission targets. However, existing analyses have centered hydrogen production instead of embedding the hydrogen transition in an understanding of how the wider energy system is likely to evolve. Here, we present results from a simulation of hydrogen pathways that could be adopted by Canada's Atlantic Maritime provinces, which are keen on achieving net-zero emissions. We consider historical growth rates of technologies, technological learning, and the evolution of the wider energy system to develop plausible fossil fuel exit strategies. Our work improves representation of the cost of a hydrogen transition and its carbon abatement potential; it also enables policymakers to set targets for the components of the integrated energy system required.

3 - Robust And Cost-effective Microgrid Design For Equitable Climate Resilience: A Case Study Of West Oakland's Resilience Hub Project

Papa Yaw Owusu-Obeng, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States

Microgrids can maintain power to critical loads in events of utility power outages caused by extreme weather. This is useful in building resilience to climate crisis—as seen in the 2020 California heat wave and 2021 Texas winter storm where vulnerable populations depended on facilities with microgrids for essential energy services. This has driven the demand for resilience hubs to provide equitable energy access to low-income communities in the event of power outage. The challenge however is that the concept of resilience hub microgrids are new and there is no blueprint for robust and cost-effective design. This work presents advancement on two fronts: 1) energy efficiency analysis to determine the optimal energy conservation measures for resilience hubs, and 2) a multi-objective optimization model for least cost microgrid design to accommodate extended power outages.

4 - Predicting Hydrokinetic Power Potential In Short Stream Reaches Via Remote Sensing Methods

Andrew MacMillan, Carleton University, Ottawa, ON, Canada

Hydrokinetic power is a promising technology to address energy security issues for rural communities. Predicting the power potential of a location via resource assessment is a crucial first step in planning new energy projects. This is important for screening out locations and determining where on-site data collection is warranted. Recent studies have used digital elevation datasets to remotely predict flow characteristics where on-site data was not available. However, the studies focused on broader watershed regions and large rivers rather than specific locations. This study seeks to apply remote sensing methods to specific stream segments and smaller rivers for hydrokinetic feasibility and to validate it against obtained ADCP data from site measurements. Results provide insights into adapting first-principles equations of river flow to shorter stream reaches.

5 - New Methods For Evaluating Energy Infrastructure Development Risks

Michael Ford, Strategy Development Director, Argonne National Laboratory, Lemont, IL, United States, Ahmed Abdulla

Many energy technologies that can provide reliable, low-carbon electricity generation are confined to nations that have access to robust technical and economic capabilities, either on their own or through geopolitical alliances. This paradigm is slowly changing, as the pressing need for low-carbon electricity generation and ongoing efforts to develop modular nuclear technologies have opened the door for potentially wider markets, including in nations without substantial institutional capacity. Here we develop new methods to evaluate national readiness for deploying these complex energy systems. We offer iconic paradigms for deploying nuclear power in each of these clusters of nations if the goal is to mitigate risk.

■ VMA40

Virtual Room 40

Learning-based Optimization in Energy

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Juan Miguel Morales Gonzalez, University of Malaga, Málaga, 29071, Spain

Co-Chair: Salvador Pineda, University of Malaga, University of Malaga, Spain

1 - Data-Driven Chance-Constrained Optimization For Flexible Resources Dispatch In Distribution Systems

Ahmed Zamzam, National Renewable Energy Laboratory, Golden, CO, 80401, United States, Joshua Comden, Andrey Bernstein

Many stochastic optimization problems include constraints that must be met with a specific probability, called chance-constraints. However, solving an optimization problem with chance-constraints assumes that the solver knows the exact underlying probability distribution which is impractical. In data-driven applications, historical data is used to calculate the sample mean and covariance, and then use them as the true mean and covariance. This often leads to the chance-constraint being violated. We bridge this gap by modifying the standard method of distributionally robust chance-constraints so that the sample mean and covariance can be used instead, and prove their guarantees. We test our method on optimal dispatch bound calculation in distribution networks. The results demonstrate the efficacy of our method in guaranteeing chance-constraint satisfaction.

2 - Data-driven Piecewise Linearization For Distribution Three-phase Stochastic Power Flow

Jiaqi Chen, University of Wisconsin-Madison, Madison, WI, United States, Wenchuan Wu, Line A. Roald

As the penetration of distributed renewable energy increases, stochastic power flow (SPF) becomes an essential tool to analyze the uncertainties in active distribution networks. The Monte Carlo (MC) method is the most straightforward and accurate technique to calculate the three-phase SPF. However, the computation burden of the MC method is significant since it involves numerous calculations of three-phase nonlinear AC power flow. This talk will introduce a piecewise linear, data-driven power flow approach for the MC-based three-phase SPF calculation. An improved K-plane regression algorithm is proposed while considering the collinearity of the training data. We demonstrate that the proposed SPF approach can handle complex operational conditions such as the correction of random variables and three-phase unbalance with high accuracy and efficiency.

3 - Leveraging Machine Learning For Power Systems Reliability Management

Laurine Duchesne, University of Liege, Liege, Belgium, Efthymios Karangelos, Louis Wehenkel

Power systems reliability management aims at taking decisions ahead in time (from several decades to several minutes ahead) to ensure the continuous supply of electricity to end-users. However, uncertainty is increasing in today's power systems due to the growth of renewable generation, making it more difficult for the systems operators to ensure the reliability of the system. In this talk, we present decision making tools for reliability management leveraging machine learning in order to deal with these increasing uncertainties. In particular, we propose to learn simplified models (called proxies) of the response of the operator to realizations of uncertainties over possible future operating conditions and we illustrate how these proxies can be used for reliability management while tackling the increasing uncertainties.

4 - Learning-based Coordination Of Transmission And Distribution Operations

Salvador Pineda, University of Málaga, Málaga, 28071, Spain, Juan Miguel Morales Gonzalez, Yury Dvorkin

This talk proposes a learning-based approach for the coordination of transmission and distribution operations. Given a series of observations of the nodal price and the power intake at the main substation of a distribution grid, we construct the nonincreasing piecewise constant function that best explains the response of the grid to the electricity price. We consider a realistic case study to compare our approach with alternative ones, including a fully centralized coordination of transmission and distribution, for different levels of grid congestion at distribution.

■ VMA41

Virtual Room 41

MINLP Applications

Sponsored: Computing Society

Sponsored Session

Chair: Burak Kocuk, Sabanci University, Turkey

1 - On The Structure Of DD-representable MIPs With Application To Unit Commitment

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

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

2 - Rank Pump: A Feasibility Heuristic For Polynomial Optimization

Chen Chen, The Ohio State University, Columbus, OH, 43201, United States, Daniel Bienstock, Gonzalo Muñoz, Pablo Carrasco

The feasibility pump is a well-known primal heuristic for integer programming that involves two alternating sequences of projections. The original pump was designed for binary problems, and found such projections using linear programming and simple rounding. Unfortunately, the elegance of the pump may be lost in other settings. For instance, a natural extension of the pump to nonconvex MINLP involves NP-hard projection problems. We present our adaptation of the feasibility pump to polynomial optimization, called the rank pump. The rank pump has polynomial-time iterations, as all its projection problems can be solved in polynomial time.

3 - An Misocp-based Decomposition Approach For The Unit Commitment Problem With Ac Power Flows

Burak Kocuk, Sabanci University, Istanbul, 34956, Turkey, Deniz Tuncer

In this work, our aim is to solve the Unit Commitment problem with AC power flow equations, which is a challenging nonconvex mixed-integer nonlinear programming (MINLP) problem, to global optimality. Our solution algorithm consists of two phases. The first phase of the algorithm solves a strengthened mixed-integer second order cone programming (MISOCP) relaxation of the UC problem with AC power flow equations. In the second phase, the optimal solution of the MISOCP relaxation, which provides the generator commitment statuses, are fixed and a multiperiod OPF problem with AC power flow equations is solved using a local solver to find a feasible solution to the original MINLP. For large-scale problem instances, we also propose a Lagrangian relaxation based decomposition. We finally provide our computational results that illustrate the effectiveness of our approach.

4 - A Scalable Lower Bound for the Worst-Case Relay Attack Problem on the Transmission Grid

Emma Johnson, United States, Santanu Dey

We consider a restriction of a bilevel attacker-defender problem to find the worst-case attack on the relays that control transmission grid components where we drop the defender constraints corresponding to Ohm's law, relaxing DCOPF to capacitated network flow. We present theoretical results on the high quality of the bound for uncongested networks and an empirical study demonstrating both quality and computational scalability for networks with varying levels of congestion.

■ VMA43

Virtual Room 43

Auction Markets

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Martin Bichler, Technical University of Munich, München, 85748, Germany

1 - Choice Screen Auctions

Michael Ostrovsky, Stanford Business School, 518 Memorial Way, Stanford, CA, 94305, United States

Choice screen auctions have been recently deployed in 31 European countries, allowing consumers to choose their preferred search engine on Google's Android platform. I show that whether these auctions are conducted on a “per appearance” or a “per install” basis plays a major role in the mix of auction winners. Moreover, per install auctions distort the incentives of alternative search engines toward extracting as much revenue as possible from each user who installs them. The distortion becomes worse as the auction gets more competitive and the number of bidders increases. Empirical evidence from Android choice screen auctions conducted in 2020 is consistent with my theoretical results.

2 - Revenue Maximization For Consumer Software: Subscription Or Perpetual License?

Ludwig Dierks, University of Zurich, Zurich, CH-8050, Switzerland, Sven Seuken

We study the revenue maximization problem of a publisher selling consumer software. We assume that the publisher sells either traditional perpetual licenses, subscription licenses, or both. For our analysis, we employ a game-theoretic model, which enables us to derive the users' equilibrium strategies and the publisher's optimal pricing strategy. Via extensive numerical evaluations, we then demonstrate the sizable impact different pricing strategies have on the publisher's revenue, and we provide comparative statics for the most important settings parameters. Although in practice, many publishers still only sell perpetual licenses, we find that offering a subscription license in addition to a perpetual license typically (but not always) leads to significantly higher revenue than only selling either type of license on its own.

3 - Core-Stability in Assignment Markets with Financially Constrained Buyers

Martin Bichler, Technical University of Munich, Garching, 85748, Germany

We consider auctions of indivisible items to unit-demand bidders with budgets. Without financial constraints and pure quasilinear bidders, this assignment model allows for a simple ascending auction format that maximizes welfare and is incentive-compatible and core-stable. Introducing budget constraints, the ascending auction requires strong additional conditions on the unit-demand preferences to maintain its properties. We show that without these conditions, there does not exist an incentive-compatible and core-stable mechanism. Even if bidders reveal their valuations and budgets truthfully, the allocation and pricing problem becomes an NP-hard optimization problem. The analysis complements complexity results for more complex valuations and raises doubts on the efficiency of simple auction designs in the presence of financially constrained buyers.

■ VMA44

Virtual Room 44

Deep Learning and Mechanism Design

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Michael Albert, University of Virginia, Charlottesville, VA, United States

1 - Auction Learning As A Two Player Game

Jad Rahme, Princeton University, Princeton, NJ, United States, Sami Jelassi, S. Matthew Weinberg

Designing an incentive compatible auction that maximizes expected revenue is a central problem in Auction Design. While theoretical approaches have hit some limits, a recent research direction initiated by Duetting et al. (2019) consists in building neural network architectures to find optimal auctions. We propose two conceptual deviations from their approach. First, we introduce a time-independent Lagrangian inspired by recent results in auction design theory. Second, we amortize the optimization procedure used in previous work to compute optimal misreports with the introduction of an additional neural network. We show the effectiveness of our approach by learning competitive or strictly improved auctions compared to prior work. Both results together further imply a novel formulation of Auction Design as a two-player game with stationary utility functions.

2 - Deep Learning For The Automated Design Of Two-sided Matching Markets

Sai Srivatsa Ravindranath, Harvard University, Cambridge, MA, United States, Zhe Feng, Shira Li, Jonathan Ma, Scott Kominers, David C. Parkes

Economic theory provides the celebrated deferred acceptance mechanism for the design of a stable, two-sided matching mechanism that is also strategy-proof on one side of the market. At the same time, it is provably impossible to achieve both stability and strategy-proofness simultaneously. But there is little understanding in regard to how to navigate the necessary tradeoffs between these two properties. In this talk, we demonstrate how deep neural networks can be used for the automated, data-driven design of matching mechanisms that strike new tradeoffs between stability and incentive alignment, expanding the efficient frontier and suggesting new targets for economic theory.

3 - Certifying Strategyproof Auction Networks

Michael J Curry, University of Maryland, College Park, MD, United States

The design of strategyproof, revenue-maximizing auctions is a classic goal of mechanism design, but in multi-agent, multi-item settings, progress has been very limited. This has motivated attempts to train deep neural networks to approximate optimal auctions. These approaches work well empirically. However, there is no way to be completely sure that they are actually strategyproof. By drawing connections between strategyproofness and adversarially robust machine learning, we devise a modified auction architecture for which it is possible to compute exact, tight certificates on the degree to which strategyproofness is violated for a given bid profile. We find that our approach is effective, though scalability could be improved, and that gradient-based approximations do underestimate the extent of violations.

4 - Provable Lower Bounds For Black Box Mechanism Design

Michael Albert, Assistant Professor, University of Virginia, Charlottesville, VA, 22903-1416, United States, Minbiao Han

The field of mechanism design has had significant success in constructing optimal mechanisms to allocate resources when there are information asymmetries. However, there are many situations under which no optimal mechanism is known, leading to the adoption of black box optimizers, such as deep neural networks, to learn good mechanisms. However, these learned mechanisms only approximately satisfy traditional mechanism design guarantees, such as incentive compatibility. Given that these mechanisms fail traditional mechanism design guarantees, they cannot guarantee any lower bound on their performance. In this work, we present a procedure where by having sample access to a mechanism we can prove a lower bound on the performance. Moreover, we develop new techniques to construct mechanisms using deep neural networks that provide good lower bounds on the performance.

■ VMA45

Virtual Room 45

Emerging Research in Behavioral Operations Management

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Stephen Leider, University of Michigan, Ann Arbor, MI, 48109-1234, United States

Co-Chair: Samer Charbaji, University of Michigan, Ann Arbor, MI, 48105, United States

1 - One Vs. Two: Task Division In Newsvendor Decision Making

Yun Shin Lee, Korea Advanced Institute of Science and Technology, Seoul, Korea, Republic of, YoungSoo Park, Enno Siemsen

We conduct behavioral laboratory experiments to examine whether task division in a newsvendor setting improves order performance and investigate how bias in component decisions change in the task division setting. In the Individual Treatment, we ask subjects to make all of the decomposed order decisions - point forecasts, distribution forecasts, and service level decisions. In the Group Treatment, there are two players framed as a demand forecaster who is in charge of making point forecasts and distribution forecasts, and an operations manager who makes service level decisions. We compare the performance in the Individual Treatment with the Group Treatment and find no benefit of the task division. We further find that bias in component decisions and group alignment depends on group structures.

2 - Wage Transparency, Negotiation, and Reference-dependent Utility

Hengchen Dai, UCLA Anderson School of Management, 110 Westwood Plaza, Suite A-405, Los Angeles, CA, 90095-0001, United States, Xiaoyang Long, Dennis Zhang

Wage transparency has become increasingly prevalent across industries as a result of government mandates, companies' voluntary disclosure, and digitization. A commonly cited benefit of wage transparency is that it can prompt underpaid workers to negotiate and thus reduce wage inequality. In this work, we conducted a series of field and laboratory experiments to empirically address how peer wage information influences wage negotiation behavior. Based on our empirical findings, we build a reference-dependent model to describe worker behavior and use it to derive the long-term implications of wage transparency for wage inequality.

3 - Don't Fake It if You Can't Make It: An Empirical Study of Last-Mile Delivery

Srishti Arora, INSEAD, Singapore, Singapore, Vivek Choudhary, Pavel Kireyev

Collaborating withone of the largest last-mile delivery firm, we find that fake remarks on faileddeliveries can result in significant (1.8%) losses in first time rightdeliveries.

4 - Creative Task Constraints and Knowledge Worker Productivity

Samer Charbaji, University of Michigan, Ann Arbor, MI, 48105, United States, Roman Kapuscinski, Stephen Leider

Knowledge workers often work on creative tasks that involve originality and recognizability aspects. It is unclear how varying recognizability constraints affects a knowledge worker's productivity in an originality-focused creative task. We conduct a lab experiment that studies the effect of varying the threshold of recognizability constraints on the average originality and recognizability of creative tasks. In the experiment, participants are asked to draw images using a set of drawing materials to depict an object and a set of emoji to depict an action on that object. Their payment depends on the originality of their submitted image on condition that it meets a certain recognizability threshold. The originality and recognizability of each image are determined by external raters. Our treatments examine how different constraints impact participant performance.

5 - Team Composition And Cooperation In Queueing Systems

Mouli Modak, Purdue University, West Lafayette, IN, United States, Yaroslav Rosokha, Masha Shunko

We study a single-queue system in which heterogeneous tasks arrive stochastically and are processed by a team of either heterogeneous or homogenous servers. Particularly, servers specialize in one type of task, which, in our model, implies a lower cost of effort while processing that type of task. The effort chosen by servers determines the processing time of a task. We show that, theoretically, in the implied stochastic dynamic game, the choice of high effort can be sustained in the subgame-perfect equilibrium if the arrival rate is high enough regardless of team composition. Further, for intermediate arrival rates, homogeneous teams perform better than heterogeneous teams when the types of arriving tasks are independent or are serially positively correlated, and heterogeneous teams perform better in the presence of negative serial correlation in the types of tasks.

■ VMA46

Virtual Room 46

AI in Healthcare

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Huihui Chi, ESCP Europe, Paris, 75006, France

1 - Unsupervised Image Manipulation Via Conjugation – With Applications On Medical Imaging

Changqing Fu, Paris Dauphine University - PSL, Paris, France, Laurent D. Cohen

A novel two-stage approach is proposed for image manipulation and generation. User-interactive image deformation is performed through editing of contours. This is performed in the latent edge space with both color and gradient information. The output of editing is then fed into a multi-scale representation of the image to recover quality output. The model is flexible in terms of transferability and training efficiency.

■ VMA47

Virtual Room 47

Financial Risk Modeling and Fintech

Sponsored: Finance

Sponsored Session

Chair: Steve Yang, Stevens Institute of Technology, Hoboken, NJ, 07310-2113, United States

1 - Learning A Functional Control For High-Frequency Finance

Laura Leal, Princeton University, Princeton, NJ, United States, Charles-Albert Lehalle, Mathieu Lauriere

We use a deep neural network to generate controllers for optimal trading on high frequency data. The DNN learns the mapping between traders' risk aversion parameters and optimal controls. Trading activity influences price dynamics in closed loop via market impact. Scarcity of financial data is solved by transfer learning: the neural network is first trained on Monte-Carlo generated trajectories, then on historical data. We project the "blackbox controls" on the space spanned by the solution of the stylized optimal trading problem, leading to a transparent structure. For more realistic loss functions that have no closed-form solution, we show that the average distance between the generated controls and their explainable version remains small. This opens the door to the acceptance of ML-generated controls by financial regulators.

2 - A New Representation Of The Risk-neutral Density And Its Applications

Zhenyu Cui, Stevens Institute of Technology, Hoboken, NJ, 07310-2113, United States, Yuewu Xu

We establish a novel model-free representation of the risk-neutral density in terms of market-observed options prices by combining exact series representations of the Dirac Delta function and the Carr-Madan asset spanning formula. Compared to the widely used Breeden-Litzenberger device, our method yields estimates of risk- neutral densities that are model-free, automatically smooth, and in closed-form. The closed-form feature of our new representation makes it ideal for many potential applications including a new model-free representation of the local volatility function in the Dupire's local volatility model. The validity of our method is demonstrated through simulation studies as well as an empirical application using S&P 500 index option data. Extension of the method to higher dimensions is also obtained by extending the spanning formula.

3 - Explainable Machine Learning For Credit Risk Analytics

Brian Clark, Assistant Professor, Rensselaer Polytechnic Institute, Troy, NY, United States, Alex Gittens

Banks are reluctant to implement AI/ML models because of a perceived lack of explainability. While much attention is paid to the development of model explainability metrics, less research is dedicated to understanding the appropriateness of these methods in the context of credit risk modeling. This paper aims to assess the validity of explainable AI/ML algorithms in the context of credit analytics by comparing the time-series and cross-sectional properties of various explainability algorithms with regard to common ML algorithms. The data includes a large sample of mortgages underwritten by over 30 different lenders over a 20-year time horizon. We assess the explainability metrics based on their accuracy, fidelity, cross-sectional consistency, and time-series stability. For example, are risk drivers consistent across banks with different business models?

4 - Modeling self-exciting extreme returns in financial market: an AR-GARCH model with Hawkes point processes
Steve Y. Yang, Stevens Institute of Technology, Hoboken, NJ, United States, Anqi Liu

This paper applies extreme value theory (EVT) and Hawkes processes in the AR-GARCH framework to model the tail risk clustering effect. The proposed model improves forecasts of the timing of extreme returns and is particularly useful for downside risk analysis. We apply this model on 90 stocks, including both large-caps and small-caps, in nine industry sectors. The in-sample experiments show a strong self-excitation of negative AR-GARCH residuals and it is well captured using the proposed model. The value-at-risk forecasting experiments over the past 25 years confirm that our model produces accurate downside risk estimations. More importantly, the proposed model provides more accurate risk analysis results during market crisis than other existing benchmark models.

■ VMA48

Virtual Room 48

Emerging Issues in IS

Sponsored: eBusiness

Sponsored Session

Chair: Zhen Sun, The George Washington University, Washington, DC, 20052, United States

1 - The Competition In Online Reputation: A Mean Field Game Approach
Mingwen Yang, University of Washington, Seattle, WA, 98195, United States, Cheng Nie, Yonghua Ji, Vijay S. Mookerjee

The online reputation is critical for the success of a business. Sellers make efforts to improve their online reputation so as to attract more future customers. In this paper, we model the sellers' competition in product ratings using a mean field game model, where we consider a large number of sellers in a market. Each seller makes an effort to improve the product ratings and having ratings close to those of other competitors benefits each seller in the market (mutual attraction). Using data from Airbnb, we estimate the parameters in the mean field game model and are able to demonstrate that the proposed model can explain the rating competition in the market.

2 - Carrot Or Stick? An Economic Analysis Of Fraud Deterrence In Online Advertising
Min Chen, Associate Professor, George Mason University, Fairfax, VA, 22030-4422, United States, Subodha Kumar, Abhishek Ray

A major source of fraud traffics in online advertising originate from publishers' websites due to an economic incentive to inflate their revenues. Ad-networks are often criticized for not doing the best for gating fraud traffics because they can also benefit from the inflated traffics and the technology employed for classifying online traffics are imperfect: it cannot identify all fraudulent traffics and may misidentify valid traffic as fraudulent. In this study, we develop a game-theoretic model to examine ad-networks' decision in technology configuration and revenue sharing, how they affect publishers' fraud generating incentives and responses from advertisers, and the implication to all stakeholders involved.

3 - Solving The Social Dilemma With Equilibrium Data Harvesting Strategies: A Game-Theoretic Approach
Hyeonsik Shin, Temple University, Philadelphia, PA, United States, Leila Hosseini, Subodha Kumar

Social media platforms collect data on users' activities in the platform, which we call data harvesting, and offer personalized contents which are more relevant to users' preferences. Practitioners from the social media industry, however, suggest that data harvesting by the platforms is hurting users by promoting social media addiction, and, therefore, lawmakers are concerned about how to regulate social media platforms. We consider a game-theoretic model in which two social media platforms compete for a heterogeneous set of users by deciding the level of data harvesting. Furthermore, we consider government's penalty on the data harvesting level in our model to provide useful insights.

■ VMA49

Virtual Room 49

Building MCDM/A Models: Practical and Methodological Issues

Sponsored: Multi Criteria Decision Making

Sponsored Session

Chair: Caroline Maria de Miranda Mota, Universidade Federal de Pernambuco, Recife, 50000000, Brazil

Co-Chair: Danielle Costa Morais, Universidade Federal de Pernambuco, Recife, PE, 52020-212, Brazil

1 - Using Fitradeoff To Prioritize Strategies Towards A Transition To A Circular Economy In Developing Countries
Wesley Silva, UFPE, Recife, Brazil, Danielle Morais

The linear model of natural resource consumption in developing countries drives to an unrestrained generation of solid waste and this is a problem with environmental, social, and economic impacts. Hence, it is necessary to change to a circular model in which the solid waste is reinserted into cycles to value recovery. To do so, there should be developed strategies for this transition to happen and a procedure to prioritize them. Thus, this study proposes a decision-making model based on FITradeoff multicriteria method to prioritize these strategies. This proposal presents a holistic consideration of a structured mechanism that prompts the transition towards a circular economy in developing countries.

2 - Gis-mcda Framework For Public Safety
Amanda Gadelha Ferreira Rosa, UFPE - Federal University of Pernambuco, Recife, Brazil, Caroline Maria de Miranda Mota

This study used a multi methodology approach combining spatial analysis and a Dominance-based Rough Set Approach. Data analysis and spatial tools are applied to explore and understand the context of the study from different perspectives. As a result, the proposed approach is applied to the context of public safety, identifying the levels of vulnerabilities of areas in a city. It shows better quality results compared to a sole criteria analysis in the sense of providing a validation based on both the preferences of a decision-maker and the real crime distribution. Moreover, the framework can be adapted to other contexts of vulnerability analysis in land use.

3 - A Multicriteria Decision Model For Selecting Subcontractors In Civil Construction Projects Using The Fitradeoff Method
Luciana Hazin Alencar, Universidade Federal de Pernambuco - UFPE, Tamarineira, Recife, 52050-138, Brazil, Jerusa Cristina de Medeiros, Raphael Harry Kramer

Civil construction is a dynamic and complex sector, presenting difficulties in reaching performance indicators. The larger the more fractional the project is, with several actors involved, consequently, the greater the complexity of managing and developing schedules, which meet multiple objectives. The fractioning of the project takes place to achieve better performance in terms of cost, duration, and quality, thus occurring the subcontracting of the work packages, highlighting the importance of selecting the right subcontractor for the activity. In this context, this works presents a multicriteria decision model for selecting subcontractors in construction projects, using the FITradeoff method.

4 - Aggregation Of Incomplete Rankings In Multiple Criteria Group Decision Making
Grzegorz Miebs, Poznan University of Technology, Poznan, Poland, Milosz Kadzinski

Most multiple criteria decision aiding methods that deliver a ranking of alternatives as output are suitable for a single decision-maker. We aim to introduce a general framework to apply any of these methods in a group decision-making process. This is attained by applying the method separately for each user and aggregating obtained outcomes into a compromise one. Our approach can work with both partial and complete rankings at both the input and output of the proposed approach. By defining the distance metric between rankings, the considered task becomes an optimization problem. In addition, we account for the weights associated with the input rankings, while minimizing either an average or a maximal distance from the input rankings.

■ VMA51

Virtual Room 51

Telecommunications

Contributed Session

Chair: Kevin J Potcner, SAS Institute Inc - JMP Division, San Francisco, CA, 94114, United States

1 - Market-based Mechanisms For Fair And Efficient Resource Allocation In Edge Computing
Duong T. A. Nguyen, Arizona State University, Tempe, AZ, United States

Edge computing enables novel Internet of Things applications and drastically enhances user experience. We propose a novel market equilibrium-based framework for allocating geographically distributed heterogeneous edge resources to competing services with diverse preferences in a fair and efficient manner. The proposed solution not only maximizes resource utilization but also gives each service its favorite resource bundle. Furthermore, the equilibrium allocation is Pareto-optimal and satisfies desired fairness properties including sharing incentive, proportionality, and envy-freeness. We also introduce privacy-preserving distributed algorithms for equilibrium computation.

2 - Adding Sentiment Analysis To Intro Statistics Curriculum
Kevin J Potcner, SAS Institute Inc - JMP Division, San Francisco, CA, United States

Statistical software has made analyzing unstructured text data simple. Requiring no prior experience in the concepts of formal statistical analyses (confidence intervals, p-values, models, etc.), extracting meaning from a large collection of text can be successfully done by a wide range of students. Due to today's students being intimately familiar with this type of data, the value of such analyses is easily appreciated by any student. Using JMP Statistical Software, the presenter will illustrate the process of analyzing text data including Sentiment Analysis - the process of quantifying the amount of positive/negative meaning.

■ VMA53

Virtual Room 53

Business Value of Social Media and Network Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Sukhwa Hong, University of Hawaii at Hilo, Hilo, HI, 96720, United States

1 - Analysis Of Orange County 311 Non-emergency Call System During The Covid-19 Pandemic
Duygu Pamukcu, Virginia Tech, Blacksburg, VA, United States, Christopher W. Zobel

Local governments are responsible for maintaining necessary services and quickly and timely informing citizens before, during, and after an emergency. To do this, governments implement smart information and communication technologies in public services. This study examines the 311 non-emergency call system reactions in the U.S. metropolitan areas to reflect the COVID-19 pandemic. We investigate if the 311 system can capture citizen needs and complaints about the pandemic. 311 system collects and reports a highly structured and location-based dataset similar to social media data in some ways. We provide a comparative analysis with geolocated tweets from the same region to examine if the 311 system is a valuable source of information and if there are additional advantages of using the 311 system over social media data to identify service needs during a crisis.

2 - The Determinants for Consumers' Privacy Concerns and Information Disclosure in Sustainable Smart-connected Cars: Logistic Regression, LDA, and PCA.
Daeeun Daniel Choi, Virginia Tech, Blacksburg, VA, 24060, United States, Paul Benjamin Lowry

This study analyzes the determinants and the best fit model for privacy and information disclosure of consumers who purchase sustainable smart-connected cars (SSC). We conducted an experimental design survey and analyzed the results with logistic regression, linear discriminant analysis, and principal component analysis. To establish determinants of privacy concerns and information disclosure in SSCs, we have applied multiple variables. The results suggest that multiple determinants allow us to predict consumers' privacy concerns and intention to information disclosure.

3 - Hierarchical Multi-instance Learning For Element Detection In Text
Sukhwa Hong, University of Hawaii at Hilo, College of Business and Economics, Hilo, HI, 96720, United States

Many new data sources generated by consumers on the Internet have provided firms with improved capabilities for monitoring product quality and performance. Due to the diversity of language, the techniques for analyzing such data have generally been applied to limited product categories and they often lack interpretability for deeper analysis. We explore several novel text analytic approaches that capture the structure of language for addressing this problem. In our study, we propose a hierarchical neural network language model combined with a multi-instance learning to detect text elements in which product quality- and performance-related information are presented.

■ VMA55

Virtual Room 55

Diversity/PSOR/MIF - Diversity, Equity and Inclusion in OR/MS/Analytics. Innovations in Research and Practice II

Committee Choice: Public Sector OR

Committee Choice Session

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

Co-Chair: Gabriela Gongora-Svartzman, Carnegie Mellon University, Pittsburgh, PA, 15213-3725, United States

1 - MD4SG: Fostering Geographic And Linguistic Diversity In Academic Conferences
Francisco Marmolejo, University of Oxford, Oxford, United Kingdom

In this talk I will reflect upon my experiences as a co-chair of the 4th workshop on Mechanism Design for Social Good (MD4SG '20) and as the current general chair of the inaugural ACM conference on Equity and Access in Algorithms, Mechanisms, and Optimization (EAAMO '21). Research within the MD4SG initiative is fundamentally interdisciplinary, inter-institutional and international. As such, the virtual nature of these events have provided a unique opportunity to increase the geographic and linguistic diversity of our participants through a variety of methods which I will share.

2 - Bringing STEM To Underserved Communities
Phebe Vayanos, University of Southern California, Los Angeles, CA, 90089, United States, Aida Rahmattalabi, Caroline Johnston

Industry and academia suffer from lack of full participation in STEM fields, excluding those from traditionally marginalized groups. To help address this problem, we partnered with Code in the Schools, a non-profit in Baltimore city and STEM academy of Hollywood, a high school in Los Angeles to bring students from traditionally under-represented groups in STEM together and engage them in fun AI/OR projects for social good. To achieve this, we held the ExplOR event in November 2020. Guided by mentors from the INFORMS community, the students worked in teams to address a range of problems in areas including public health, conservation, etc. The goal was to raise students' interest in AI/OR and help them build a network with mentors and fellow students.

3 - Fairness, Equality, And Power In Algorithmic Decision-making
Maximilian Kasy, University of Oxford, United Kingdom

Much of the debate on the impact of algorithms is concerned with fairness, defined as the absence of discrimination for individuals with the same ``merit." We argue that leading notions of fairness suffer from three key limitations: they legitimize inequalities justified by ``merit;" they are narrowly bracketed, considering only differences of treatment within the algorithm; and they consider between-group and not within-group differences. We consider two alternate perspectives: the first focuses on inequality and the causal impact of algorithms and the second on the distribution of power. We formalize these perspectives drawing on causal inference and empirical economics, and characterize when they give divergent evaluations. We present theoretical results and empirical examples, and use these insights to present a guide for algorithmic auditing.

4 - Developing Principles For Dei-informed Research In Or/analytics Through An Analysis Of Published Journal Articles
Michael P. Johnson, University of Massachusetts-Boston, Boston, MA, 02125-3393, United States, Tayo Fabusuyi

We describe a project to develop principles by which researchers in OR/analytics may integrate ideas about diversity, equity and inclusion, racial and social justice and antiracism into research ideas that span application areas, disciplinary modes and analytic methods. These principles are derived from a mixed methods analysis of INFORMS journal publications including thematic analysis and author interviews. This project has the potential to improve the profession (how the work gets done, and the environment within which the work is done) as well as the discipline (the academic and scholarly place within which the work is situated).

■ VMA56

Virtual Room 56

OR/MS in Industry Practice - III

Informs Special Session: Informs Section on Practice

Informs Special Session Session

Chair: Craig T Nilson, US Coast Guard, Bethesda, MD, 20817-5814, United States

1 - Developing Holistic Airline Schedule Recovery Solutions Without Manual Intervention
Srinivas Bollapragada, GE Global Research Center, Niskayuna, NY, 12309, United States, Sanket Bhat, Nitish Umang, Hocine Bouarab, Marc Garbiras

Recovering disrupted airline schedules is a complex problem that is currently solved after decomposing it into three subproblems. The solution of the first subproblem, known as the ops-recovery problem, determines aircraft rerouting, flight delays and cancellations that are needed to meet the new constraints imposed by disruptions. The crew-recovery problem is then solved to re-assign crews to rescheduled flights. Finally, passengers on cancelled and delayed flights are re-routed. This sequential approach can lead to ops-recovery solutions that are not feasible for the crew-recovery subproblem. Multiple manual iterations are then needed to generate a feasible solution. We developed a new methodology to simultaneously generate ops, crew, and passenger schedules without manual intervention.

2 - Workforce Retention Modeling With Survival Analysis
Craig T. Nilson, US Coast Guard, Bethesda, MD, 20817-5814, United States

This presentation will provide an overview of how survival analysis is used by the U.S. Coast Guard's Office (USCG) of Strategic Workforce Planning & HR Analytics to estimate retention probabilities over time for service members. First, it will highlight examples of how the results of survival analysis have been used in the USCG. These results will include metrics that assess disparities between demographic groups as well as how policy has been strategically applied to improve the retention of underrepresented groups. Then, the presentation will briefly explore how the retention probability estimates produced by survival analysis provide a basis for sampling agent survival times in discrete, event-based simulation models.

■ VMA58

Virtual Room 58

Advances in Material Handling

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Debjit Roy, Indian Institute of Management, Ahmedabad, 380015, India

Co-Chair: Sadan Kulturel-Konak, Penn State Berks, Reading, PA, 19610-6009, United States

1 - Considering The Role Of Personality In The Impact Of Emphasis On Safety And Productivity In Warehouse Driving: A VR Experiment
Mahsa Alirezaei, Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands, Jelle de Vries, René B.M. De Koster

Organizations emphasize safe and productive work through various forms of performance feedback. However, the combined impact of emphasis on speed, quality, and safety remains unclear in warehousing industries. This study employs controlled laboratory experiments involving a Virtual Reality (VR) simulator to examine the impact of verbal reminders on the performance of warehouse vehicle drivers. Furthermore, it is likely that workers with different types of personalities will be affected differently by the verbal reminders. We therefore also measure individual differences between drivers in terms of the Big five personality traits and Regulatory Focus.

2 - Exact Analysis Of Manual Order Picking Routes
Tim Engels, Eindhoven University of Technology, Eindhoven, Netherlands

We analyze the picking time of orders in a rectangular warehouse consisting of multiple parallel aisles and consider 4 routing heuristics: Return, Midpoint and S-shaped, Largest Gap routing. We assume that the storage of items is random, i.e. uniform across and within aisles. For each of these routing heuristics we determine the mean and variance of the picking time of an order. We, furthermore, consider the case of Poisson order sizes separately and derive exact expressions for the distribution of the picking time. Based on these results we conclude with a comparison of the routing heuristics

3 - Nash Equilibrium Sorting Genetic Algorithm for Simultaneous Competitive Maximal Covering Location Problem
Sadan Kulturel-Konak, Penn State Berks, Redding, PA, United States, Abdullah Konak, Lawrence Snyder

In this article, we introduce a new genetic algorithm called Nash Equilibrium Sorting Genetic Algorithm (NESGA) to identify Nash equilibria for the Competitive Maximal Covering Location Problem with two and three competitors, which is a combinatorial game theory problem where it is computationally intractable to enumerate all decision options of the competitors. Computational experiments show that the NESGA can discover multiple Nash equilibria in a single run and outperform another game-theoretic GA.

4 - Travel Time Model For Multi-deep AS/RS
Timo Lehmann, Karlsruhe Institute of Technology, Karlsruhe, Germany, Kai Furmans, Jakob Hussmann

Automated storage and retrieval systems (AS/RS) with multi-deep racks lead to two aspects compared to single-deep AS/RS: higher space utilization rates and higher travel times. Space utilization rates are higher due to the necessity of less S/R machines. Travel times arise, because S/R machines need longer in the channels of a rack and relocations can be necessary due to blocking goods. A travel time model for multi-deep AS/RS is presented which uses four different storage assignment strategies and shows that the relocation quantity is linear dependent on the rack's depth. A general model contrasts these two aspects and gives an outlook for the feasibility and applicability of multi-deep AS/RS in industry.

5 - Design Of Facilities In The Next-generation Logistic System
Dilhani S. Marasinghe, Graduate Student, Clemson University, Clemson, SC, United States, William G. Ferrell

A new facility design in a new logistic system based on horizontal collaboration is presented. These facilities organize and reroute pallets or similar-sized transportation containers. Unlike current large facilities with high throughput, these have some storage capacity to hold some pallets. This study explores the critical operational issue of dynamically deciding the action to take on each pallet that is either inbound or in storage at the beginning of a time period. The decisions are made dynamically because information on inbound pallets might only be known a few hours in advance of arrival. A generalized assignment model is introduced to solve the problem in a single period.

■ VMA59

Virtual Room 59

Freight Transportation III

Sponsored: TSL/Freight Transportation

Sponsored Session

Chair: Gita Taherkhani, Loyola University Chicago, Chicago, IL, United States

Co-Chair: Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States

1 - Operational Planning For Many-to-One-to-Many Freight Transportation
Wenjing Guo, Université du Québec à Montréal, Montreal, QC, Canada, Teodor Gabriel Crainic, Michel Gendreau, Walter Rei

We address the operational planning of a M1M aiming to decide to accept, reject, or postpone time-dependent shipper transportation requests and carrier service offers, assign shipments to services, and determine service departures and shipment itineraries. Requests and offers are received dynamically. We develop a myopic approach, which does not consider future outcomes and events, and a multi-period model with look-ahead capabilities. The performance of these two approaches is tested is a rolling-horizon setting on a comprehensive set of instances.

2 - Load Plan Scheduling Problem
Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States, Fabien Lehuede

We introduce a new optimization problem, the Load Plan Scheduling Problem that is relevant to Less-than-truckload freight transportation carriers. This problem seeks to determine a schedule for a given set of shipment paths that minimizes transportation costs by achieving high levels of consolidation. We present different integer programming formulations of this problem. One formulation is based on a time-space network. We illustrate how the size of that network can be reduced through a filtering procedure and propose multiple classes of valid inequalities. Another formulation does not involve a time-space network but instead is an extended formulation, which we propose solving with a branch-and-price solution approach. We report on the effectiveness of these techniques with a computational study.

3 - Tactical Capacity Planning In An Integrated Multi-stakeholder System
Gita Taherkhani, Loyola University Chicago, Chicago, IL, United States

This study focuses on investigating tactical planning of an integrated multi-stakeholder system. The system receives time-dependent requests from carriers and shippers and optimizes in time and space the operations and transportation activities through consolidation of loads of different shippers into the same vehicles and synchronization of activities. The aim of tactical planning in this system is to build an efficient service network and schedule to satisfy the demand and requirements of shippers by making use of the predicted services and their capacities offered by the carriers. A novel mathematical formulation of the problem is introduced. Extensive computational analysis is performed on the split and unsplit shipment-flow versions of the problem to evaluate the solution potential of the proposed model with emphasis on the effect of the choice of parameters.

■ VMA60

Virtual Room 60

Advances in Analytics for Military and Security Applications I

Sponsored: Military and Security

Sponsored Session

Chair: Trevor Bihl, Air Force Research Laboratory, Wheelersburg, OH, 45694, United States

1 - Equitable Assignment Of U.S. Marine Corps Reserve Recruiting

Gary Lazzaro, Permanent Military Professor, United States Naval Academy, Annapolis, MD, United States

We focuses on the assignment of new reservist Marines to jobs at Reserve Centers by Marine Corps Recruiting Command (MCRC). Recruiting Substations acquire new reservists to be stationed at Reserve Centers to fill specific job openings. Manual assignment of jobs to Recruiting Substations takes MCRC weeks to complete. We create a novel application of the classic assignment problem with additional constraints for maximum travel distance and recruiter workload to automate the process. Our model displays the 6,011 job openings for FY2021, their assigned Recruiting Substation, and the distance between the Recruiting Substation and Reserve Center in miles.

2 - Early-Stage Naval Ship Distributed System Design Using Dynamic Architecture Flow Optimization

Mustafa Yasin KARA, Virginia Tech, Blacksburg, VA, United States, Mark A. Parsons, Alan J. Brown

Energy conservation approach is proving to be efficient for large systems and our Architecture Flow Optimization (AFO) formulation is directly linked to ship synthesis using the network framework which is logical and flexible and enables application in design optimization and knowledge-based approaches. We are proposing to use this same AFO formulation to perform time-based recoverability analyses in a series of weapon-hit scenarios, performing an Dynamic AFO after each time step to apply specified battle doctrine and load priority and to simulate a controlled system recovery including the sizing and definition of required energy storage.

■ VMA62

Virtual Room 62

Emerging Applications of Scheduling

Informs Special Session: Scheduling and Project Management

Informs Special Session Session

Chair: Zhixin Liu, University of Michigan-Dearborn, Dearborn, MI, 48126-2638, United States

1 - Minimizing Makespan On Parallel Machines With Processor Sharing

Hairong Zhao, Purdue University Northwest, Hammond, IN, 46323-2068, United States

In this talk, we will study scheduling problems on parallel machines where there is processor sharing between the primary jobs and secondary jobs during some intervals. The goal is to minimize the makespan - the maximum completion time of the primary jobs. We will show that if the sharing ratio is arbitrary, there is no approximation algorithm unless $\P=\NP$. Then we consider the case where the sharing ratios on some machines are bounded by a constant. Under this assumption, we analyze the performance of the list scheduling and modified LPT (longest processing time). We then developed two approximation schemes for the problem.

2 - Parallel Batch Scheduling With Job Compatibility And Controllable Processing Times

Jun Xu, Northwestern Polytechnical University, Xian, 710072, China, Jun-Qiang Wang, Zhixin Liu

We consider scheduling problems on parallel batch machine with job compatibility and controllable processing times to minimize the weighted sum of makespan and total compression cost. The processing time of each job is a specific interval and can be compressed by allocating additional resources. Parallel batch machine can simultaneously process several jobs as a batch. The number of jobs in the batch does not exceed the machine capacity and the processing time intervals of every job in the batch have a non-empty intersection. We study both problems on a single machine and parallel identical machines. We present several heuristics and analyze corresponding worst case ratios.

3 - On-line Scheduling On Parallel-batch Machines To Minimise Maximum Flow-time With Delivery Times

Ran Lin, Northwestern Polytechnical University, Xi'an, China, Wenhua Li, Xing Chai

We consider on-line scheduling on m parallel-batch machines with equal-length jobs. The jobs arrive over time and the goal is to minimise the maximum flow-time with delivery times. In considering the benefit of the customer, the objective is to minimise the maximum flow-time adding the delivery times of jobs. We provide an on-line algorithm for the problem and discuss the lower bound and the competitive ratio of the algorithm for the problem.

4 - Scheduling Jobs With Non-identical Job Sizes On Mixed Batch Machines

Guoqiang Fan, Xidian University, Xi'an, SN 29, China, Jun-Qiang Wang, Zhixin Liu

We consider a mixed batch scheduling problem with non-identical job sizes. The mixed batch machine batch machine can process multiple jobs simultaneously as a batch as long as the total size of jobs in the batch does not exceed the machine capacity. The processing time of a batch is the weighted sum of the maximum processing time and total processing time of jobs in the batch. The objective is to minimize the makespan. We show that the problem is strongly NP-hard, and analyze the worst-case performance ratio of longest processing time first fit (LPTFF) algorithm for the problem. We present the longest processing time first fit greedy (LPTFFG) algorithm with worst-case performance ratio better than LPTFF algorithm.

5 - Drone-assisted On-time Delivery In Urban Areas

Lindong Liu, University of Science and Technology of China, School of Management, HeFei, 230000, China, Liu Wenqian, Xiangtong Qi

As one of the emerging technologies, drones may play an indispensable role in facilitating last-mile delivery. In this paper, we investigate the drone-assisted resupply delivery problem (DRP) where a distribution center employs trucks (deliverymen) to make direct deliveries, and uses drones as assisting tools to reload trucks with late arrived packages, in heavily-populated urban areas. After observing two optimality conditions, namely, sequence consistency and idleness mutual exclusion, we are able develop a time-expanded network flow formulation that solves DRP, along with a dynamic programming that solves DRP with single truck and single drone. In addition, we also design an approximate solution approach to solving DRP via greedy method. In the end, we demonstrate computational studies to illustrate the effectiveness of the proposed solution approaches.

■ VMA63

Virtual Room 63

JuMP and Optimization in Julia

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

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

Co-Chair: Miles Lubin, Google, New York, NY, 10011, United States

1 - The State Of JuMP

Miles Lubin, Google, New York, NY, 10011, United States

2021 marks nine years since the beginnings of JuMP as an open-source modeling language for mathematical optimization embedded in Julia. In this period, JuMP has accumulated close to 1000 citations. We review JuMP's impact to date and provide an update on the state of the project, including ongoing and upcoming milestones like the 1.0 release and beyond.

2 - JuMP Extensions For Bilevel Programming And For Differentiating Optimization Problems

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

Two extensions of the JuMP open-source algebraic modeling language are presented. Both of them heavily rely on MathOptInterface (MOI), the low-level data-structure behind JuMP. First, BilevelJuMP is a library for modeling and solving bilevel optimization problems, also built on top of Dualization.jl's automatic dualization features. Second, DiffOpt is a library to compute derivatives of optimization solutions with respect to problem data.

3 - Recent Improvements To MathOptInterface

Benoît Legat, MIT, Cambridge, MA, United States

MathOptInterface (MOI) provides a intrinsically flexible and extensible API.Such design often comes at the cost of reduced performance over specialized interface.In this presentation, we discuss the challenges for MOI to both be generic and performant.We focus on two specific approaches to this: mutable arithmetics and matrix representations.

4 - Mixed-integer Programming With Disjunctions: Designing A Solver From The Ground Up

Joey Huchette, Rice University, Houston, TX, 02143-4139, United States, Ross Anderson

Disjunctive programming (DP) is a powerful framework for modeling complex logic in optimization problems. Typically, DP problems are reformulated as mixed-integer programming (MIP) problems, and then passed to a MIP solver. Crucially, the MIP solver only receives this "flattened" MIP reformulation, and not the original, rich DP structure. This work explores how an LP-based branch-and-cut solver can take advantage of DP structure. We develop a solver for mixed-integer programming that treats disjunctive constraints as first-class objects. We discuss how this structural information can be used within the search tree for dynamic reformulation and domain propagation without breaking incremental LP solves, a crucial ingredient for the success of modern branch-and-cut solvers. We present results on scheduling problems to illustrate the potential of our solver.

■ VMA64

Virtual Room 64

Real-world Applications With Emerging Methods for Optimization : Reinforcement Learning and Quantum Optimization

Sponsored: OPT/Global Optimization

Sponsored Session

Chair: Shreyas Subramanian, Amazon

1 - Scheduling the NASA Deep Space Network with Deep Reinforcement Learning

Bharath Balaji

The Deep Space Network (DSN) consists of antennas around the world that, in coordination, enable communications with interplanetary space missions. These missions request communications/tracking time on a weekly basis, specifying preferences based on their specific needs. Due to the increasing number of active missions and higher fidelity instruments, the requested time frequently exceeds DSN's capacity. Operational constraints such as those governed by spacecraft position/visibility in the sky further preclude full utilization of the DSN's full capacity. We pose the scheduling optimization problem as a Markov Decision Process and propose reinforcement learning (RL) algorithms to solve the problem. We show that RL brings unique advantages compared to traditional optimization algorithms, and discuss challenges in dealing with the problem's unconventional constraints. We experiment with multiple problem formulations, algorithmic approaches, and present our results.

2 - Combinatorial Optimization with Physics-Inspired Machine Learning

Martin Schuetz, Amazon, Bellevue, WA, United States

We demonstrate how machine learning tools can be used to solve combinatorial optimization problems. Our approach is broadly applicable to canonical NP-hard problems in the form of quadratic unconstrained binary optimization problems, such as Maximum Cut, Minimum Vertex Cover, Maximum Independent Set, and higher-order generalizations thereof in the form of polynomial unconstrained binary optimization problems. We showcase our approach with numerical results for the canonical Maximum Cut and Maximum Independent Set problems. We find that our machine-learning-based optimizer performs on par or outperforms existing solvers, with the ability to scale beyond the state of the art to problems with millions of variables.

3 - Quantum Optimization: Facts and Myths

Helmut G. Katzgraber, Senior Practice Manager, Amazon Web Services, One Microsoft Way, Seattle, WA, 98052, United States

Quantum computing promises to solve seemingly intractable problems. In the medium term, both optimization and chemistry will likely be the only impactful application for this novel technology. In this talk an overview of quantum optimization-as well as facts and myths-is presented. It is argued that quantum optimization machines are still superseded by classical approaches on CMOS for the foreseeable future. However, problem modeling as well as physics-inspired algorithms present new, potentially transformative, ways to solve hard combinatorial optimization problem across industries.

4 - Emerging Deep Learning Approaches for the Problems of Airfoil Performance Prediction and Airfoil Inverse Design

Emre Yilmaz, Georgia Tech, Atlanta, GA, United States, Brian J German

This presentation describes the application of deep learning methodologies to two specific problems from the field of aerospace engineering design which are i) airfoil performance prediction and ii) airfoil inverse design. An emerging approach to avoid the parameterization related issues with conventional methods is to formulate these problems in data driven optimization framework. By training deep convolutional neural network structures, the focus is on learning the hypothesis that represents the relationship between the airfoil geometries and the performance metrics. Additionally, an approach based on conditional generative adversarial networks (CGANs) is applied to create new airfoil shapes based on a vector set of conditional data indicating desired performance.

■ VMA65

Virtual Room 65

Integer Programming and Combinatorial Optimization

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Yajun Lu, Bucknell University, Lewisburg, PA, 17837, United States

1 - Cross-dock Truck Scheduling With Workforce Constraint In Freight Transportation

Ritesh Ojha, PhD Student, ISyE Georgia Tech, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Alan Erera

Freight transportation companies operate cross-docking terminals to enable freight transfer between trailers throughout their consolidation network. This research addresses the integrated truck and workforce scheduling problem at unloading doors in a cross-dock. The objective is to minimize the total violation of fixed deadlines at the loading doors. We develop an optimization-based methodology, equipped with an iterative time refinement exact algorithm, for creating a timed schedule of trailer unloading activities with worker assignments. The algorithm solves small integer programs in each iteration to yield the optimal solution. A computational study demonstrates the utility of the model and effectiveness of the algorithm to solve practical instances based on data, representative of a large cross-dock, provided by our research partner.

2 - The Lifted Multicut Polytope On Trees

Silvia Di Gregorio, TU Dresden, Dresden, 53715-1119, Germany, Bjoern Andres, Jan-Hendrik Lange

The lifted multicut problem on trees is NP-hard in general and solvable in polynomial time for paths. We perform a polyhedral study for the standard setting where the tree is lifted to the complete graph. In particular, we characterize facets of the lifted multicut polytope corresponding to the canonical relaxation. Moreover, we present a new class of facet-defining inequalities arising from paths. Taken together, our facets yield a complete totally dual integral description of the lifted multicut polytope for paths. This description establishes a connection to the combinatorial properties of the sequential set partitioning problem. Lastly, we define new valid inequalities for the case where we lift the tree to an arbitrary graph, and provide necessary conditions for these inequalities to be facet-defining.

3 - On Fault-tolerant Low-diameter Clusters In Graphs

Yajun Lu, Assistant Professor, Jacksonville State University, Jacksonville, AL, 17837, United States, Hosseinali Salemi, Baski Balasundaram, Austin Buchanan

Cliques and their generalizations are frequently used to model "tightly knit" clusters in graphs, and identifying such clusters is a popular technique used in graph-based data mining. One such model is the s-club, which is a vertex subset that induces a subgraph of diameter at most s. This model has found use in a variety of fields because low-diameter clusters have practical significance in many applications. In this talk, we discuss a fault-tolerant extension of the s-club model that has spawned two variants: hereditary s-clubs and robust s-clubs. Our complexity results, formulations, and computational techniques lay the foundations for an effective mathematical programming approach for finding fault-tolerant s-clubs in large-scale networks.

4 - Updates To The Tex2solver Online Tool

Dowon Lee, University at Buffalo, Amherst, NY, United States, Chase Murray

tex2solver (https://tex2solver.com) is an online tool that converts mixed integer linear programs (MILPs) from LaTeX syntax into solver code. It supports output in the form of AIMMS, .lp file format, PuLP, Gurobi, and more. Users unfamiliar with LaTeX may take a picture of an MILP to automatically convert to LaTeX. In this talk we will describe the tex2solver features that may be particularly attractive to students who may be new to MILP model building and to instructors.

■ VMA66

Virtual Room 66

Nonlinear Programming

Contributed Session

Chair: Jordan Armstrong, United States Air Force, Knoxville, TN, United States

1 - Polyhedral Relaxations For Nonlinear Univariate Functions
Kaarthik Sundar, Los Alamos National Laboratory, Los Alamos, NM, United States

This talk will present linear programming and mixed-integer linear programming relaxations for the graph of a univariate, bounded, nonlinear function f(x) that converge to its convex hull and the its graph, respectively. Theoretical convergence guarantees and rates of convergence will be discussed. Efficacy of utilizing these relaxations in global optimization algorithms to solve Mixed Integer Non-Linear Programs (MINLPs) will be shown. Furthermore, we will also show techniques to use these relaxations to build convex relaxations for non-linear on-off constraints.

2 - Algorithms For Difference-of-Convex Programs Based On Difference-of-Moreau-Envelopes Smoothing
Kaizhao Sun, Georgia Institute of Technology, Atlanta, GA, United States, Xu Andy Sun

We consider minimization of a difference-of-convex (DC) function with and without linear constraints. We first study a smooth approximation of a DC function termed difference of Moreau envelopes (DME), which captures geometric properties of the original function and enjoys some growth conditions. Then we show that the gradient descent method and an inexact variant converge on the DME and deliver a stationary solution of the original DC function. Furthermore, when the minimization is constrained in an affine subspace, we proposed two variants of the augmented Lagrangian method based on DME, which allow a nonsmooth concave component in the objective compared to the literature.

3 - Adjusted Portfolio Selection Models Reflecting The Baltic Dry Index And Interest Rates
Jihye Yang, Yonsei University, Seoul, Korea, Republic of, Soonbong Lee, Seongmoon Kim

This study suggests improved investment strategy based on Markowitz's portfolio selection model reflecting the Baltic Dry Index and Interest rates which are macro variables predicting the stock return. BDI and IR portfolio selection model 1 adjust the total proportion of capital invested in risky assets conservatively or aggressively depending on the level of BDI and IR. BDI and IR portfolio selection model 2 adjust the proportion of capital invested in each risky asset depending on the BDI and IR sensitivity of each stock. Lastly, BDI and IR portfolio selection model 3 are a combination of the two models. We evaluate the performance of the proposed models in 12 industrialized countries.

4 - Windowed Parametric Nonconvex Regression Of The Capture Cross Section In The Resolved Resonance Region
Jordan L Armstrong, United States Air Force, Knoxville, TN, United States, Hugh R. Medal, Vladimir Sobes

Resonance identification is done manually by expert nuclear data evaluators in a laborious, time-consuming, and unreproducible manner resulting in missed resonances and underestimated uncertainty. The cross section can be parameterized; however, the parameterization is a function of the number of resonances, which is unknown. Our proposed model correctly extracts the true cross section parameterization from the experimental data in both the number and values of the parameters through a novel windowing approach. Quantile regression supplements the windowed approach in providing a consistent and experimentally representative estimation of the uncertainty in the identification process.

■ VMA67

Virtual Room 67

Recent Advances in Stochastic Gradient Algorithms

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Lam M. Nguyen, IBM Thomas J. Watson Research Center, Ossining, NY, 10562-6037, United States

Co-Chair: Trang H. Tran, Cornell University, Ithaca, NY, United States

1 - Shuffling Gradient-Based Methods
Trang Tran, Cornell University, Ithaca, NY, United States, Lam M. Nguyen, Quoc Tran Dinh, Katya Scheinberg

We combine two advanced ideas widely used in optimization for machine learning: shuffling strategy and momentum technique to develop a novel method with momentum for finite-sum minimization problems. We establish that our algorithm achieves a state-of-the-art convergence rate for any shuffling strategy under standard assumptions. In particular, if a random shuffling strategy is used, we can further improve our convergence rate by a fraction of the data size. When the shuffling strategy is fixed, we develop another new algorithm that is similar to existing momentum methods. We prove the same convergence rate of this algorithm under the L-smoothness and bounded gradient assumptions. We demonstrate our algorithms via numerical simulations on standard datasets and compare them with existing shuffling methods.

2 - Hogwild! Over Distributed Local Data Sets With Linearly Increasing Mini-batch Sizes
Lam M. Nguyen, IBM Thomas J. Watson Research Center, Ossining, NY, 10562-6037, United States

We consider big data analysis where training data is distributed among local data sets in a heterogeneous way - and we wish to move SGD computations to local compute nodes where local data resides. The results of these local SGD computations are aggregated by a central "aggregator" which mimics Hogwild!. We show how local compute nodes can start choosing small mini-batch sizes which increase to larger ones in order to reduce communication cost. We improve state-of-the-art literature and show O(K^{0.5}) communication rounds for heterogeneous data for strongly convex problems, where K is the total number of gradient computations across all local compute nodes. For our scheme, we prove a tight and novel non-trivial convergence analysis for strongly convex problems for heterogeneous data which does not use the bounded gradient assumption as seen in many existing publications.

3 - Stochastic Gradient Descent-Ascent and Consensus Optimization for Smooth Games: Convergence Analysis under Expected Co-coercivity
Nicolas Loizou, Mila - Quebec Artificial Intelligence Institute, Montreal, QC, Canada

Two of the most prominent algorithms for solving unconstrained smooth games are the classical stochastic gradient descent-ascent (SGDA) and the recently introduced stochastic consensus optimization (SCO) (Mescheder et al., 2017). SGDA is known to converge to a stationary point for specific classes of games, but current convergence analyses require a bounded variance assumption. SCO is used successfully for solving large-scale adversarial problems, but its convergence guarantees are limited to its deterministic variant. In this work, we introduce the expected co-coercivity condition, explain its benefits, and provide the first last-iterate convergence guarantees of SGDA and SCO under this condition for solving a class of stochastic variational inequality problems that are potentially non-monotone. We prove linear convergence of both methods to a neighborhood of the solution when they use constant step-size, and we propose insightful stepsize-switching rules to guarantee convergence to the exact solution. In addition, our convergence guarantees hold under the arbitrary sampling paradigm, and as such, we give insights into the complexity of minibatching.

4 - Asynchronous Decentralized Accelerated Stochastic Gradient Descent
Yi Zhou, IBM Research, San Jose, CA, United States, George Lan

In this talk, we introduce an asynchronous decentralized accelerated stochastic gradient descent algorithm for decentralized stochastic optimization. Considering communication and synchronization costs are the major bottlenecks, we attempt to reduce these costs via randomization techniques. Our major contribution is to develop a class of accelerated randomized decentralized algorithms for solving general convex composite problems. We establish O(1/) (resp., O(1/√)) communication complexity and O(1/ 2) (resp., O(1/)) sampling complexity for solving general convex (resp., strongly convex) problems. It worths mentioning that our proposing algorithm only sublinear depends on the Lipschitz constant if there is a smooth component presented in the objective function.

■ VMA68

Virtual Room 68

Advances in Derivative-Free Optimization I

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Lindon Roberts, The Australian National University

1 - Derivative-free Optimization For Constrained Least-squares
Matthew Hough, The University of Queensland, Brisbane, Australia, Lindon Roberts

Derivative-free optimization (DFO) algorithms are a class of optimization methods for situations where derivatives are unavailable or unreliable. For example, DFO algorithms are often necessary for applications where the objective is noisy, computationally expensive, or black-box. Least-squares problems arise across a wide variety of disciplines, and optimization algorithms for solving them are well-established. While progress has been made to exploit the least-squares problem structure in unconstrained or bound-constrained DFO methods, here we consider least-squares problems with general convex constraints (accessed via projections). This talk will introduce a DFO method for convex constrained least-squares, outline its convergence guarantees, and compare its performance to existing methods.

2 - A One-Bit Gradient Estimator for Comparison-Based Optimization

Daniel Mckenzie, University of California, Los Angeles, CA, United States, HanQin Cai, Wotao Yin, Zhenliang Zhang

Comparison-based optimization is a particularly restrictive form of derivative-free optimization. Instead of having access to function evaluations one only assumes access to an oracle which, given two points x and y, returns a single bit of information indicating which is larger, f(x) or f(y). This paradigm arises frequently in practice in optimization problems where humans are providing the feedback, e.g. website AB testing, as asking humans to compare two options is typically more reliable than asking them to assign a numerical score of "goodness". In this talk we will survey recent progress on making comparison-based optimization more query efficient, with an emphasis on a recent work by the listed authors that exploits gradient sparsity to construct an algorithm with query complexity sub-linear in the problem dimension.

3 - A Zeroth Order, Block Coordinate Descent Method For Huge-scale Problems

Yuchen Lou, The University of Hong Kong, Hong Kong, HanQin Cai, Daniel Mckenzie, Wotao Yin

Zeroth-order optimization (a.k.a. derivative-free optimization) is becoming more and more attractive for solving huge-scale problems. In this setting one only has the access to the function queries (function value of f evaluated at a given point x) without any gradient information. This type of optimization method is now very popular in finding policies of reinforcement learning and generating adversarial examples. For huge-scale problems, say million-dimensional, one requires an algorithm using as few query calls and vector operations as possible. In this talk we will present a novel algorithm, coined ZO-BCD, that exhibits favorable query complexity, memory footprint, and operation efficiency, with an illustration on attacking both image and audio classifiers in a wavelet domain, which results in problems with over one million variables.

■ VMA70

Virtual Room 70

Recent Advances in Multistage Stochastic Programming

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Harsha Gangammanavar, Southern Methodist University, Dallas, TX, 75275, United States

1 - Data-driven Multi-stage Stochastic Optimization On Time Series

Jim Luedtke, University of Wisconsin-Madison, Madison, WI, 53706, United States, Rohit Kannan, Nam Ho-Nguyen

We study a data-driven framework for multi-stage stochastic optimization. Specifically, we assume we have access to a single historical sample path of data drawn from a stationary time series. Conditional on the most recent observation of the time series, the goal is to determine a decision policy that minimizes the expected cost over the next T time periods. We investigate a data-driven approximation in which a time-series model is fit based on the historical data, and then the residuals from this fit are used to build a discrete approximation of the stochastic process. The approximation we study can be solved via the stochastic dual dynamic programming algorithm. We derive conditions on the underlying stochastic process, the time series model, and the optimization model under which solutions to the approximation possess asymptotic and finite sample guarantees.

2 - Complexity Of Stochastic Dual Dynamic Programming

Guanghui Lan, ISyE Ga Tech, Atlanta, GA, 30332, United States

Stochastic dual dynamic programming is widely used for solving multi-stage stochastic optimization in practice during the past few decades. We provide an affirmative answer to a long-standing conjecture is that its complexity mildly depends on the number of stages, among other developments.

3 - A Multiple-replication Approach To Multistage Stochastic Linear Programming

Jiajun Xu, University of Southern California, Los Angeles, CA, 90007-2285, United States, Suvrajeet Sen, Harsha Gangammanavar

We present a multi-replication algorithm based on stochastic dynamic linear programming (SDLP), which, by exploiting parallel computing, can be used to build accurate function approximations in a limited time. We investigate stopping criteria where we apply a hypothesis test and find a probabilistic guarantee for each node in the validation scenario tree. We also introduce an upper bound function using Basic Feasible Policies. Together with the lower bound function, we can restrict the gap of the estimated function value at any state.

4 - A Time Windows Approach For Project Scheduling Under Uncertainty

Bernardo Kulnig Pagnoncelli, Universidad Adolfo Ibanez, Santiago, 7910000, Chile, Marcos Goycoolea, Patricio Lamas

In this work, we address the problem of determining the starting times of a set of activities in order to maximize the expected net present value of a project. We assume that each activity is characterized by a random duration and a random profit with known probability distributions. The approaches in the literature either generate a baseline schedule (proactive approaches) or a policy that reacts to the revelation of uncertainty (reactive approaches). We propose an integrated proactive/reactive approach that simultaneously generates both a baseline time window for each activity's start time and a policy. Our computational results show that, in general, the solutions generated by our approach dominate, in terms of expected net present value and variability of the starting times of the activities, those generated by the alternatives in the literature.

5 - Multistage Stochastic Programming with Optimal Stopping

Rui Peng Liu, Georgia Institute of Technology, Atlanta, GA, United States

The theory of optimal stopping finds interesting applications in house selling, one-armed bandit, option trading, etc. In this talk, we present a general formulation of multistage stochastic programming that incorporates optimal stopping. This formulation can be solved, as usual, by writing down the Bellman equation and applying dynamic programming. Our focus will be on applications and computational aspects of the formulation.

■ VMA71

Virtual Room 71

Railroad Maintenance

Sponsored: Railway Applications

Sponsored Session

Chair: Faeze Ghofrani, Penn State Altoona, Altoona, PA, United States

1 - Deep Learning For The Detection And Recognition Of Rail Defects In Ultrasound B-scan Images

Qing He, Southwest Jiaotong University, Chengdu, 610031, China

Rail defect detection is crucial to rail operations safety. Aiming at the problem of high false alarm rates and missed detection rates in rail defect detection, this paper proposes a deep learning method using B-scan image recognition of rail defects with an improved YOLO (You Only Look Once) V3 algorithm. The detection accuracy and efficiency are improved compared with the original model and the final mAP can reach 87.41%.

2 - Willow Digital Twin for Railway Networks: Lessons and Challenges

Ali Jamshidi, Willow Inc, Amersfoort, Netherlands

Having more areas encompassed with railway tracks demand robust technologies to keep asset managers, passengers and environmental policy makers at an acceptable satisfaction. To do so, the whole system performance should be interconnected to level up track availability and business continuities. This cannot be effectively done unless digitalizing the whole system performance. Yet, developing digital twin for railway networks can be challenging as infrastructure managers can neither solely rely on data driven models nor physics-based approach. In this presentation, the most influential challenges in this context will be addressed based on the real case studies conducted by Willow company.

3 - Use Of Ground Penetrating Radar Measured Track Conditions To Predict Track Geometry Degradation

Allan M. Zarembski, PhD, University of Delaware, Newark, DE, United States

This paper presents the results of a series of studies examining the relationship between track geometry defects and track subsurface conditions as measured by Ground Penetrating Radar (GPR). Data analytic techniques were applied to this large data set to develop a relationship between significant geometry degradation, which represents a major maintenance and safety issue in railroad operations, and the GPR measured ballast condition parameters. The results of these analyses showed that there was a statistically significant relationship between high rates of geometry degradation and poor subsurface condition as defined by the GPR parameters: Ballast Fouling Index (BFI) and Ballast Layer Thickness (BLT). Furthermore, a predictive model was developed to determine the probability of a high rate of geometry degradation as a function of these key GPR parameters.

4 - Inspection Technologies For Reliable Railway Transportation Systems

Faeze Ghofrani, Assistant Teaching Professor, Pennsylvania State University, Altoona, PA, 16803, United States

This study delivers an in-depth review of the state-of-the-art technologies relevant to inspection technologies giving emphasis to their use in railroad systems. The review not only looks at the research being carried out but also investigates the commercial products available for railroad systems inspection. It continues further to identify the methods suitable to be adopted in a moving vehicle detection system. Even though flaw detection has been a well-researched area for decades, an in-depth review summarizing all available technologies together with an assessment of their capabilities has not been provided in the recent past according to the knowledge of the authors. As such, it is believed that this study will be a good source of information for future researchers in this area.

■ VMA73

Virtual Room 73

Game Theory Applications

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Haiying Yang, Syracuse University, Syracuse, NY, 13203-2627, United States

1 - Non-clairvoyant Dynamic Mechanism Design With Budget Constraints And Beyond

Song Zuo, Google, NYC, NY, United States

We provide a general design framework for dynamic mechanisms under complex environments, coined Lossless History Compression mechanisms. Lossless history compression mechanisms compress the history into a state carrying the least historical information without losing any generality in terms of either revenue or welfare. The characterization works for almost arbitrary constraints on the outcomes, and any objective function defined on the historical reports, allocations, and the cumulative payments. We then apply our framework to design an approximately optimal non-clairvoyant dynamic mechanism under budget and ex-post individual rationality constraints.

2 - The Pareto Frontier Of Inefficiency In Congestion Games

Rahul Chandan, PhD Student, University of California, Santa Barbara, CA, United States, Dario Paccagnan, Jason R. Marden

We consider the design of incentives in congestion games and show that there exists an inherent tradeoff between the worst-case and best-case equilibrium performance (price of anarchy and stability). Our main result characterizes such a tradeoff in terms of the Pareto frontier between these two metrics. Perhaps surprisingly, we show that i) the incentive that optimizes the price of anarchy yields a matching price of stability, and ii) the joint performance guarantees of unincentivized congestion games do not even lie on the Pareto frontier.

3 - Optimal Incentives To Mitigate Epidemics: A Stackelberg Mean Field Game Approach

Gokce Dayanikli, Princeton University, Princeton, NJ, United States, Alexander Aurell, Rene A. Carmona, Mathieu Lauriere

Motivated by the models of epidemic control, we consider a Stackelberg mean field game between a principal and a mean field of agents whose states evolve in a finite state space. The agents play a noncooperative game in which they control their transition rates between states to minimize an individual cost. The principal influences the Nash equilibrium through incentives to optimize its own objective. We show an application to an epidemic model of SIR type in which the agents control their contact rates, and the principal is a regulator acting with non pharmaceutical interventions. We propose a numerical approach based on Monte Carlo simulations and machine learning tools for stochastic optimization.

4 - Continuous Patrolling Games

Katerina Papadaki, Associate Professor, London School of Economics & Political Science, London, United Kingdom, Steve Alpern, Thomas Lidbetter

We study a zero-sum game in which a Patroller chooses to patrol a network over an infinite continuous time horizon and an Attacker picks a point of the network, which may be on the interior of an arc, to launch an attack. The attack duration is the length of time needed for the attack to be completed and it is known to both players. The payoff to the Attacker is the probability the attack is successful (not intercepted). We give optimal strategies and the value of the game for arbitrary networks for a range of values of the attack duration. Further we provide solutions for tree networks under more relaxed conditions on the attack duration (these include symmetric stars and the line network).

5 - The Impact Of Cost Auditing On Supply Chain's Social Responsibility Level

Haiying Yang, Syracuse University, Syracuse, NY, 13203-2627, United States, Zhengping Wu

Cost auditing is becoming an increasingly important tool to improve supply chain efficiency and mitigate the influence of information asymmetry. We study how cost auditing indirectly influences retailer and supplier's behavior in social responsibility. We also discuss the potential negative social responsibility externalities of conducting an audit and the managerial insights. Finally, we find that customers' attitude towards different products changes retailer and supplier's social responsibility preference.

■ VMA75

Virtual Room 75

OR/ML Practice at Amazon

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Kaiyue (Kay) Zheng, Amazon, Bellevue, WA, 98004, United States

1 - Speed Up Solving Large-scale Facility Location Model

Shanshan Zhang, Amazon, Bellevue, WA, 98006-5434, United States

The essential problem in last mile network design space is to solve varied versions of capacitated facility location problems (CFLP). Given the rapid growth of Amazon last mile delivery service, the scale of CFLP increase dramatically, which motivates the work in this paper. This paper presents an algorithm that speeds up solving large-scale CFLP via the combination of a customized greedy heuristic, three local search strategies, and a standard MIP approach. CFLP is NP-Hard. When the problem size becomes large, solving it using commercial solvers to the desirable optimality gap is time consuming or sometimes infeasible. Our numerical results show that the proposed algorithm can provide similar or even better solutions much faster than using commercial solvers directly.

2 - Sortation Optimization And Allocation Planning In Amazon Middle Mile Network

Kay Zheng, Research Scientist, Amazon, Bellevue, WA, 98004, United States

Middle mile network involves the transportation and sortation of goods from warehouses to the last mile carriers that provides final-mile delivery services. Amazon middle mile transportation paths can include one or more sortation processes along the way and span hundreds or even thousands of miles. Sortation resource optimization and allocation at the middle mile network plans for where, when and how to sort packages along their shipment paths so as to achieve cost, speed or other goals given limited resources at warehouses and on the road. In this work, we present a mixed-integer programming based planning approach to model the trade-offs in the network and discuss the complexities due to the interconnectedness of network structure.

3 - Combined Machine-Learning (ML) and Optimization Forecast Model for Long-Term Supply Chain Planning

Hadi W Purnomo, Amazon, Seattle, WA, 98133, United States

We present empirical approaches for combining the use of optimization and machine learning to generate long-term forecasts in supply chain planning.

We report two successful applications in production environments on quantile inventory forecasts for storage planning and transportation order fulfillment forecast to estimate speed delivery impact. Our key learnings show that optimization can improve ML output quality by satisfying customized business constraints such as speed targets, increasing prediction interval bands and correcting ML model deficiencies in targeted area.

4 - Presenter

Richa Tiwari, Research Scientist, Amazon India, Bengaluru, India

Exchange points are an extension of Delivery stations (DS) and act as forward transfer points in Amazon last mile (LM) landscape. They a) act as a handoff point for containers between DS and delivery service providers (DSPs)/I have space (IHS)associates, b) help in improving on-road efficiency by reducing the stem time and allowing additional delivery window. In order to efficiently manage LM operations, it is important to optimize XPT topology and DS-XPT-DSP/IHS routes. We provide a consolidated model formulation for this problem and the then solve it efficiently using a combination of off the shelf solver and mataheuristics.

■ VMA76

Virtual Room 76

OR and Advanced Analytics Practice

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Aravind Govindarajan, Target Corporation, Santa Clara, 95054, United States

1 - Digital Operations At Target: Achieving Tactical Outcomes Through Operational Execution

Aravind Govindarajan, Target Corp, New Haven, United States

Covid-19 has accelerated Target's e-commerce business, and increased the scale of digital operations. We discuss some fundamental operational decisions in the online "ship-to-home" order fulfillment process, and the complications that arise from increased demand. In particular, we focus on the last mile transportation and order allocation problems, and discuss how day-to-day operational decisions can be enhanced to achieve desired longer term tactical outcomes through forecasting and optimization.

2 - Presenter

Qingyang Li, Didi, San Jose, CA, United States

Reinforcement learning aims at searching the best policy model for decision making. The training of the policy by RL, however, is placed in an environment. In many real-world applications, the policy training in the real environment can cause an unbearable cost due to the exploration. Environment estimation from the past data is thus an appealing way to release the power of RL. The estimation of the environment is, basically, to extract the causal effect model from the data. However, real-world applications are often too complex to offer fully observable environment information. Therefore, quite possibly there are unobserved variables lying behind the data, which can obstruct an effective estimation of the environment. In this talk, we introduce a partially-observed multi-agent environment estimation approach to learn the partially-observed environment.

■ VMA77

Virtual Room 77

SOLA Best Student Paper Award

Sponsored: Location Analysis

Sponsored Session

Chair: Baris Yildiz, Koc University, Sariyer, 34450, Turkey

1 - Urban Bike Lane Planning with Bike Trajectories: Models, Algorithms, and a Real-World Case Study

Sheng Liu, University of Toronto, Toronto, ON, M5S 1J5, Canada

We study an urban bike lane planning problem based on the fine-grained bike trajectory data,which is made available by smart city infrastructure such as bike-sharing systems. The key decision is where to build bike lanes in the existing road network. As bike-sharing systems become widespread in metropolitan areas, bike lanes are being planned and constructed by many municipal governments to promote cycling and protect cyclists. Traditional bike lane planning approaches often rely on surveys and heuristics. We develop a general and novel optimization framework to guide bike lane planning from bike trajectories. We formalize the bike lane planning problem in view of the cyclists' utility functions and derive an integer optimization model to maximize the utility. To capture cyclists' route choices, we develop a bilevel program based on the Multinomial Logit model. We derive structural properties about the base model and prove that the Lagrangian dual of the bike lane planning model is polynomial-time solvable. Furthermore, we reformulate the route choice based planning model as a mixed integer linear program using a linear approximation scheme. We develop tractable formulations and efficient algorithms to solve the large-scale optimization problem. Via a real-world case study with a city government, we demonstrate the efficiency of the proposed algorithms and quantify the trade-off between the coverage of bike trips and continuity of bike lanes. The proposed framework drives the data-driven urban planning scheme in smart city operations management.

2 - Exact Solution of Stochastic Dynamic Facility Location Problems with Probabilistic Service Levels on Delivery Times

Aditya Malik, Concordia University, Montreal, QC, Canada

We study a general class of stochastic dynamic capacitated location problems with single assignments arising in the design of e-commerce supply chains. We consider probabilistic service level constraints to ensure orders are delivered within a prescribed time limit with a probability greater than or equal to a threshold value. We propose two mixed-integer linear programs to formulate this class of problems. One formulation is based on the use of an exponential number of cover-type inequalities, whereas the other is based on a polynomialnumber of residual capacity constraints to model with linear inequalities the nonconvex probabilistic service level constraints. We propose an exact branch-and-cut algorithm and embed several algorithmic refinements to accelerate its convergence. These include exact and heuristic separation routines that efficiently generate cover inequalities at integer and fractional points, a preprocessing phase to fix variables, a matheuristic to provide initial feasible solutions, an in-tree local search heuristic to efficiently explore partitions of the solution space, and additional valid inequalities that strengthen the formulation and help improve the overallperformance of the enumeration algorithm. Extensive computational experiments are performed to evaluate the strength of the two formulations and the performance of the exact algorithm. We report the results of extensive computational experiments based on real location data from the USA to evaluate the efficiency and limitations of proposed solution algorithm. Results obtained on large problem instances with up to 2,500 customers and 225 potential facilities, three capacity levels, and four time periods under different service level scenarios confirm the effectiveness of the proposed algorithm. We also provide detailed sensitivity analyzes to assess the solutions under different input parameter settings

3 - Robust-stochastic Models for Profit Maximizing Hub Location Problems

Gita Taherkhani, University of Waterloo, Waterloo, ON, N2T2L1, Canada

This paper introduces robust-stochastic models for profit maximizing capacitated hub locationproblems in which two different types of uncertainty including stochastic demand and uncertainrevenue are simultaneously incorporated into the problem. First, a two-stage stochastic program is presented where demand and revenue are jointly stochastic. Next, robust-stochastic models are developed to better model uncertainty in the revenue while keeping the demand stochastic. Two particular cases are studied based on the dependency between demand and revenue. In the first case, a robust-stochastic model with a min-max regret objective is developed assuming a finite set of scenarios that describe uncertainty associated with the revenue under a revenue-elastic demand setting. For the case when demand and revenue are independent, robust-stochastic models with a max-min criterion and a min-max regret objective are formulated considering both interval uncertainty and discrete scenarios, respectively. It is proved that the robust-stochastic version with max-min criterion can be viewed as a special case of the min-max regret stochastic model. Exact algorithms based on Benders decomposition coupled with sample average approximation scheme are proposed. Exploiting the repetitive nature of sample average approximation, generic acceleration methodologies are developed to enhance the performance of the algorithms enabling them to solve large-scale intractable instances. Extensive computational experiments are performed to consider the efficiency of the proposed algorithms and also to analyze the effects of uncertainty under different settings. The qualities of the solutions obtained from different modeling approaches are compared under various parameter settings. Computational results justify the need to solve robust-stochastic models to embed uncertainty in decision making to design resilient hub networks.

■ VMA78

Virtual Room 78

Relief Distribution Strategies for Vulnerable and Hard to Reach Populations

Committee Choice: Committee's Choice

Committee Choice Session

Chair: Tanzid Hasnain, North Carolina State University, Raleigh, NC, 27606, United States

1 - Agent-based Simulation: Modeling the Impact of Client-choice Food Distribution at Food Pantries

Benjamin F. Morrow, North Carolina A&T State University, Haw River, NC, 27258, United States

Client-choice food pantries are quickly becoming a vital instrument in the fight against food insecurity. This research aims to use agent-based simulation to model the impact of client-choice food distribution on client food choices at a food pantry. Using survey results, we show that such interventions result in significantly healthier food choices.

2 - Elicitation Of Preference Among Multiple Criteria In Food Distribution By Food Banks

Tanzid Hasnain, North Carolina State University, Raleigh, NC, 27606, United States, Irem Sengul Orgut, Julie Simmons Ivy

Food banks are nonprofit organizations that collect food donations and distribute to the food-insecure populations in their service regions. Three criteria are often considered by the food banks while determining the distribution of the donated food: equity, effectiveness, and efficiency. Models that assume predetermined sets of weights on these criteria may produce inaccurate results as the preference of the food banks over these criteria may vary. We develop a weighted multi-criteria optimization model that capture the varying preferences over the three criteria. We propose a novel algorithm that elicits the inherent preference of a food bank by analyzing its actions within a single-period and that does not require direct interaction with the decision-maker. We illustrate results using real life data from our food bank partner and discuss managerial insights.

3 - Drone Logistics for Uncertain Demands of Disaster-impacted Populations

Zabih Ghelichi, University of Louisville, Louisville, KY, United States, Monica Gentili, Pitu B. Mirchandani

In this study, we present a stochastic optimization model to address the challenges associated with timely delivery of aid packages to disaster-affected regions via a fleet of drones while considering the set of demand locations is unknown. The main problem is to locate a set of drone platforms such that with a given probability, the maximum total cost (or disutility) under all realizations of the set of demand locations is minimized. We formulate and solve a time-space drone scheduling model for a set of scenarios to build up the total disutility distribution. We also propose an algorithmic solution approach which decomposes the problem into three tractable subproblems.

■ VMA79

Virtual Room 79

Operations Management in Agriculture

Informs Special Session: Agriculture

Informs Special Session Session

Chair: Milind Dawande, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - Can Producers Be Testers? A Peer-to-peer Testing Framework For Milk Cooperatives

Sameer Mehta, Erasmus University, Rotterdam, Netherlands, Milind Dawande, Vijay S. Mookerjee

We develop and analyze a peer-to-peer testing framework for milk cooperatives. We show that our framework addresses farmers' adverse incentive to free-ride, generates higher income for them compared to the status-quo framework, and further incentivizes more farmers to join the cooperative, thus generating a beneficial virtuous cycle.

2 - Negotiating Government-to-government Food Importing Contracts: A Nash-bargaining Framework

Liying Mu, University of Delaware, Newark, DE, 19716-2706, United States, Bin Hu, Amarender Reddy, Srinagesh Gavirneni

Inspired by India's pulses importing challenges, we study the negotiation of government-to-government food importing contracts, with a focus on comparing ad-hoc and forward multiple-sourcing negotiations (i.e., negotiating an importing contract after or before the domestic pulses yield is realized). We find that while forward negotiations are not necessarily better than ad-hoc negotiations for the buyer, it would be true with sufficiently many suppliers. When facing a supplier pool, we show that it may be optimal to mix forward and ad-hoc suppliers. In general, fewer suppliers should be assigned as ad-hoc as the pool size increases. We also find that adding a hybrid supplier (engaged in a forward negotiation with an existing ad-hoc supplier) may be better or worse than adding a new forward supplier in the presence of other suppliers.

■ VMA81

Virtual Room 81

Innovative Transportation and Urban Planning

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

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

Co-Chair: Liwei Zeng, University of Minnesota, Minneapolis, MN, 55455, United States

1 - Partitioning For On-time Delivery

Han Yu, University of Southern California, Los Angeles, CA, 90007, United States, Nooshin Salari, Sheng Liu, John Gunnar Carlsson

We analyze a practical dispatching and routing strategy called partitioning strategy, which assigns every driver to predefined subregions. The driver will be dedicated to serving orders from the assigned subregion. The goal is to find a convex partition of the region such that the corresponding partitioning strategy yields the shortest expected delivery time. The optimal partitioning strategy balances two measurable functions between different subregions. We prove that, in heavy traffic, there exists a convex partitioning strategy that achieves the same expected delivery time as in Bertsimas and Van Ryzin (1993a). We validate the superior performance of our partitioning strategy on both simulated and real-world data sets. Compared with alternative partitioning methods, the proposed partitioning strategy provides consistently shorter average delivery times.

2 - Infrastructure Planning For Hydrogen Fuel-cell Vehicles

Nan Ke, National University of Singapore, Singapore, Long He, Wei Qi, Hongcai Zhang

In this talk, we study how to promote the adoption of hydrogen fuel-cell vehicles (HFVs) by deploying supporting infrastructures and utilizing renewable energy. Taking the perspective of a government that wishes to achieve a target level of HFV adoption at minimum cost, we formulate a planning model that integrates transportation and power grid networks, to jointly determines the locations and capacities of hydrogen refueling stations and hydrogen plants, as well as power generation, electricity transmission, and grid upgrade. We apply our model to the case of Sichuan Province in China and develop insights into effective infrastructure deployment strategies.

3 - Last-Mile Delivery: Scheduling Mobile Parcel Lockers Under Customer Choice

Liwei Zeng, University of Minnesota, Minneapolis, MN, 55455, United States, Yiling Zhang

The movable unit equipped with a set of parcel lockers has been developed as a new model to improve the efficiency of last-mile delivery systems. Different from traditional lockers, mobile lockers can be relocated to accommodate the changing demand from location to location over time. The service providers face issues such as time-varying demands from the heterogeneous customer groups depending on the arrival and departure times of the mobile lockers. We consider a mobile parcel locker scheduling problem under customer choice model. The problem is formulated as a 0-1 non-convex program. We develop a 0-1 second-order cone programming reformulation and propose valid inequalities by exploiting submodularity and aggregating demands. Numerical studies of real-world data have been conducted.

4 - Allocation And Reposition Of Reusable Empty Containers In B2C E-commerce

Xue Luo, Tsinghua University, Beijing 100084, China, Lei Zhao, Stein W Wallace

In a business-to-customer (B2C) e-commerce company, for economic and sustainable considerations, transferred goods among distribution centers (DCs) are packed in reusable and stackable containers. Paper boxes are used in case of container deficiency. The structural imbalance in the flows of goods results in the buildup of empty containers at some DCs and the shortage of them at some others, leading to the overuse of paper boxes. We study the empty container allocation and reposition problem and formulate it as a two-stage stochastic program. The demands of loaded containers on legs are correlated due to leg sharing among the origin-destination (O-D) routes of goods. We use a copula-based scenario generation method, test the in-sample and out-of-sample stability, and perform a numerical study based on the real network of a B2C e-commerce company.

■ VMA82

Virtual Room 82

Emerging Topics in Facility Logistics

Sponsored: TSL/Facility Logistics

Sponsored Session

Chair: Amir Gharehgozli, California State University-Northridge, Northridge, CA, 91330-0001, United States

1 - Human-robot Collaboration In Order Picking Operations

Mahmut Tutam, Dr., Erzurum Technical University, Erzurum, Turkey, René De Koster

Order picking operations contribute a large portion to the warehousing costs and require strenuous activities which can lead to physical distress. To improve the picking productivity and ergonomics, ride-on cobots are deployed in an increasing number of warehouses. The order-picker can ride to a stop location, gets off the cobot and walks to the pick location. After dropping off the product picked, s/he can ride the cobot to the next pick location or walk alongside while the cobot moves autonomously. Because our problem is computationally intractable for large-sized problems, we propose a dynamic programming approach by nesting the travelling salesman sub-problems recursively. Based on simulation, our results show the optimal collaboration strategy improves total travel time up to 20% for one-block and 15% for two-block warehouses compared to a heuristic from practice.

2 - Impact Of Route Planning On Workforce Scheduling In Distribution Centers

Arpan Rijal, University of Groningen, Groningen, Netherlands, Marco Bijvank, René De Koster

When the distribution of ordered items from a warehouse to customers is scheduled, the transportation planning is generally done first and this serves as input for the planning of warehouse operations. However, when the deliveries to customers have time window restrictions and the availability of order picking or staging capacities at the warehouse is limited, the sequential approach of transportation-first-warehousing-second is not only sub-optimal but the routes can also be infeasible for warehouse managers to implement. This paper studies the routing decisions of vehicles to customer locations with hard time windows while considering scheduling of order pickers - determining batch size of orders

and their sequencing - with limited staging. We propose a mathematical model for the integrated problem and propose solution approaches.

3 - Increasing Shelving Density In A Robotic Mobile Fulfillment Warehouse Using Overhead Lifting System

Leily Farrokhvar, California State University-Northridge, Northridge, CA, 91330-0001, United States, Vy Nguyen, Northridge, CA, 91330-0001,Kenneth Currie

A robotic mobile fulfillment (RMF) system is proven to be a solution for the fast-growing, rapid, and dynamic demand of e-commerce. With many advantages on pick time, efficiency, and accuracy, an RMF system is often limited to a one-dimension operation on the floor coupling with heavy utilization of robots. We propose implementing an overhead lifting system to take advantage of the vertical space, increase warehouse density, improve robot utilization, and save space costs. We simulate restricted environments and analyze pick time, picker utilization, and throughput times.

■ VMA83

Virtual Room 83

Advances in Transportation Modeling

Sponsored: TSL/Intelligent Transportation Systems

Sponsored Session

Chair: Valentijn Stienen, Tilburg University, Tilburg, Netherlands

1 - Quantifying Driver Behavior Using Dynamic Semi-continuous Zero-inflated Model

Tianshu Feng, University of Washington, Seattle, WA, United States, Linda Boyle

Time series of zero-inflated data is frequently encountered in transportation. However, previous studies focused largely on counts and neglected the continuous variations, which can provide greater insights on driver behavior. In this study, we demonstrate the use of a dynamic semi-continuous zero-inflated (DSCZI) model to quantify drivers' brake responses using data from a naturalistic field operational test. The results show that we can use DSCZI to predict the likelihood that a driver will brake in a safety-critical situation, as well as the magnitude of braking.

2 - Network Traffic Model With Accidents

Marcel Kleiber, Leibniz Universität-Hannover, Hannover, Germany, Stefan Weber

Accidents are rare events but may cause significant losses to the society. Based on a modular modeling approach, we propose a flexible and scalable network traffic model which describes the movement of vehicles subject to the risk of accidents. Specifically tailored importance sampling algorithms facilitate the efficient estimation of accidents and allow to quantify their impact on traffic flow. Engineering solutions can mitigate emerging risks only to a certain extent. We complement the analysis by studying insurance solutions that cover residual risks financially. This yields a novel framework to study risk transfer instruments for emerging risks in (future) traffic systems.

3 - Create, Merge And Enrich Digital Road Networks For Optimization In Remote Areas Using Openstreetmap And Gps Traces

Valentijn Stienen, Tilburg University, Tilburg, Netherlands

An accurate representation of a road network that includes realistic travel times is essential when performing network analyses. We can often rely on maps such as OpenStreetMap (OSM) and Google Maps for these representations. However, this is not always the case. For instance, in remote areas, roads may not exist in OSM or are not accurately connected with each other. This might lead to significant flaws in optimal routing decisions that are based on these road networks. We develop an incremental insertion method that creates, combines or extends large road networks in data scarce environments.

■ VMA84

Virtual Room 84

Daniel H. Wagner Prize for Excellence in the Practice of Advanced Analytics and Operations Research: I

Award Session

Chair: Margret V. Bjarnadottir, University of Maryland, College Park, MD, 20742, United States

1 - Data-Driven Optimization for Atlanta Police Zone Design

Shixiang Zhu, Georgia Institute of Technology, Marietta, GA, 30067, United States, He Wang, Yao Xie

We present a data-driven optimization framework for redesigning police patrol zones in an urban environment. The objectives are to rebalance police workload among geographical areas and to reduce response time to emergency calls. Our proposed design was implemented by the Atlanta Police Department in March 2019. By analyzing data before and after the zone redesign, we show that the new design has reduced the response time to high priority 911 calls by 5.8% and the imbalance of police workload among different zones by 43%.

2 - Solving the Ride-sharing Productivity Paradox: Priority Dispatch and Optimal Priority Sets

Garrett J van Ryzin, Amazon Corporate LLC, Brooklyn, NY, 11217-2973, United States

Transportation Network Companies are often tasked with balancing rideshare markets as they fluctuate between different marketplace balance conditions. During the Covid-19 pandemic, a particularly salient problem has been 'oversupply', where there is an excess of active drivers relative to the stream of passenger requests. The Priority Mode Controller is a novel solution to this problem, granting a certain subset of drivers access to prioritized dispatch. In this paper, we discuss the algorithmic and logical foundations of this product, rolled out successfully by Lyft throughout North America.

Monday, 7:00AM - 7:30AM

■ VM85-2

Virtual Room 85

Technology Showcase: Take your Optimization Model (CPLEX or others) to the Cloud with DBOS!

Technology Showcase

1 - Take your Optimization Model (CPLEX or others) to the Cloud with DBOS!

Michel Eisenmann, DecisionBrain, France

DecisionBrain Optimization Server (DBOS) is specifically designed to help build and deploy fully scalable optimization-based applications. It enables optimization developers to focus on their models and help them effortlessly deploy those models in production in a context that will support multiple parallel runs on dedicated resources. To achieve this, DBOS lets you encapsulate any computational module (optimization solvers, analytics modules, etc.) into so-called “Workers”. Workers can be deployed on dedicated resources (local, private, or public cloud) to ensure the best execution time. When deployed on Kubernetes, Workers may be activated on-demand to reduce cloud costs. DBOS can be used in a stand-alone mode to run computations (for development purposes for example). It can also be integrated with existing applications to let them provide scalable and on-demand optimization capabilities as well as powerful monitoring capabilities. In this presentation, we will demonstrate how this technology can be used to: Encapsulate a Cplex model in a Worker; Deploy this Worker on a Kubernetes cluster using resources only on-demand; Monitor Real-time Executions.

■ VM85-3

Virtual Room 85

Technology Showcase: Radical Simplification for the Creation of Optimization Models

Technology Showcase

1 - Radical Simplification for the Creation of Optimization Models

Segev Wasserkrug, IBM Reserach Lab, Haifa, Israel, Dharmashankar Subramanian

We will demonstrate a unique technology being developed by IBM to radically simplify and speed up the creation of optimization models. This is done through a combination of data driven and simplified modeling techniques, thereby also creating end-to-end data to decisions pipelines.When you interact with IBM, this serves as your authorization to INFORMS or its vendor to provide your contact information to IBM in order for IBM to follow up on your interaction. IBM’s use of your contact information is governed by the IBM Privacy Policy

Monday, 7:45AM - 9:15AM

■ VMB01

CC - Ballroom A / Virtual Theater 1

Hybrid - AAS Special Speaker Talk

Sponsored: Aviation Applications

Sponsored Session

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

1 - Introduction of AI/ML Capabilities into Airline Industry

Sergey Shebalov, Sabre Holdings, Southlake, TX, 76092, United States

AI/ML capabilities are being widely adopted across many industries. We will share practical experience of introducing these capabilities into airline industry. There are several key properties of AI/ML that generate incremental value compare to decision support approaches used in the past. We describe specific use cases to illustrate these properties and discuss typical challenges and roadblocks for successful implementation of AI/ML capabilities. We will also look beyond creating ML models to into data management and MLOps areas that are crucial for AI/ML adoption. Finally, we'll make a few suggestions on the role of academic community in this process and describe a path toward closer collaboration between academia and industry.

■ VMB02

CC - Ballroom B / Virtual Theater 2

Hybrid - Inverse Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States

1 - Learning Personalized Diabetic Retinopathy Screening Preferences

Fariha Kabir Torsha, University of Houston, Houston, TX, United States, Taewoo Lee

Diabetic retinopathy (DR) is the leading cause of vision loss in working-age Americans. Due to the asymptomatic early stages of DR, the American Diabetes Association recommends annual eye screening exams for all diabetic patients. However, not all patients are screened annually; compliance rate varies significantly across different types of patients, typically within the range of 20-60%. In this study, we model the patient's screening decision-making process as a Markov decision process (MDP) and use inverse optimization to infer the patient's reward function from his/her past screening decisions. We then use the inferred reward function to generate personalized screening decisions.

2 - A Penalty Block Coordinate Descent Algorithm for Data-driven Inverse Convex Optimization

Rishabh Gupta, University of Minnesota, Minneapolis, MN, United States, Qi Zhang

We consider inverse convex optimization where the goal is to jointly infer the unknown objective and constraint parameters of a convex NLP from noisy observations. We formulate the problem as a bilevel program and apply a KKT-based approach to obtain a single-level reformulation. The resulting nonconvex nonlinear problem is solved with an approximate block coordinate descent method. We show that the proposed algorithm is guaranteed to converge to a stationary point for several important classes of forward problems such as convex QCQPs and geometric programs. Numerical experiments on synthetic datasets demonstrate the computational advantage of our method against standard commercial solvers.

3 - Optimality-Based Clustering

Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States, Zahed Shahmoradi

Clustering is a well-known technique to group a set of data points into smaller clusters such that the data points in the same cluster are closer to each other than to those in other clusters based on some similarity function. We propose a new clustering approach, called optimality-based clustering, that clusters data points based on their encoded decision preferences. We model the problem as a mixed-integer program and propose efficient heuristics.

■ VMB03

CC - Ballroom C / Virtual Theater 3

Hybrid - Markov Lecture

Sponsored: Applied Probability Society

Sponsored Session

Chair: Rhonda L Righter, University of California-Berkeley, Berkeley, CA, 94720-1777, United States

1 - Fragmenting Financial Markets

Darrell Duffie, Stanford University, Stanford, CA, 94305-5015, United States

This talk on financial market design addresses the costs (and sometimes the benefits) of fragmenting trade across multiple venues.Size discovery trading crosses buy and sell orders, with no bid-ask spread and no price impact, by exploiting the price determined on a separate exchange market.Although popular in practice, size discovery reduces the depth of exchange markets and, as modeled, worsens overall allocative efficiency.On the other hand, fragmenting trade in the same asset across multiple exchanges can improve allocative efficiency.This talk draws from research with Samuel Antill, Daniel Chen, and Haoxiang Zhu.

2 - Discussant

Mathieu Rosenbaum, Ecole Polytechnique, France

■ VMB04

CC - Ballroom D /Virtual Theater 4

Hybrid - Predictive Analytics Applications

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Yixin Lu, The George Washington University, Washington, DC, 20052, United States

Co-Chair: Francesco Balocco, Rotterdam School of Management - Erasmus University, Rotterdam, 3011 ZX, Netherlands

1 - Tech Tax: Ad Exchanges' Fees In Display Advertising

Francesco Balocco, Rotterdam School of Management - Erasmus University, Rotterdam, 3011 ZX, Netherlands, Yixin Lu, Ting Li

We study the Ad Exchanges' (ADX) fee optimization problem under the two dominant mechanisms in the display advertising market: the waterfall and the header bidding mechanism. We address two research questions: (1) What are the welfare implications of ADXs' fee structures? (2) How do ADXs' optimal fee structures evolve under different market configurations? Our study contributes to both theory and practice of digital advertising. First, to the best of our knowledge, this study is among the first to examine the welfare implications of ADXs' fee structures under different market mechanisms. Second, our findings shed light on the underlying drivers for the publisher's move from the waterfall mechanism to the header bidding mechanism. Finally, our model allows ADXs to perform policy counterfactuals, providing useful implications for their decisions on fee structures.

2 - Investigating The Willingness To Pay For Enhanced Mobile Internet Services: Evidence From A Mobile Network Upgrade

Yi Zhu, University of Minnesota at Twin Cities, Minneapolis, MN, United States, Jason Chan, Xuan Bi

We investigate consumers' willingness to pay (WTP) for two mobile internet pricing models, the speed-based model and the data-consumption-based model. We examine consumer sentiment toward unexpected slow network speed and data overuse problems, which provides valuable information for understanding customers' WTP for increasing network speed or data allowance. Our empirical strategy leverages the staggered introduction of 4G network across various districts in a metropolitan Asian city and a quasi-experimental setup. We find that consumers are more willing to pay for increasing network speed than data allowance in the new mobile internet era. We also show that substantial heterogeneity in consumer sentiment is explained by consumers' income and age. These insights can inform relevant stakeholders of optimal responses around future mobile network pricing models.

3 - How Local Competition Reshapes Consumers' Review Behavior: An Empirical Investigation

Xinyu Zang, University of Florida Warrington College of Business, Gainesville, FL, United States, Xiang (Shawn) Wan, Naveen Kumar, Liangfei Qiu

We examine how local competition of a restaurant might affect its consumers' propensity to write two types of influential reviews: informative reviews and negative reviews. Building on the antecedents of review contributions and expectation-confirmation theory, we hypothesize as the local competition level

increases, the number of informative reviews and the number of negative reviews received by a restaurant will first increase up to a point and then decrease (i.e., inverted U-shaped relationships). We also hypothesize the restaurant's popularity could moderate such relationships. Leveraging a Yelp dataset, we empirically confirm the existence of inverted U-shaped relationships and the moderating role of the restaurant's popularity. Taken together, we find the geographic location of a business plays a prominent role in reshaping consumers' review behavior.

4 - Life-event Targeting And Customer Uncertainty - Evidence From Field And Online Experiments

Zherui Yang, Erasmus University, Rotterdam, 3062PA, Netherlands, Ting Li

Life-event targeting has gained increasing attention that companies target customers for marketing activities based on life-event prediction. However, seldom has study explored its underlying mechanism. We conduct experiments to examine life-event targeting, and dive into literature on information seeking, behavioral targeting and customer uncertainty theory to explore its underlying mechanism. Our findings suggest that customers' information-seeking need mediates the effect of life-event targeting on customers' response, which is contingent on different customer uncertainty. Specifically, customers with higher choice uncertainty and those with lower knowledge uncertainty are more likely to respond to life-event targeting. This paper contributes to IS research by adding an information perspective to the growing practice of life-event targeting.

■ VMB05

CC - Ballroom E / Virtual Theater 5

Hybrid - TSL Award Session I

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States

■ VMB01

Virtual Room 01

Advances in Machine Learning and Optimization Methods

Sponsored: Data Mining

Sponsored Session

Chair: Petros Xanthopoulos, Stetson University, DeLand, FL, 32723, United States

1 - Scenario-based Robust Optimization For Decision-making Under Binary Uncertainty

Kai Wang, Carnegie Mellon University, Pittsburgh, PA, 02215-4212, United States, Alexandre Jacquillat, Mehmet Aydemir

This paper addresses data-driven optimization problems under categorical uncertainty. We propose a scenario-based robust optimization approach that combines stochastic programming (by constructing scenarios), robust optimization (by building discrete uncertainty sets), and data-driven optimization (by defining scenarios and uncertainty sets from machine learning classification outputs). We implement it on vehicle routing problem and ambulance dispatching problem. Results suggest that our approach outperforms benchmarks based on deterministic, stochastic, and robust optimization.

2 - Unsupervised Ensemble Learning Based on Internal Quality Measures and Modern Portfolio Theory

Petros Xanthopoulos, Stetson University, DeLand, FL, 32723, United States

Unsupervised ensemble learning or consensus clustering is the process of combining multiple clustering solutions into one with more robust characteristics. In this presentation we propose an weighted consensus clustering approach based on internal quality measures. We demonstrate the its advantages in terms of clustering quality and robustness. We also describe its performance improvement in terms of number of cluster identification. We present a tweak based on modern portfolio theory that allows to control the algorithmic robustness through a simple optimization model.

3 - Sequential Data-driven Change Detection by Optimal Weighted L2 Divergence

Liyan Xie, Georgia Institute of Technology, Atlanta, GA, 30339-3208, United States

We present a new non-parametric statistic, called the weighed L2 divergence, for sequential change-point detection when the data-generating distributions are unknown. Sample complexity and fundamental performance metrics (including the false alarm rate and the detection delay) are characterized. The good performance of the proposed method is validated through simulation and a real data example on human gesture detection.

4 - Constrained Multi-Objective Derivative-free Optimization for Automatic Bias Mitigation of Machine Learning

Yan Xu, SAS Institute, Cary, NC, 27519-8762, United States

Recent research has made it clear that "fairness through unawareness" is not a viable strategy for mitigating model bias. The power of ML based AI tools cannot be safely leveraged if fairness concerns cannot efficiently and systematically be address. We present an AutotML framework that support multiple objectives and constraints, which can be used to mitigate this rising challenge.

■ VMB02

Virtual Room 02

Data-Driven Analyses of Field Failures and Faults for Critical Infrastructure Systems

Sponsored: Data Mining

Sponsored Session

Chair: Thushara Gunda, Sandia National Laboratories, United States

1 - Bayesian Detection Of High-dimension Low-probability Failures In Complex Systems: A Case Study Of Photovoltaics

Michael Hopwood, University of Central Florida, FL, United States

In recent years, monitoring systems have become important research areas for water and energy resources management. Accurate assessments are highly valuable since perturbations in performance can have large impacts on the system's physical and financial health. Often influenced by changing environments, these resource systems can be challenging to model. Characterizing rare system-states is often impossible due to insufficient sample size; in these cases, the use of external information is paramount. Using photovoltaic systems as a case study, we utilize both system-specific data and system-agnostic information (i.e. failure densities across different conditions) to develop a failure prediction model.

2 - Machine Learning Based Fault Detection And Location In Electric Power Distribution Systems

Matthew J. Reno, Sandia National Laboratories, Albuquerque, NM, United States

Electric distribution system protective relays equipped with machine learning (ML) algorithms can improve power system reliability and resilience by performing an automated and self-learning monitoring and decision making analysis. ML algorithms can be trained offline using simulation data and are then embedded inside each relay to provide decision making support based on the analysis of typical electrical performance measurements. The results showed that the algorithm deployed inside each relay could accurately classify three fault conditions that occur anywhere on the feeder, estimate the fault's region, and define a specific action for the relay switch. This assessment indicates that advanced, data-driven relay analysis could provide value in a typical feeder.

3 - Improving Power Systems Reliability Via Adaptive Grid Partitioning

Alessandro Zocca, Vrije Universiteit Amsterdam, Amsterdam, Netherlands, Chen Liang, Linqi Guo, Steven Low, Adam Wierman

Transmission line failures in power systems propagate and cascade non-locally, making it even more challenging to optimally and reliably operate these complex networks. We present a comprehensive framework based on spectral graph theory that fully and rigorously captures how multiple simultaneous failures propagate, both for non-cut and cut set outages. Leveraging this theory, we propose an adaptive network topology reconfiguration paradigm that uses a two-stage algorithm. The first stage aims to identify optimal clusters using spectral methods and the second stage refines the network structure by means of optimal line switching actions.

■ VMB03

Virtual Room 03

Applied Data Mining

Sponsored: Data Mining

Sponsored Session

Chair: Zahra Sedighi-Maman, Adelphi University, Garden City, NY, United States

1 - Physical Fatigue Prediction For Manufacturing Workers

Lin Lu, Assistant Professor, Fairfield University, Fairfield, CT, 06824, United States, Zahra Sedighi Maman, Lora Cavuoto

Physical fatigue has been a prevalent symptom across U.S. workforce, which can lower productivity and increases the incidence of accidents. Previous research has studied fatigue detection to identify potential factors associated with fatigue. However, there has not been a study that predict the time to fatigue. This paper aims to predict the time to a worker's fatigue considering the work and worker characteristics. The study utilizes a work-task simulating experiment that contains both uncensored and censored observations. Non-parametric, semi-parametric, and machine learning methods were used to predict the survival probabilities of fatigue, median time to fatigue, and hazard rate of fatigue.

2 - Effect Of Clinical Measurement Errors On Tuberculosis Treatment Outcomes Prediction

Maryam Kheirandish, University of Arkansas, Fayetteville, AR, United States, Shengfan Zhang

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

3 - A Two Stage Modeling Approach For Breast Cancer Survivability Prediction

Zahra Sedighi-Maman, Adelphi University, Garden City, NY, 11530, United States, Alexa Mondello

This paper proposes a two-stage data analytic framework, where Stage I classifies the survival and deceased statuses and Stage II predicts the number of survival months for deceased females with cancer. Since medical data are not entirely clean nor prepared for model development, we aim to show that data preparation can strengthen a simple Generalized Linear Model (GLM) to predict as accurate as the complex models like Extreme Gradient Boosting (XGB) and Multilayer Perceptron based on Artificial Neural Networks (MLP-ANNs) in both stages.

■ VMB04

Virtual Room 04

Deep Learning and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Jeongsub Choi, West Virginia University, Morgantown, WV United States

Co-Chair: Byunghoon Kim, Hanyang University, Korea, Republic of

1 - Deep Learning For Virtual Metrology With Automatic Sensor Selection At Semiconductor Manufacturing Process

Jeongsub Choi, West Virginia University, Morgantown, WV, 08854-8018, United States, Youngdoo Son, Jihoon Kang

As numerous sensors on the process equipment in semiconductor manufacturing processes are involved in modeling for virtual metrology, it is essential to extract critical features from such sensors for accurate prediction. In the model building process for virtual metrology, the existing studies, however, focus mainly on feature selection without consideration of costly sensors. In this talk, we present a new deep learning-based virtual metrology model using group regularization for automatic sensor selection with a group-level sparsity. We evaluate the proposed model on synthetic datasets and a real-life case for automatic sensor selection in virtual metrology modeling for an etching process in semiconductor wafer fabrication.

2 - A Multi Class Anomaly Detection Method For Classifying Pre-defined Defect Patterns And Detecting Undefined Patterns

ChangYong Song, Hanyang University, Ansan, Korea, Republic of, Young-Seon Jeong, ByungHoon Kim

The pattern analysis of the wafer bin maps(WBM) is important in semiconductor manufacturing as it helps to trace the cause of the defect. Therefore, it is important to accurately classify the defect patterns of WBM. Recently, many studies have been conducted to classify defects patterns of WBM using deep learning. These methods can only classify pre-defined defect patterns. However, it is impossible to define all defect patterns in advance. Therefore, in this paper, we propose a method that classifies pre-defined defect patterns and detects undefined defect patterns at the same time.

3 - Deep Learning-based Review Prediction For Smart Health Monitoring Wearable Device

Rui Wang, North Carolina State University, Raleigh, NC, United States, Mengmeng Zhu, Jeongsub Choi

Smart health-monitoring wearable device (SHMWD) can provide qualitative and affordable healthcare services. The existing studies aim to find significant features of SHMWD that affect customers' purchase and use. However, there is a lack of understanding about how reviews vary based on different levels of customers' interest in features. This article aims to use artificial neural networks (ANNs) to classify customers' reviews regarding different levels of interest in features. Data is collected from real online customers' comments. Isolation forest, chi-squared test are utilized to clean the data. The ANN provides a result of 72.3% accuracy in classification. Support vector machine, random forest, and k-nearest neighbor are utilized to compare with the results of the ANN. The ANN performs the best regarding the accuracy, mean square error, and mean absolute error.

4 - Prediction Of Material Removal Rate And Interpretation Of Sensor Importance In Wafer Polishing Using Explanationable Convolutional Neural Network

Hyun-Seo Kim, Hanyang University, Ansan, Korea, Republic of, Byung-Hoon Kim

Chemical Mechanical Polishing(CMP) is an essential planarization process for precise machining of the wafer surface and is under several chemical and mechanical effects. Material removal rate(MRR) is one of important quality indicator in CMP, but the relationship between sensor data has not been established. To solve this problem, We predict MRR through time series sensor data and Convolutional Neural Network(CNN) and evaluate the importance of Sensor using Class Activation Map(CAM). The experimental results show that the importance of Sensor for the predictive model is quantified and that the model learned with the main sensor is effective.

5 - Imputation of Missing Value based on Uncertain data for Effective Classification

SeungWoo Kim, Hanyang, Gyeonggi-do, Korea, Republic of, ByungHoon Kim

In the real world, missing values occur frequently for various reasons. Usually, you delete the data or proceed with the learning with a single value estimated. However, missing values are indeed unknown to us, and are characterized by very uncertain values. Incorrect one Imputed value predicted has a negative effect on learning. In this paper, we propose a Missing value imputation using deep learning data method that models the distribution of instrumented data rather than a single expected value. By maintaining the uncertainty of missing values and learning the corresponding model, we robustly learn the classification model considering the uncertain missing values.

■ VMB05

Virtual Room 05

Optimization in Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Rafid Mahmood, Nvidia, Mississauga, ON, L5M 7Y6, Canada

1 - Causal Inference for Panel Data with General Treatment Patterns

Tianyi Peng, MIT, Cambridge, MA, United States, Andrew A. Li, Vivek Farias

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

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

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

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

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

4 - Low Budget Active Learning Via Wasserstein Distance: An Integer Programming Approach
Rafid Mahmood, Nvidia, Mississauga, ON, L5M 7Y6, Canada, Marc Law, Sanja Fidler

Given resource limits on collecting data, active learning is the process of training a machine learning model by selecting and labeling a small subset from an unlabeled data pool. Although selecting the most useful points for training is an optimization problem, the size of deep learning data pools forces most strategies to use heuristics. Instead, we propose a new integer program for selecting a core set by minimizing the discrete Wasserstein distance from the unlabeled pool and we solve this problem using Generalized Benders Decomposition. Our strategy requires high-quality latent features which we obtain by self-supervised learning. Numerical results on image classification datasets show that our optimization approach is competitive with baselines and particularly outperforms them in the low budget regime where less than one percent of the data can be labeled.

■ VMB06

Virtual Room 06

Recent Advances in Robust and Trustworthy Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Yiming Ying, State University of New York-Albany, Albany, NY, 12222, United States

Co-Chair: Feng Chen, UT Dallas, Dallas, TX, United States

1 - The Application Of Deep Autoencoders For Anomaly Detection
Sanjay Chawla, Qatar Computing Research Institute, HBKU

Autoencoders are neural networks which learn a representation of data in an unsupervised manner. They are primarily used for inferring the intrinsic low-dimensional data manifold. We will overview the use of deep autoencoders for anomaly detection and compare them against their "neural-free' counterparts.

2 - Plug-and-Play Risk-Aware Policy Search
Bo Liu, Auburn University, Auburn, AL, United States

This talk identifies a critical factor for establishing the safety of autonomous systems: risk-awareness. To enhance safety and risk-awareness in decision-making, we propose the Mean-Variance Policy Iteration (MVPI) algorithm family. Instead of merely maximizing the expected mean of cumulative rewards in sequential decision-making, the MVP algorithm enables a trade-off between the mean and variance by utilizing Legendre-Fenchel duality. Unlike conventional mean-variance optimization, which often has multi-timescale stepsizes to tune, this algorithm is single-time-scale and can thus scale up easily. I will also discuss a magic meta-algorithm framework that can "robustify" any off-the-shelf risk-oblivious decision-making algorithms. This work has a wide range of practical applications such as e-commerce, autonomous driving, and medical treatment.

3 - Stochastic Optimization Of Area Under Precision-Recall Curve With Provable Convergence
Qi Qi, The University of Iowa, Iowa City, IA, United States, Tianbao Yang

In this work, we propose a principled technical method to optimize area under Precision-Recall Curve (AUPRC) for deep learning. Our approach is based on maximizing the averaged precision (AP), which is an unbiased point estimator of AUPRC. We cast the objective into a sum of dependent compositional functions with inner functions dependent on random variables of the outer level. We propose efficient adaptive and non-adaptive stochastic algorithms with provable convergence guarantee under mild conditions by using recent advances in stochastic compositional optimization. Extensive experimental results on graphs and image datasets demonstrate that our proposed method outperforms prior methods on imbalanced problems. To the best of our knowledge, our work represents the first attempt to optimize AUPRC with provable convergence.

4 - Multidimensional Uncertainty Quantification For Graph Neural Networks
Feng Chen, University of Texas at Dallas, TX, United States

Inherent uncertainties derived from different root causes have realized as serious hurdles to find effective solutions for real-world problems. Critical safety concerns have been brought due to a lack of considering diverse causes of uncertainties, resulting in high risk due to misinterpretation of uncertainties (e.g., misclassification by an autonomous vehicle). Graph neural networks (GNNs) have received tremendous attention in the data science community. Despite their superior learning performance, they didn't consider various types of uncertainties in their decision process. In this talk, I will present a general approach to quantifying the inherent uncertainties of GNNs that are derived from different root causes in training data, such as vacuity (i.e., uncertainty due to a lack of evidence) and dissonance (i.e., uncertainty due to conflicting evidence).

5 - Differentially Private Stochastic Gradient Descent With Non-Smooth Losses
Yiming Ying, State Univeristy of New York-Albany, Albany, NY, 12222, United States

Differentially private (DP) stochastic gradient descent (SGD) has been widely studied in the literature. However, existing work requires the loss function to be both Lipschitz continuous and strongly smooth, which is violated in practice (e.g., the hinge loss for SVM and the absolute loss in robust regression). In this talk, I will present our recent work on DP SGD with non-smooth losses. Specifically, the loss function is relaxed to have alpha-Holder continuous gradient (referred to as alpha-Holder smoothness). We show that DP SGD with alpha-Holder smooth losses can attain (epsilon, delta)-DP and optimal statistical generalization performance. In particular, we show that alpha-Holder smoothness with alpha larger than 1/2 is sufficient to guarantee the (epsilon, delta)-DP of SGD while achieving optimal statistical performance with linear gradient complexity.

■ VMB07

Virtual Room 07

Interpretable Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Tong Wang, University of Iowa, Iowa City, IA, 52245-9322, United States

1 - PaCMAP: A New Algorithm for Dimension Reduction
Cynthia Rudin, Duke University, Durham, NC, 27708, United States

Dimension reduction (DR) techniques such as t-SNE, UMAP, and TriMap have demonstrated impressive visualization performance on many real world datasets. One tension that has always faced these methods is the trade-off between preservation of global structure and preservation of local structure: these methods can either handle one or the other, but not both. In this work, our main goal is to understand what aspects of DR methods are important for preserving both local and global structure: it is difficult to design a better method without a true understanding of the choices we make in our algorithms and their empirical impact on the lower-dimensional embeddings they produce.

2 - Intelligible and Editable Differentially Private Machine Learning: Don't Leave Home Without It
Rich Caruana, Microsoft, Redmond, WA, United States, Harsha Nori

In domains such as healthcare it is critical that our models are correct, safe to deploy and protect privacy. For these reasons, whenever possible it is important to use glass-box learning methods that make it possible vet, correct and insure privacy prior to deployment. In the talk I'll present case studies where interpretable learning methods uncover surprising, risky patterns in the data that would be learned by all machine learning models, and I'll show how glass-box methods can be used to discover and correct these problems while also guaranteeing differential privacy with little or no loss in accuracy.

3 - ProtoryNet -Interpretable Sequence Classification Via Prototype Trajectory

Tong Wang, University of Iowa, Iowa City, IA, 52245-9322, United States,, Dat Hong, Stephen Baek

We propose a novel interpretable DNN for text classification, called ProtoryNet, based on a new concept of prototype trajectories. Motivated by the prototype theory in modern linguistics, ProtoryNet makes a prediction by finding the most similar prototype for each sentence in a text sequence and feeding an RNN backbone with the proximity of each sentence to the corresponding prototype. Prototype trajectories enable intuitive and fine-grained interpretation of the reasoning process of the RNN model, in resemblance to how humans analyze paragraphs. Experiments on public data sets reveal that the ProtoryNet is not only more interpretable but also more accurate than interpretable baseline methods. Furthermore, we report a survey result indicating that human users find ProtoryNet more intuitive and easier to understand, compared to the other prototype-based methods.

4 - One Explanation Does Not Fit All: A Toolkit And Taxonomy Of AI Explainability Techniques

Vijay Arya, IBM Research, New Delhi, India, Rachel K Bellamy, Pin-Yu Chen, Amit Dhurandhar, Michael Hind, Samuel C Hoffman, Stephanie Houde, Vera Q. Liao, Ronny Luss, Aleksandra Mojsilovic, Sami Mourad, Pablo Pedemonte, Ramya Raghavendra, John T. Richards, Prasanna Sattigeri, Karthikeyan Shanmugam, Moninder Singh, Kush R. Varshney, Dennis Wei, Yunfeng Zhang

As machine learning algorithms make further inroads into society, calls are increasing from multiple stakeholders for these algorithms to explain their outputs. Moreover, these stakeholders, whether they be government regulators, affected citizens, domain experts, or developers, present different requirements for explanations. To address these needs, we introduce AI Explainability 360, an open-source software toolkit featuring eight diverse state-of-the-art explainability methods, two evaluation metrics, tutorials to introduce AI explainability to practitioners, and an extensible software architecture that organises these methods according to their use in the AI modelling pipeline. Our toolkit can help improve transparency of machine learning models and provides a platform to integrate new explainability techniques as they are developed.

5 - Matching Afters Learning to Stretch (MALTS)

Harsh Parikh, Duke University, Durham, NC, United States, Alexander Volfovsky, Cynthia Rudin

We introduce a flexible framework that produces high-quality almost-exact matches for causal inference. Most prior work in matching uses ad-hoc distance metrics, often leading to poor quality matches, particularly when there are irrelevant covariates. In this work, we learn an interpretable distance metric for matching, which leads to substantially higher quality matches. The learned distance metric stretches the covariates according to their contribution to outcome prediction. The framework is flexible in that the user can choose the form of the distance metric and the type of optimization algorithm. Our ability to learn flexible distance metrics leads to matches that are interpretable and useful for the estimation of conditional average treatment effects.

■ VMB08

Virtual Room 08

Data Analytics and Optimization: New Framework Development

Sponsored: Data Mining

Sponsored Session

Chair: Mona Jabbari, University of Oregon, Eugene, United States

1 - Data And Knowledge Driven Optimization Model Generation For Flow Based Optimization Problems

Dharmashankar Subramanian, IBM TJ Watson Research Center, Yorktown Heights, NY, United States, Segev Wasserkrug, Pavankumar Murali, Dzung Phan, Parikshit Ram, Orit Davidovich, Xavier CEUGNIET, Ferenc Katai

Optimization can provide exceptional value, but requires significant time and skills to implement, thereby significantly limiting its widespread use.

In this talk, we will show how optimization models for flow-based problems can be automatically generated from a combination of data and easily specifiable knowledge. We will describe the underlying technology and present a brief demonstration. In addition, we will discuss several approaches for overcoming the inherent inaccuracies existing in automatically generated models, so as to ensure the quality of the provided optimization solutions.

2 - An Optimization Framework For The Optimal Investment Technology To Support The Grid Hosting Electric Vehicles' Fast-charging Demand

Harprinderjot Singh, PhD Student, Michigan State University, East Lansing, MI, United States, Farish Jazlan, Mohammadreza Kavianipour, Mehrnaz Ghamami, Ali Zockaie

The rapid market growth of electric vehicles (EV) and the energy demand will affect grid stability and supply-demand balance in the electricity distribution system. Distributed energy resources (DER) (i.e., solar, battery, flywheel) can mitigate these impacts. This study proposes an optimization framework capturing EVs travel and grid requirements to support the EV demand at fast-charging stations while minimizing the total system cost, including potential grid upgrades, electricity cost, and solar and/or energy storage installation. The case study (Michigan) shows that the results are sensitive to the unit cost of DER, weather conditions, seasonal variation in solar and grid conditions.

3 - Stochastic Optimization Of Inventory At Large-scale Supply Chains

Larry Z Jin, Senior Data Scientist, Redwood City, CA, United States, Mehdi Maasoumy, Yimin Liu, Zeshi Zheng, Zizhuo Ren

Suboptimal reorder parameter settings can cause excessive inventory holding cost. By formulating the inventory management problem as a constrained stochastic optimization problem, and solving with a simulation-based optimization approach, we achieve significant reduction in the inventory holding cost without sacrificing service level, using real manufacturing company supply chain data at a global scale.

4 - Adversarial Robust Estimate and Risk Analysis in Linear Regression

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

Adversarially robust learning aims to design algorithms that are robust to small adversarial perturbations on input variables. We study the statistical properties of adversarially robust estimates and analyze adversarial risk in the setup of linear regression models. We propose a straightforward two-stage adversarial learning framework, which facilitates to utilize model structure information to improve adversarial robustness.

5 - A Collaborative Decision Support System For Multi-criteria Automatic Clustering

Mona Jabbari, University of Oregon, Eugene, OR, United States, Meysam Rabiee, Asil Oztekin, Shaya Sheikh

Automatic clustering can be challenging when the decision-maker is unfamiliar with the dataset's nature and the criteria of interest. In this framework, we developed a mixed-integer non-linear programming model, and a decision support system to solve this problem. Our proposed methodology is applied to one synthetic and two secondary datasets.

■ VMB09

Virtual Room 09

Panel: Communicating with Stakeholders in Health

Committee Choice: Health Applications Society

Committee Choice Session

Chair: Hui Zhao, The Pennsylvania State University, University Park, PA, 16802, United States

1 - Communicating with Stakeholders in Health to Make an Impact

Hui Zhao, The Pennsylvania State University, University Park, PA, 16802, United States

There has been much healthcare research in our field that could make larger impact. In this panel, we invited a few researchers in our field who have done a great job in communicating with various stakeholders including industry, media, and government agencies about their research and have seen an impact from that. We are sure their stories, experiences, and maybe cautions will be very beneficial for our profession and HAS members. Together, we can increase the impact of our field through more intentional and powerful communications with the different stakeholders outside our academic world.

2 - Panelist

Pinar Keskinocak, ISyE Georgia Tech, Atlanta, GA, 30332, United States

3 - Panelist

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States

4 - Panelist

Julie L. Swann, North Carolina State University, Raleigh, NC, 27695, United States

■ VMB10

Virtual Room 10

Data-Driven Decision-Making in Healthcare Applications

Sponsored: Health Applications Society

Sponsored Session

Chair: Anahita Khojandi, University of Tennessee-Knoxville, TN, 37996, United States

Co-Chair: Zeyu Liu, University of Tennessee-Knoxville, Knoxville, TN, 37919-3317, United States

1 - Patient Preference Solicitation Using Inverse Reinforcement Learning

Shan Liu, University of Washington, Seattle, WA, 98195-2650, United States, Mutita Siriruchatanon

Increased patient involvement in clinical decision-making has shown to improve patients' satisfaction in their care. With co-decision making for treatment, patients and doctors can weigh on several different objectives such as treatment effectiveness and side effects according to patient preference. We formulate a treatment selection problem as a Markov Decision Process and estimate patient specific preference weights in the reward function. Given simulated patient trajectories generated from expert policies and the trajectory rankings, we develop an algorithm to seek an improved treatment policy using a variant of apprenticeship learning and inverse reinforcement learning method.

2 - The Effectiveness Of Remote And Hybrid Instruction As An Intervention For Covid-19 In University Settings

Lauren N. Steimle, Georgia Institute of Technology, Atlanta, GA, 30308, United States, Jingyu Li, Meghan Meredith, Dima Nazzal

The COVID-19 pandemic forced colleges and universities to make challenging decisions about when and how to reopen. In additional to traditional public health interventions like testing, contact tracing, and isolation of symptomatic individuals, universities also considered switching the delivery of some courses from in-person format to remote or hybrid format as a way to limit the spread of disease on campus. We use an agent-based simulation model to examine the effectiveness of different course delivery modes as an intervention and explore the trade-offs between the health and educational burdens associated with different modes.

3 - Prediction Of Mechanical Ventilation Outcome In Intensive Care Units Using Modified Recurrent Neural Network

Maryam Alimohammadi, University of Arkansas, Fayetteville, AR, 72701, United States, Shengfan Zhang

Mechanical ventilation is one of the most widely used interventions in ICU. Because of the high usage and limited sources, the management of mechanical ventilation is significant. Predicting the ventilation outcome before the start of ventilation or at the beginning of the ventilation can improve decision-making in mechanical ventilation interventions in the ICU. However, dealing with the electronic health record data of patients admitted to ICU is complicated due to its complex temporal nature, noisiness, and irregularity. We proposed a modified recurrent neural network to predict the mechanical ventilation outcome using optimized decision-making time windows. This method helps reduce the missingness and noisiness of data and predicts the outcome with higher accuracy in comparison to the traditional classification methods.

4 - Augmenting Early Sepsis Prediction Model With Biomarkers: When Should Blood Test Be Administered?

Zeyu Liu, University of Tennessee, Knoxville, TN, 37919-3317, United States, Anahita Khojandi, Xueping Li, Robert Davis

Sepsis is one of the leading causes of death in the ICU in the U.S., whose successful treatment depends on early detection. Biomarkers obtained from blood tests are decisive evidence for early sepsis diagnosis. In this work, we aim to optimally time the administration of blood test to augment the performance of predictive models previously built on physiological data for early sepsis detection. We develop a two-stage framework that combines machine learning (ML) with a partially observable Markov decision process (POMDP), where the ML model predicts sepsis probabilities and the POMDP administer blood tests and predict when patients have sepsis. We evaluate the framework using a dataset available to researchers. Results suggest that the proposed framework is efficient in eliminating false positive cases, reducing false alarms, and improving prediction performance.

5 - Optimizing Patient-Specific Medication Regimen Policies Using Wearable Sensors in Parkinson's Disease

Matthew Baucum, University of Tennessee Knoxville, Knoxville, TN, 90034, United States, Anahita Khojandi, Rama Vasudevan, Ritesh Ramdhani

Parkinson's disease (PD) treatment is a continual challenge for healthcare providers. We develop a reinforcement learning (RL) framework to optimize PD medication regimens through wearable sensors, using data from 26 patients. We train a model predicting how patients respond to medication, then pair this model with an RL algorithm that recommends optimal medication types, timing, and dosages during the day. Our RL-prescribed regimens outperform physician recommendations. We also identify patients who could benefit from reduced medication frequencies or advanced therapies.

■ VMB11

Virtual Room 11

Information, Technology, and Analytics in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: Mehmet U.S. Ayvaci, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - The Impact Of Physician Payment Sunshine Act On Brand-name Drug Prescriptions

Zhen Sun, The George Washington University, Washington, DC, 20052, United States, Wenjing Duan, Sherri Cheng

Enacted in 2013, Physician Payment Sunshine Act (PPSA) mandated nationwide disclosure on pharmaceutical companies' payments to physicians and aimed to provide solutions to the above problems with enhanced accountability and credibility to the medical field. This research aims to explore PPSA's impacts on physicians' branded drug prescriptions based on physicians' granular payment profiles.

2 - Does Emr Adoption By Nursing Homes Decrease Hospitalization Costs ?

Atiye Cansu Erol, University of Pennsylvania, Philadelphia, PA, United States, Lorin Hitt, Prasanna Tambe

Electronic Medical Records (EMR) have the potential to decrease medical expenditures by increasing communication between healthcare providers and by reducing unnecessary tests and medical errors. Using a three−year panel of Medicaid spending for long−term care patients in nursing homes, we find evidence that EMR adoption by nursing homes reduces hospitalization costs for residents by 3.5−14 percent. We also find a further reduction of hospitalization costs for residents when hospitals and nursing homes both adopt EMR: an average savings of 13 percent of Medicaid expenditure and as much as 35 percent for system−member hospitals. Given the interdependent nature of healthcare delivery for long−term care patients or patients with chronic conditions, our findings underscore the importance of looking outside the adopting institution when accounting for health IT value.

3 - Nursing Home Staff Networks And Covid-19

Elisa F. Long, UCLA Anderson School of Management, Los Angeles, CA, 90024-5055, United States, Keith Chen, Judith Chevalier

Skilled nursing homes (SNFs) accounted for a disproportionate share of COVID-19 fatalities worldwide, with outbreaks persisting despite the March 2020 nationwide ban on visitors. Using device-level geolocation data for 50 million smartphones, we analyze SNF connections via shared staff and observe 500,000 individuals entering at least one SNF, with 5.1% entering two or more facilities. Nursing homes share connections with 7.1 other facilities, on average. Network measures of connectivity, including node degree, strength and Eigenvector centrality, are highly predictive of COVID-19 cases, whereas traditional regulatory quality metrics are unimportant in predicting outbreak size.

4 - A Multi-treatment Forest Approach For Analyzing The Heterogeneous Effects Of Team Familiarity

Minmin Zhang, The University of Texas at Dallas, Richardson, TX, 75252, United States, Wallace J Hopp, Guihua Wang, Michael Mathis

We study the heterogeneous effects of team familiarity on surgery duration. We develop a multi-treatment forest consisting of multiple tree models that divide patients into different subgroups based on their features and estimate the effects of familiarity within each subgroup. The results show that the effects of familiarity are different for different types of patients. Our results can help hospital administrators to improve operational efficiency by matching patients with surgery team members using patient-specific information.

5 - A Tool To Inform Global Hepatitis C Elimination In Developing Countries

Huaiyang Zhong, Harvard Medical School, Massachusetts General Hospital, Boston, MA, United States, Madeline Adee, Lindsey Hiebert, John Ward, Jagpreet Chhatwal

The World Health Organization (WHO) recently launched a global campaign for eliminating hepatitis C virus (HCV) as a public health threat by the year 2030. However, most countries do not have a national strategy for HCV screening and treatment that can lead to HCV elimination. We developed a microsimulation model to assess various combinations of screening and treatment strategies, and built an online, publicly accessible tool to help policy makers identify a path to HCV elimination.

6 - Repairing The Digital Divide Can Increase The Service Divide: The Effects Of Patient Portal On Kidney Allocation

Yeongin Kim, Virginia Commonwealth University, Glen Allen, VA, 23059-5572, United States, Mehmet U.S. Ayvaci, Srinivasan Raghunathan, Bekir Tanriover

Whether the adoption of patient portals improved the allocation process and reduced the disparities in the kidney transplant context is not yet fully understood. Our study shows that a patient access to portals can reduce the time to receiving a kidney transplant, therefore positively contributing to the reduction of an important inefficiency. However, the impact varies on sub-populations based on the education level of patients, some clinical indicators, age, and geographical location. The finding suggests that the efforts to bridge the digital divide may benefit some patient groups at the expense of other groups, leading to further disparities in the care service.

■ VMB12

Virtual Room 12

Healthcare Reimbursement and Incentive Design

Sponsored: Health Applications Society

Sponsored Session

Chair: Jingyao Huang, University of Texas at Austin, Austin, TX, 78705, United States

Co-Chair: Diwakar Gupta, University of Texas, Austin, TX, 78712-1750, United States

1 - Pay-for-performance Programs Effectiveness In Healthcare: The Case Of The End-stage Renal Disease Quality Incentive Program

Saeed Piri, University of Oregon, Eugene, OR, 97403, United States

This paper focuses on the first pay-for-performance program in the US, ESRD-QIP. QIP aims to promote high-quality services in dialysis facilities by tying their payments to their performance on a set of quality measures. We examine the effectiveness of QIP by exploring the changes (improvement vs. no change) in various clinical/operational measures. To conduct our analysis, we combine multiple public datasets containing dialysis facilities' costs, staffing level, QIP scores, performance in QIP measures, size, workload, and chain affiliations. To investigate the impact of QIP, we employ the difference-in-difference specification through a fixed-effect linear regression model.

2 - The Benefits-Value-Advisor Program For Shoppable Medical Services

Jingyao Huang, The University of Texas at Austin, Austin, TX 7870, United States, Diwakar Gupta

There is a great deal of variation in prices charged by providers of non-urgent and routine medical procedures. Insurers have recently introduced the Benefits-Value-Adviser (BVA) program to help improve the quality and reduce the cost of such services. We ask the following question: can the BVA program add value? We incorporate the characteristics of healthcare markets in a game-theoretic model of provider competition to derive the providers' decisions in price-only and comprehensive equilibrium settings. In the price-only equilibrium, the BVA program is guaranteed to add value in a market where the differences in providers' pre-existing quality and marketing activity levels are both simultaneously low. In the comprehensive model, the BVA program adds more value when it can affect a large increase in quality sensitivity relative to the change in price sensitivity.

3 - Optimizing Financial Incentives For Medication Adherence

Joel Goh, NUS Business School, Singapore, 119245, Singapore Joel Goh, Harvard Business School, Boston, MA, United States, Sze-chuan Suen, Diana Maria Negoescu

We investigate the problem of designing a schedule of incentive payments to induce socially-optimal treatment adherence levels in a setting where treatment adherence can be observed (e.g. through Directly Observed Therapy for tuberculosis) but patient preferences for treatment adherence are heterogeneous and unobservable to a health provider. The novel elements of this problem stem from its institutional features: there is a single incentive schedule applied to all patients, incentive payments must be increasing in patients' adherence, and patients cannot be a priori prohibited from any given levels of adherence. We conduct a numerical study using representative data in the context of the tuberculosis epidemic in India. Our study shows that our optimally-designed incentive schedules are generally cost-effective compared to a linear incentive benchmark.

4 - An Analysis of Incentive Schemes for Participant Retention in Clinical Studies

Xueze Song, University of Illinois-Urbana-Champaign, Champaign, IL, United States, Mili Mehrotra, Tharanga K. Rajapakshe

Patient retention is one of the critical issues that haunt clinical studies. This paper analyzes two interventions—incentive payment and effort—and identify their optimal combination for retaining desired number of participants. Also, we examine several commonly observed payment schemes in practice and compare their relative performances under different settings.

■ VMB13

Virtual Room 13

Health Care II

Contributed Session

Chair: Gizem Koca, Dalhousie University, Halifax, NS, Canada

1 - The Impact Of Economic Insecurity On Covid-19 Mitigation Efforts

Kellas Cameron, Assistant Professor, University of South Florida, Tampa, FL, United States, Deepti Singh

Due to the way that the US federal government delegated the effort to mitigate the impact of the Covid-19 pandemic to state governments, we saw how various prevention methodologies significantly impacted both state infection rates and economic impacts. Different lockdown protocols, social distancing mandates, and mask requirements, implemented over the three waves of the pandemic were posited to have different impacts dependent on state culture, climate, and economic stability. Our work compares three economically similar states - Texas, California, and Florida - and demonstrates how a state's view of economic insecurity significantly drove infections rates and economic recoveries.

2 - Contributed Submission

Sofia V Ortega, Graduate Research Assistant, The University of Texas at El Paso, El Paso, TX, United States, Sreenath Chalil Madathil, Myrtede Alfred, Thenral D. Mangadu, Amit Lopes, Bill Tseng

Healthcare organizations are striving to improve patient experience and move towards a patient-centered care. Utilizing patient journey mapping can better capture experiences throughout all stages of the patient's journey and provide improvement recommendations. This research aims to develop an evaluation of patient experience using NLP algorithms, by analyzing data from social media referent to breast cancer patient experiences. NLP algorithms are applied to identify hotspots and conduct a sentimental and thematic analysis to evaluate the patients' experiences and provide recommendations. This study provides valuable insights for a patient-centered care in clinical systems.

3 - Optimization Of Acute Ischemic Stroke Treatment Process Prior To Hospital Arrival Using Discrete-Event Simulation

Gizem Koca, PhD Student, Dalhousie University, Halifax, NS, Canada, Noreen Kamal

As the leading cause of severe disability, stroke is a devastating disease. Treatments such as thrombolysis with alteplase and endovascular thrombectomy are highly time-dependent and synergistic to be given to the patients together or alone, depending on their contraindications. This study focuses on the acute stroke process prior to hospital arrival, including those that arrive by private vehicle, and aims to assist healthcare decision-makers to implement impactful improvements. A discrete-event simulation model is developed to illustrate the treatment process and the impact of changes.

■ VMB15

Virtual Room 15

Mechanism Design, Networks, and New Markets

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States

Co-Chair: Francisco Castro, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

1 - Optimal Dynamic Allocation: Simplicity Through Information Design

Afshin Nikzad, University of Southern California, Palo Alto, CA, 94301, United States

We study dynamic nonmonetary markets where objects are allocated to unitdemand agents with private types. An agent's value for an object is supermodular in her type and the quality of the object, and her payoff is quasilinear in her waiting cost. We analyze direct-revelation mechanisms that elicit agents' types and assign them to objects over time. We identify the welfare-maximizing mechanism and show that it can be implemented by a first-come first-served wait-list with deferrals when the marketmaker can design the information disclosed to agents about the objects. The optimal disclosure policy pools adjacent object types.

2 - Mechanism Design under Approximate Incentive Compatibility

Francisco Castro, UCLA Anderson School of Management, Los Angeles, CA, 90024, United States

We extend the classical Myerson setting to the case where the buyer is not a perfect optimizer and only -incentive compatibility is required. Our paper is the first to study the design of optimal mechanisms in the space of approximate IC mechanisms and to explore how much revenue can be garnered by moving from exact to approximate incentive constraints. We show that deterministic mechanisms are not optimal and that randomization is needed. We then establish that no mechanism can garner gains higher than order 2/3. This improves upon known results that imply maximum gains of 1/2. Furthermore, we construct a mechanism that is guaranteed to achieve order 2/3 additional revenues, leading to a tight characterization of the revenue implications of approximate IC constraints. Importantly, to find the optimal mechanism it is necessary to optimize over best reporting functions.

3 - Optimal Disclosure Of Information To A Privately Informed Receiver

Ozan Candogan, University of Chicago, Booth School of Business, Chicago, IL, 27708, United States, Philipp Strack

We study information design settings where the designer controls information about a state and the receiver is privately informed about his preferences. The receiver's action set is general and his preferences depend linearly on the state. We show that to optimally screen the receiver, the designer can use a menu of "laminar partitional" signals. These signals partition the state space and send the same non-random message in each partition element. The convex hulls of any two partition elements are such that either one contains the other or they have an empty intersection. Furthermore, each state is either perfectly revealed or lies in an interval in which at most n + 2 different messages are sent, where n is the number of receiver types. Finally, we establish that public signals in general achieve only a 1/n share of the optimal value for the designer.

4 - Dynamic Moral Hazard with Adverse Selection: A Pontryagin Approach

Feifan Zhang

We study the optimal incentive scheme for a long-term project with both moral hazard and adverse selection. The moral hazard issue is due to the fact that the agent's effort, which increases the arrival rate of a Poisson process, is not observable by the principal. In addition, the agent's effort cost, which needs to be reimbursed by the principal, is also the agent's private information. This gives rise to the adverse selection problem. The principal needs to design the optimal menu of contracts, each of which is chosen by the agent with a specific effort cost. We fully characterize the optimal menu in the case of two types of agents. Specifically, the agent with a lower cost is offered a probation contract, which confirms the agent's type if there is an arrival during a probation period; the agent with the higher cost is offered a sign-on-bonus contract with an immediate direct initial payment. We then explore the more general case with continuous types of agents. In particular, we provide an easy-to-compute upper bound on the principal's utility. The upper bound computation also yields a feasible menu of probation and sign-on-bonus contracts, and the corresponding lower bound it generates. We further provide a condition which can be used to verify whether the upper and lower bounds coincide, implying the optimality of our feasible menu of contracts. Numerical studies confirm that the verficiation condition almost always holds for commonly used probability distributions of the effort cost.

■ VMB16

Virtual Room 16

Platforms, Data, and Algorithms

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ali Makhdoumi, Duke University, Durham, NC, 27708-9972, United States

1 - Data And Incentives

Annie Liang, Northwestern, Evanston, IL, United States, Erik Madsen

"Big data" gives markets access to previously unmeasured characteristics of individual agents. Policymakers must decide how to regulate the use of this data, which may reshape important economic interactions. We study how new data affects incentives for agents to exert effort in settings such as the labor market, where an agent's quality is initially unknown but is forecast from observed outcomes. We characterize the average effect of new covariates, and show that the direction of this effect is determined entirely by whether the covariate is informative about long-run quality or a short-run shock to outcomes. For a certain class of covariates, the effect on effort is uniform across agents. More generally, new measurements can have disparate impact, benefiting certain agents at the cost of others. We apply these findings to characterize the welfare consequences of new data.

2 - Misinformation: Strategic Sharing, Homophily, And Endogenous Echo Chambers

James Siderius, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Daron Acemoglu, Asuman Ozdaglar

We present a model of online content sharing where agents can "fact-check" to determine if this content contains misinformation. While agents value shares, they simultaneously fear getting caught sharing misinformation. With little homophily in the social network, misinformation is often quickly identified and brought to an end. However, when homophily is strong, whereby agents anticipate that only those with similar beliefs will view the article, misinformation spreads more rapidly because of echo chambers. We use this to show that a social media platform that wants to maximize engagement should propagate extreme articles amongst extremist users. This creates an endogenous echo chamber, or "filter bubble," that is highly conducive to viral misinformation. We conclude with a few policy suggestions to combat platform incentives to recommend misinformation.

3 - Mean Estimation with User-level Privacy under Data Heterogeneity

Rachel Cummings, Columbia University, New York, NY, 30332-0205, United States

A key challenge for data analysis in the federated setting is that user data is heterogeneous, i.e., it cannot be assumed to be sampled from the same distribution. Further, in practice, different users may possess vastly different number of samples. In this work we propose a simple model of heterogeneous user data that differs in both distribution and quantity of data, and we provide a method for estimating the population-level mean while preserving user-level differential privacy. We demonstrate asymptotic optimality of our estimator within a natural class of private estimators and also prove general lower bounds on the error achievable in our problem. In particular, while the optimal non-private estimator can be shown to be linear, we show that privacy constrains us to use a non-linear estimator.

4 - Passing Data Directly Into Prescriptive Analytics

Lennart Baardman, University of Michigan, Ann Arbor, MI, 48103, United States

Analytics has seen an increase in use to solve operational problems. Often, data-driven algorithms take a two-stage approach involving predictive and prescriptive analytics. Predictive analytics is used to develop models of uncertain quantities, which can then be used in mathematical optimization models of prescriptive analytics. In this work, we propose a framework that can directly translate data into decisions using only a single mathematical optimization model. Using a single model avoids any errors due to overfitting on predictions in a sequential approach or the misspecification of a predictive model. Additionally, our approach can deal with highly non-linear objective functions. We show the strength of our model both in theory and practice, and solves complex problems quickly.

5 - Optimal Data Acquisition With Privacy-Aware Agents

Juba Ziani, Georgia Institute of Technology, Atlanta, GA, United States, Rachel Cummings, Hadi Elzayn, Vasilis Gkatzelis, Emmanouil Pountourakis

We look at a data analyst that must optimally buy data from individually rational, privacy-aware agents, to compute a statistic. Agents derive utility from the output of the statistic, and trade-off the privacy costs they incur from revealing their data with the utility they get from the statistic. They may decide to opt out if their privacy costs are high. The analyst provides differential privacy guarantees to her computation, and adjusts the level of noise she offers to affect the agents' privacy costs. She does so to optimize the accuracy of her computation, and must take into account the trade-off between i) adding more noise to incentivize participation and data collection through lower privacy costs and ii) adding less noise to obtain more accurate data points. We provide near-optimal algorithms for the optimization and mechanism design problems faced by the analyst.

■ VMB17

Virtual Room 17

Learning Algorithms in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Anyan Qi, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

Co-Chair: Zhichao Feng, University of Texas at Dallas, Richardson, TX, 75080-2233, United States

1 - Joint Optimization And Learning For Revenue Management Problems With Add-on Discounts

Huanan Zhang, University of Colorado Boulder, Boulder, CO, United States, David Simchi-Levi, Rui Sun

We consider a revenue management problem with add-on discounts. The problem is motivated by the practice in the video game industry, where a retailer offers discounts on selected supportive products (e.g. video games) to customers who have also purchased the core products (e.g. game consoles). In the base model, we focus on an independent demand structure. To overcome the computational challenge of this optimization problem, we propose an efficient FPTAS algorithm that solves the problem approximately to any desired accuracy. Moreover, we consider the problem in the setting where the retailer has no prior knowledge of the demand functions of different products. To solve this joint learning and optimization problem, we propose a UCB-based learning algorithm that uses the FPTAS optimization algorithm as a subroutine. We further extended the results to MNL choice models.

2 - To Interfere Or Not To Interfere: Information Revelation And Price-setting Incentives In A Multiagent Learning Environment

Hongfan Chen, The Chinese University of Hong Kong, Hong Kong, 999077, China, John R. Birge, N. Bora Keskin, Amy R. Ward

We consider a platform in which multiple sellers offer their products over a multiperiod time horizon. Each seller sets its own price. The platform collects a fraction of the sales revenue and provides price-setting incentives to the sellers to maximize its own revenue. The demand for each seller's product is a function of all sellers' prices and some customer features. Initially, neither the platform nor the sellers know the demand function. They can learn about it through sales observations. In this setting, the platform faces a trade-off between exploiting its informational advantage and revealing information to facilitate demand learning. We design policies that enable the platform to judiciously manage information revelation and price-setting incentives.

3 - Optimal Policies For Dynamic Pricing And Inventory Control With Nonparametric Censored Demands

Yining Wang, University of Florida, Gainesville, FL, United States, Boxiao Chen, Yuan Zhou

We study the fundamental model in joint pricing and inventory replenishment control under the learning-while-doing framework, with T consecutive review periods and the firm not knowing the demand curve a priori. We propose a novel inversion method based on empirical measures to consistently estimate the difference of the instantaneous reward functions at two prices, directly tackling the fundamental challenge brought by censored demands, without raising the order-up-to levels to unnaturally high levels to collect more demand information. In the more general case of non-concave reward functions, we design an active tournament elimination method that attains O(T^{3/5}) regret, based also on the technical innovation of consistent estimates of reward differences at two prices. We complement the O(T^{3/5}) regret upper bound with a matching T^{3/5} regret lower bound.

4 - An Asymptotically Tight Learning Algorithm for Mobile-Promotion Platforms

Zhichao Feng, University of Science and Technology of China, Hefei, China, Milind Dawande, Ganesh Janakiraman, Anyan Qi

Operating under both supply-side and demand-side uncertainties, a mobile-promotion platform conducts advertising campaigns for individual advertisers. Campaigns arrive dynamically over time. Each campaign requires the platform to deliver a target number of impressions from a set of locations over a desired time interval. The platform fulfills these campaigns by procuring impressions from publishers, who supply advertising space on apps. Each location is characterized by its win curve, i.e., the relationship between the bid amount and the probability of winning an impression at that bid. The win curves are initially unknown to the platform, and it learns them on the fly based on the bids placed and the realized outcomes. Each acquired impression is allocated to an ongoing campaign. The platform's objective is to minimize its total cost over the time horizon of interest.

5 - A Joint Pricing And Capacity Decision Problem In Railways

Seetharama Chandrasekhar Manchiraju, University of Texas-Dallas, Richardson, TX, 75080-3021, United States, Milind Dawande, Ganesh Janakiraman, Arvind Raghunathan

We study a joint pricing and capacity decision problem in the railway industry. Unlike in industries such as aviation, capacity in the railway industry can be decided at the end of the sales horizon due to the flexibility in choosing the number of coaches used on a train. The flexibility in varying capacity and a unique structure of the cost function distinguish this problem from the traditional RM pricing problems. Similar to the dynamic-pricing problems in RM literature, this problem is not tractable in general. Therefore, we obtain an easily implementable static policy and show that this policy is asymptotically optimal when the demand and capacity are proportionally scaled. We also obtain a dynamic policy which converges to optimality, faster than the static policy, as the scaling factor is increased.

■ VMB18

Virtual Room 18

Text Analytics & Natural Language Processing

Sponsored: Information Systems

Sponsored Session

Chair: Reza Mousavi, The University of Virginia, Charlottesville, VA, 22903, United States

Co-Chair: Reza Mousavi, University of Virginia, Charlottesville, VA, 22904, United States

1 - What Types Of Crowds Generate More Valuable Content? Evidence From Cross-platform Posting

Xiaohui Zhang, Arizona State University, Tempe, AZ, United States, Qianzhou Du, Zhongju Zhang

We examine the value of user-generated content by various crowds on a financial social media platform. The value of such content is measured by the incremental accuracy of using the cues from those content to predict stock volatility. We argue that the characteristic features of a crowd such as crowd size, crowd diversity, and crowd independence have significant impact on the predictive value of the subsequent content generated by the crowd. Leveraging a natural experiment setup where the financial platform no longer receives cross-postings from another major social media platform, we show empirical evidence that the composition of crowds (i.e., size, diversity, and independence) does matter. Furthermore, the impacts of the characteristic features on the value of generated content are likely heterogeneous and non-monotone.

2 - NetRank: Network Based Ranking Of Person Name Entities From Noisy OCR Text

Haimonti Dutta, University at Buffalo, Buffalo, NY, 14260, United States, Sean Sanders

In many large scale text repositories, digitized data is made available by Optical Character Recognition (OCR). The output of OCR software, however, is often garbled due to errors in transcription rendering characters, words and even entire sentences illegible. Researchers and scholars are therefore increasingly faced with the challenge of processing garbled OCR. In this paper, we study the problem of identifying named entities (people) from text and ranking them based on profiles created for them. Furthermore, we study relationships between names (if any) and represent such associations using a bi-partite graph. A ranking algorithm (birank) helps to generate the ranked list of entity names from the bipartite graph. Our research studies the impact of the noise both on the profiles of people and the associated graph and recommends several ways of dealing with OCR noise.

3 - The Effect Of Resilience Messaging On Community Conformity To Government Healthcare Guidelines

Reza Mousavi, University of Virginia, Charlottesville, VA, 22904, United States, Bin Gu

To withstand the COVID-19 pandemic, communities need to follow the healthcare guidelines provided by public health authorities such as the CDC. In this research we examine to what extent governors' social media posts and resilience messaging within those posts impact the time residents in their states spend at home and avoid nonessential trips. We use NLP to measure resilience-related content in governors' tweets. We find that governors' tweets about COVID have limited impact, while resilience-related tweets is positively associated higher level of community conformity. Our study can provide a set of guidelines for political leaders to be able to more effectively communicate with constituents.

■ VMB19

Virtual Room 19

Applications of Markov Decision Processes

Sponsored: Applied Probability Society

Sponsored Session

Chair: Daniel F Silva, Auburn University, Auburn, AL, 36849, United States

1 - Queuing Systems with Preferred Service Start Times and Multiple Customer Classes

Melis Boran, METU, Turkey, Bahar Cavdar, Tugce Isik

Addressing operational problems in curbside pickup systems, we study a joint problem of capacity allocation and admission control in a multi-class queuing system where arriving customers have preferred service delivery times and different priorities. In our system, customer priority increases as they wait longer in the queue. We introduce a Markov Decision Process model and develop efficient solution methods to solve this problem.

2 - Revenue Management In Queueing Systems With Price And Congestion Sensitive Customers

Xinchang Wang, Washington State University, Pullman, WA, 99164-4746, United States, Sigrun Andradottir, Hayriye Ayhan

This work is concerned with the optimal pricing problem in single-server queueing systems that offer services to price and congestion sensitive customers. The objective is to determine the dynamic pricing policies that maximize the long-run average revenue of the service provider. We formulate Markov decision process (MDP) models for both observable and unobservable systems (depending on how customers learn information upon arrival) and characterize the structure of the optimal policies. For unobservable systems, the problem is studied using an MDP with equilibrium constraints.

3 - Analysis Of Overdiagnosis In Cervical Cancer Screening Using An Incidence-based Personalized Pomdp

Raha Akhavan, Sabanci University, Istanbul, Turkey, Malek Ebadi

Population level screenings with a fixed frequency assumes homogeneity of the patients in different risk factors. This assumption causes unnecessary screenings and follow ups and impose considerable burden on the patients and healthcare systems. In this study, we consider different cohorts of patients with different prevalence and age-specific incidence rate of the infection, and aim to study the overdiagnosis of cervical infections and low grade lesions using a POMDP model tailored to incorporate incidence rate for each cohort. Our primary analysis confirms the presence of overdiagnosis in low and medium risk cohorts.

4 - Revisiting Linear Programming To Solve Markov Decision Processes Under The Long-run Average Reward Criterion

Daniel F. Silva, Auburn University, Auburn, AL, 36849, United States

We compare the computational performance of Linear Programming and the Policy Iteration Algorithm for finding optimal solutions to discrete time, infinite-horizon, unichain Markov decision processes under the long-run average reward criterion. We compare the computational performance of the linear programming method and the policy iteration algorithm over test instances with varying sizes of state space, action space, as well as different sparsity and structure of the transition probability matrices. The results of our experiments show that linear programming methods are faster than the policy iteration algorithm for problems with relatively small action spaces and large state spaces, while the policy iteration algorithm is faster for problems with small state spaces and large action spaces.

■ VMB20

Virtual Room 20

APS - Fairness in Sequential-Decision Making

Sponsored: Applied Probability Society

Sponsored Session

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

Co-Chair: Sean Sinclair, Cornell University, Ithaca, NY, 14853, United States

1 - Group Fairness In Online One-sided Matching

Nisarg Shah, University of Toronto, Toronto, ON, Canada

We introduce a novel group fairness notion in the classical sequential decision-making paradigm of online one-sided matching. In this setting, n agents are present and n objects arrive online. As an object arrives, a subset of agents reveal that they like the object (i.e. agents have dichotomous utilities) and the object must be allocated to one of them (or split between them if it is divisible). We assume that the agents are partitioned into groups apriori, and introduce group envy-freeness, which requires that no group be able to improve the total utility of its agents by receiving the allocation of another group and optimally matching that to its own agents. We identify the best possible approximations of group envy-freeness (or its relaxations) when the objects are divisible and indivisible.

2 - Fair Algorithms For Multi-Agent Multi-Armed Bandits

Evi Micha, University of Toronto, Toronto, ON, Canada

We propose a multi-agent variant of the classical multi-armed bandit problem, in which there are N agents and K arms, and pulling an arm generates a (possibly different) stochastic reward for each agent. Unlike the classical multi-armed bandit problem, the goal is not to learn the "best arm"; indeed, each agent may perceive a different arm to be the best for her personally. Instead, we seek to learn a fair distribution over the arms. Drawing on a long line of research in economics and computer science, we use the Nash social welfare as our notion of fairness. We design multi-agent variants of three classic multi-armed bandit algorithms and show that they achieve sublinear regret, which is now measured in terms of the lost Nash social welfare.

3 - Fairness And Utilization In Allocating Resources With Uncertain Demand

Kate Donahue, Cornell University, Ithaca, NY, United States

In this work, we consider fairness questions for resource allocation when the demands for the resource are distributed across multiple groups and drawn from probability distributions. In such cases, a natural fairness requirement is that individuals from different groups should have (approximately) equal probabilities of receiving the resource. A largely open question in this area has been to bound the gap between the maximum possible utilization of the resource and the maximum possible utilization subject to this fairness condition. Here, we obtain some of the first provable upper bounds on this gap: for arbitrary distributions we show the gap can be unboundedly large, but we also show that specific families of distributions can have much a gap that is low or non-existent.

4 - Fair Resource Allocation: A Reinforcement Learning Environment

Christopher Archer, Cornell University, Ithaca, NY, United States

We introduce ORSuite, an open-source library containing environments, algorithms, and instrumentation for operational sequential decision-making problems. One such application is to the fair online resource allocation problem, with the Food Bank of the Southern Tier, NY as the primary motivation. We formulate this problem as a reinforcement learning environment and discuss implemented heuristic algorithms. Additionally, we exploit the guaranteed fairness of the offline maximum Nash Social Welfare solution to find mathematical representations for online fairness metrics.

5 - Fair And Efficient Online Allocations With Normalized Valuations

Alex Psomas, Purdue University, West Lafayette, IN, United States

A set of divisible resources becomes available over a sequence of rounds and needs to be allocated immediately and irrevocably. Our goal is to distribute these resources to maximize fairness and efficiency. Achieving any non-trivial guarantees in an adversarial setting is impossible. However, we show that normalizing the agent values, a very common assumption in fair division, allows us to escape this impossibility. Our main result is an online algorithm for the case of two agents that ensures the outcome is envy-free while guaranteeing 91.6% of the optimal social welfare. We also show that this is near-optimal: there is no envy-free algorithm that guarantees more than 93.3% of the optimal social welfare.

■ VMB22

Virtual Room 22

Computation Services in Cybermanufacturing Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xiaoyu Chen, Virginia Tech, Blacksburg, VA, 24060-2575, United States

Co-Chair: Ran Jin, Virginia Tech, Blacksburg, VA, 24061-1019, United States

1 - Bayesian Sparse Regression For Mixed Multi-responses With Application To Runtime Metrics Prediction In Fog Manufacturing

Xiaoyu Chen, University of Louisville, Louisville, KY, 24060-2575, United States, Xiaoning Kang, Ran Jin, Xinwei Deng

Fog manufacturing enhances traditional manufacturing systems by engaging distributed Fog computation units governed by predictive computational workload offloading methods. The predictive offloading methods highly depend on accurate prediction and uncertainty quantification of runtime performance metrics, containing multivariate mixed-type responses (i.e., continuous, counting, binary). In this work, we propose a Bayesian sparse regression for multivariate mixed responses to enhance the prediction of runtime performance metrics and enable the statistical inferences. The proposed method considers both group and individual variable selection to jointly model the mixed types of runtime performance metrics. A simulation study and a real case example in a Fog manufacturing are conducted to demonstrate the merits of the proposed model.

2 - Monitoring And Anomaly Diagnosis For Metro System Based On Tensor Normal Distribution

Man Li, HKUST, Kowloon, Hong Kong, Kai Wang, Fugee Tsung

Process monitoring and anomaly diagnosis are both important tasks for traffic system which can help real-time and long-term traffic management. However system-wise monitoring for Metro system is difficult since factors to consider are numerous, like stations, time and flow types,, which causes the feature dimension to be relatively high. Then, we develop a monitoring methodology for the global level using tensor normal distribution which can achieve both real-time and long-term monitoring and integrate the metro system's structure. Under the practical assumption that not all features shift simultaneously, minimal concave penalty (MCP) is applied for variable selection, and laplacian penalty is implemented to add the network structure. Therefore, process monitoring and anomaly diagnosis can be achieved in this scheme simultaneously.

3 - Generalized Additive Models For Prediction And Compensation Of Shape Deviation Of Large-scale Additive Manufactured Products

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

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

■ VMB23

Virtual Room 23

Multimodal Data Fusion for Healthcare Applications

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Nathan B. Gaw, Georgia Institute of Technology, Scottsdale, AZ, 85258-2222, United States

1 - Statistical Inference For High-dimensional And Large-scale Data With Noisy Labels

Hyebin Song, Pennsylvania State University, University Park, PA, United States

In many classification applications, we are presented with data with partially observed or contaminated labels. One example of such an application is in the analysis of datasets from deep mutational scanning (DMS) experiments in proteomics, which typically do not contain non-functional sequences. In this talk, I will present statistical approaches and algorithms for analyzing noisy, high-dimensional binary data, demonstrating the optimality and scalability of our proposed methods. Finally, I will present an application of our methodology to inferring sequence-function relationships and designing highly stabilized enzymes based on large-scale DMS data.

2 - High-resolution Spatio-temporal Model For County-level COVID-19 Activity In The U.S.

Shihao Yang, ISyE Georgia Tech, Atlanta, GA, United States

We present an interpretable high-resolution spatio-temporal model to estimate COVID-19 deaths together with confirmed cases one-week ahead of the current time, at the county level and weekly aggregated, in the United States. Our model considers the (a) temporal auto- and pairwise correlation of the confirmed cases and death of the COVID-19, (b) correlation between locations, and (c) covariates such as local within-community mobility and social demographic factors. We impose sparsity structures as constraints and emphasize the impact of the top ten metropolitan areas in the nation, which we refer to as hubs. The proposed multivariate predictive models were designed to be highly interpretable, with clear identification and quantification of the most important factors that determine the dynamics of COVID-19.

3 - Cross Recurrence Analysis For Pattern Matching Of Multidimensional Physiological Signals

Adam Meyers, Doctoral Candidate, The Pennsylvania State University, University Park, PA, United States, Hui Yang, Mohammed Buqammaz

Cross recurrence quantification analysis (CRQA), based on cross recurrence plot (CRP), is an effective method to characterize and quantify nonlinear interrelationships between pairs of time series. Despite its many advantages, CRQA has largely been unutilized for pattern mining of multidimensional, especially spatiotemporal, physiological signals. We present new methodology to visualize a patient-to-patient network where distance corresponds to pairwise patient dissimilarity based on CRQA statistics. This methodology is evaluated on real data consisting of 3D spatiotemporal vectorcardiogram signals from healthy and diseased patients. Experimental results show that certain diagonal line measures in the CRP, including our proposed measure characterizing maximum pairwise similarity between signals, are effective in distinguishing between patients.

4 - Presenter

Zhen Zhong, Georgia Tech, Atlanta, GA, 30318, United States

■ VMB25

Virtual Room 25

Blockchain in Supply Chains

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Yao Cui, Cornell University, Ithaca, NY, 14853-6201, United States

Co-Chair: Jingchen Liu, Nanjing University, Nanjing, 210093, China

1 - Platform Tokenization: Financing, Governance, And Moral Hazard

S. Alex Yang, London Business School, London, NW1 4SA, United Kingdom, Jiri Chod, Nikolaos Trichakis

This paper highlights two channels through which blockchain-enabled tokenization can alleviate moral hazard frictions between founders, investors, and users of a platform: token financing and decentralized governance. We consider an entrepreneur who uses outside financing and exerts private effort to build a platform, and users who decide whether to join in response to the platform's dynamic transaction fee policy. The paper shows: 1. raising capital by issuing tokens rather than equity mitigates effort under-provision. 2. Decentralized governance associated with tokenization eliminates a potential holdup of platform users, reducing the entrepreneur's financing burden. 3. The downside of tokenization is that it puts a cap on how much capital the entrepreneur can raise.

2 - To Infinity And Beyond: Financing Platforms With Uncapped Crypto Tokens

Jingxing (Rowena) Gan, Assistant Professor, Cox School of Business, Southern Methodist University, Dallas, TX, 75225-4036, United States, Gerry Tsoukalas, Serguei Netessine

Initial Coin Offerings (ICOs) are an emerging form of crowdfunding for blockchain-based startups. We examine the conditions under which uncapped ICOs are optimal and provide guidance for their optimal design. In particular, we model game-theoretic interactions among various stakeholders in an infinite-horizon setting with network effects, taking account of operational details.

3 - Blockchain Adoption For Traceability In Food Supply Chain Networks

Lingxiu Dong, Professor, Washington University in St. Louis, Saint Louis, MO, 63130-4899, United States, Puping Jiang, Fasheng Xu

Innovative retailers in food supply chains have been exploring blockchain as part of an ongoing effort to reduce contamination risks and food waste. We develop a three-tier supply chain model to investigate: how blockchain adoption affects incentives of supply chain members, and whether and how its anticipated benefits can be realized. We find that full traceability brings direct revenue benefit to every supply chain member by saving uncontaminated food from disposal (pure traceability effect), but also leaves each tier of the supply chain vulnerable to its immediate downstream buyer's exploitation through strategically lowering the purchasing price (strategic pricing effect). The interplay of the two effects may result in some of the supply chain members being worse off with blockchain adoption, and the system being exposed to higher contamination risk.

4 - An Investigation On The Impact Of Counterfeiting And Traceability In The Secondary Market

Hubert Pun, The University of Western Ontario, London, ON, N6G0N1, Canada, Jay Swaminathan, Jing Chen

We use a two-period game to study the impact of blockchain for combating counterfeits in the secondary market. In the first period, a manufacturer sells a new product to customers. At the end of the first period, some of these customers would sell their product as used good to an authentic used goods reseller. In the second period, there is a secondary market that has two firms: the used goods reseller and a deceptive counterfeiter. Customers know that new products from the manufacturer are genuine, but they are uninformed about authenticity information in the secondary market. The manufacturer and the used goods reseller suffer reputation damage when customers buy a fake product unknowingly. The manufacturer has the option to implement traceability to reveal product information so that customers can identify which products in the secondary market are authentic.

5 - Blockchain Collaboration In A Supply Chain Network:

Benefits, Challenges, And Design
Jingchen Liu, Nanjing University, Nanjing, 210093, China, Yao Cui, Vishal Gaur

Field research has shown that companies are investing in blockchain technology for their supply chains to benefit from enhanced transparency and verifiability, but face challenges in creating partnerships with other firms in their supply chain, some of whom could be competitors, under uncertainty about the cost and benefit of blockchain. We investigate these questions theoretically by studying two fundamental effects of blockchain in a supply chain network setting. In the upstream of the supply chain, blockchain can increase the flexibility in wholesale price contract for the manufacturer. In the downstream, blockchain can increase the transparency of ordering status for buyers who compete for capacity. By comparing the cases with and without blockchain, we uncover how the two effects of blockchain interact with each other and jointly impact the supply chain network.

■ VMB26

Virtual Room 26

Influence of Supply Chain Practices on Emerging Economies

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Beril L Toktay, Georgia Institute of Technology, Georgia Institute of Technology, Atlanta, GA, 30308-1149, United States

1 - Analysis Of Farm Equipment Sharing In Emerging Economies
Priyank Arora, University of Massachusetts Amherst, Easthampton, MA, 01027, United States, Olufunke Adebola, Can Zhang

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.

2 - Treat, Dump, Or Export? How Domestic And International Waste Management Policies Shape Waste Chain Outcomes
Sytske Wijnsma, University of Cambridge, Cambridge, United Kingdom, Dominique Lauga, Beril Toktay

Investigations have revealed that firms can be inclined to violate waste regulations when this is more profitable than following them. Moreover, due to the decentralized nature of the waste chain, regulations targeted at a particular agent can affect others along the chain, creating complex interactions between enforcement and firm behaviors. We analyze the effects of regulations targeting waste export to emerging economies and dumping in the country of origin on firm incentives and compliance. Our analysis reveals that only regulating low-quality wastes can have unintended consequences on firms initially in compliance and deteriorate waste management outcomes. Interestingly, poor information on the chain partner may increase value-added treatment and enhance profits of compliant firms, but only when non-compliance costs are carefully balanced between agents.

3 - The Value Of Long-Term Relationships When Selling To Informal Retailers - Evidence From India
Olumurejiwa Fatunde, Massachusetts Institute of Technology, Cambridge, MA, 02138, United States, Andre Du Pin Calmon, Joann de Zegher, Gonzalo Romero

Attempts to distribute durable, life-improving goods to customers at the Base of the Pyramid (BoP) through traditional supply chains or e-commerce have struggled to succeed at scale. One potential explanation is poor relationship management with small informal retailers, which are often deeply embedded within communities. We provide empirical evidence for this hypothesis through an analysis of panel data from a distributor selling to 331 formal retailers and 493 informal retailers in India from April 2016 to December 2019. We demonstrate that after a sales agent reallocation, informal retailers take longer to recover than formal retailers. This indicates that social/ business relationships, and disruptions to these relationships, are particularly important when selling to retailers in informal markets.

4 - Business Model Implications of Right-to-Repair: Economic and Environmental Consequences
Ece Gulserliler, INSEAD

The Right-to-Repair (RTR) regulations require producers to design easy-to-repair products and supply necessary information and parts for consumers to independently undertake repairs. While this policy aims to prolong product lifetimes through repairs, increase secondhand use, and reduce waste; the ease of access to proprietary information and spare parts may have unintended consequences such as inviting cloning by third parties. The increased risk of cloning under RTR may encourage producers to reconsider their business model choice between ownership and non-ownership models (e.g. leasing). In this paper, we use an analytical model to examine the effect of RTR regulations on business model choice, and its implications on producers, consumers, and the environment. We find that the regulations may motivate producers to retain ownership of products and bear responsibility of repairs, hence avoiding competition from secondary market or third-party clones. Although RTR regulations may lessen the environmental impact for some products, they may lead to lower producer profits and consumer surplus, while also curtailing producer's incentives to innovate.

■ VMB27

Virtual Room 27

Climate Change

Contributed Session

Chair: Andrea Arriet, Pontificia Universidad Catolica de Valparaiso, Lubbock, TX, 79401

1 - An Adaptive Transfer-learning Based Missing Data Imputation for Reliable Accounting of Building Carbon Footprint
Manikandan Padmanaban, IBM Research, Bangalore, India, Jagabondhu Hazra, Ayush Jain, Andres Rodriguez

Buildings generate nearly 40% of annual global GHG emissions. In recent years, many organizations set goals to develop Zero-energy buildings by the next decade. But most of the organization is facing a challenge in getting high-quality building level energy consumption data. To address this challenge, we developed an adaptive transfer learning-based methodology to impute the different rate of missing energy consumption data with over 90% accuracy.

2 - Long-term Pathways for Carbon-neutrality From Chile: Variability in Absorption CO2
Yolanda Matamala, Pontificia Universidad Católica de Valparaíso, Valparaiso, Chile, Francisco Flores Gajardo, Andrea Arriet, Felipe A. Feijoo

This study uses a detailed Latin American representation of the Global Change Analysis Model (GCAM-LA) to study the Chilean energy systems transformation to reach carbon by mid-century. We propose alternative deep-decarbonization pathways, which differ from the Chilean ministry strategies, to reduce reliance on increasing levels of land use CO2 sequestration. To do so, we use the GCAM-LA model to implement different biomass potential scenarios and demonstrate that stringent policies reduce CO2 emissions by increasing green penetration and electrification in different demand sectors.

3 - Electrification Strategies for the Chilean Energy Transition Towards Carbon-neutrality by 2050
Andrea Arriet, Texas Tech University, Lubbock, TX, United States Andrea Arriet, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile, Francisco Flores, Yolanda Matamala, Felipe A. Feijoo

Complying with the Paris Agreement (PA) is challenging for all countries. Depending on the economic conditions and the availability of natural resources, this goal could be even harder to achieve. Chile, a middle-income economy with a remarkable renewable energy potential, ratified the PA. Chile committed to achieving carbon neutrality by 2050, eliminating all carbon plants by 2040. This study uses an integrated assessment model to evaluate eight different policies based on the Chilean NDC's. Results show that green sources in the primary sector will represent up to 82%. In the secondary sector, green electricity will rise to 64%. Transport will reduce its oil consumption by 10.4%.

■ VMB28

Virtual Room 28

Learning Algorithms in Resource Allocation and Healthcare Applications

Sponsored: MSOM/Healthcare

Sponsored Session

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

1 - Online Resource Allocation With Personalized Learning: Theory And Application To Advance Scheduling

Mohammad Zhalechian, University of Michigan, Ann Arbor, MI, 48109-2117, United States, Esmaeil Keyvanshokooh, Cong Shi, Mark P. Van Oyen

We develop an online contextual learning and resource allocation algorithm called the Personalized Advance Scheduling while Learning with Delay (PAS-LD). The PAS-LD algorithm offers an appointment (server and date) in real-time to each customer based on the contextual information on the customer and servers. In a limited capacity system, it operates under adversarial arrivals, uncertainty in both heterogeneous rewards and service times, delayed feedback, and the possibility of no-show. We provide a theoretical performance guarantee in terms of Bayesian regret and demonstrate its practicality and efficacy using real clinical data from a partner health system.

2 - Near-optimal Bayesian Online Assortment Of Reusable Resources

Yiding Feng, Northwestern University Electrical Engineering and Computer Science, Evanston, IL, United States, Rad Niazadeh, Amin Saberi

Motivated by the applications of rental services in e-commerce, we consider revenue maximization in online assortment of reusable resources for a stream of arriving consumers with different types. We design competitive online algorithms with respect to the optimum online policy in the Bayesian setting, in which types are drawn independently from known heterogeneous distributions over time. In the regime where the minimum of initial inventories c_min is large, our main result is a near-optimal 1-min(1/2,\sqrt{log(c_min)/c_min}) competitive algorithm for the general case of reusable resources. For the special case of non-reusable resources, we further show an improved near-optimal 1-1/\sqrt{c_min+3} competitive algorithm.

3 - Data-pooling For Personalized Intervention In Healthcare

Xiuwen Wang, Chinese University of Hong Kong, Shenzhen, China, Xinyun Chen, Pengyi Shi

Personalized intervention management in healthcare has received a rapidly growing interest in the big-data era yet still is a burgeoning field. A key challenge is data scarcity. One often needs to leverage historical data from patients with potentially different characteristics to develop personalized plan for new patients, who have limited data. This small sample issue makes standard learning methods hard to learn the right policy and/or suffer from large variances. In this research, we extend the data-pooling technique from the bandit setting to the reinforcement learning (RL) context that are more suitable for healthcare management problem and make the following contributions: develop a novel data-pooling estimator; establish theoretical performance guarantee for RL with data-pooling; and demonstrate its empirical success on both synthetic data and real data.

4 - Clinical Trial Design From A Network Meta-analysis Lens

John M. Silberholz, University of Michigan Ross School of Business, Ann Arbor, MI, 48103-2380, United States, Roman Kapuscinski, Xiaoyu Wu

Often many treatments exist for a particular disease, but a relatively small number of treatment pairs have been compared in randomized controlled trials. Network meta-analysis (NMA) is a powerful methodology that compares therapies using both direct and indirect evidence (e.g. learning about A vs. C by combining results of A vs. B and B vs. C trials). We use NMA to identify the most informative new comparative effectiveness trial to run. We analytically characterize the optimal strategy, obtaining managerial insights, and numerically demonstrate that our designs could be more informative than the comparative effectiveness trials that have actually been run in practice.

■ VMB29

Virtual Room 29

New Strategies and Technologies in the Operations/Finance Interface

Sponsored: MSOM/iForm

Sponsored Session

Chair: N. Bora Keskin, Duke University, Durham, NC, 27708, United States

Co-Chair: Yuan-Mao Kao, Duke University, Durham, NC, 27705-3387, United States

1 - Flexibility Value Of Reshoring Under Tariff Uncertainty And Competition

Xiao Tan, Ph.D. Candidate, Washington University in St. Louis, St. Louis, MO, 63130, United States, Panos Kouvelis, Sammi Tang

Establishing domestic production capacities provides a global firm with sourcing and production flexibility when facing tariff uncertainty. We develop a three-stage game for an offshoring company that operates existing production facilities in a foreign country and sells to the domestic market. The model captures the long-term reshoring quantity decision, the medium-term output quantity decision, and the short-term sourcing and production decision. We analyze the impact of tariffs and domestic competition on the optimal reshoring decision.

2 - The Analysis Of Blockchain-based Decentralized Exchanges

Ruizhe Jia, Columbia University, NY, United States, Agostino Capponi

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

3 - Buyer's Bankruptcy Risk, Sourcing Strategy, And Firm Value: Evidence From The Supplier Protection Act

Karca D. Aral, Syracuse University, Syracuse, NY, 13244-4418, United States, Erasmo Giambona, Ye Wang

What should a distressed buyer's sourcing strategy be? We find that this depends on the dynamics in a potential in-court bankruptcy. To establish causality, we use a novel sourcing dataset in combination with a unique quasi-natural experimental setting provided by a regulatory shock: the Supplier Protection Act. We find that, following this regulatory change, the number of suppliers for buyers near financial distress increased by 35% relative to financially sound firms. This shift allowed distressed buyers to obtain more trade credit, expand inventory, and increase performance, leading to an increase in firm value of 7.2%, and to a sizable reduction in the probability of bankruptcy. Our findings suggest that right-sizing the supply base can be critical for buyers near financial distress, and implementing policies to protect suppliers can be the way out of distress.

4 - Matching Platforms For Smallholder Supply Chains

Sergio Camelo, Stanford University, Stanford, CA, 94305, United States, Dan Iancu, Joanne de Zegher

We design a centralized platform that matches smallholder farmers with middlemen that provide transportation for their fruit. The platform sells the fruit and uses its revenue to pay both parties. Payments are designed to ensure that participating in the platform is more profitable for both farmers and middlemen than working outside of it. To model the profits that both parties could obtain outside of the platform we use historical data on thousands of fruit pickups, gathered through GPS trackers installed on middlemen trucks in our field site in Sumatra. To account for uncertainty in data collection, we rely on a distributionally robust optimization approach based on the Wasserstein metric. We show that such a platform can reduce transportation costs, while also easing the digitization of agricultural data and improving the transparency of smallholder supply chains.

5 - Modeling Disruption Cascades in Supply Networks

Nitin Bakshi, University of Utah, Salt Lake City, UT, 84112-8939, United States, Shyam Mohan

We model a setting that involves mitigating the risk of supply chain disruptions in a decentralized network. Our key contribution is to identify the phenomenon of diminishing vertical dependence (DVD) when the shocks are non-concurrent: A firm's investment in mitigation shows decaying sensitivity to the parameters of firms that are further away in terms of tier distance. Thereafter, for both non-concurrent and concurrent shocks, we explore the managerial implications of DVD in terms of how much network visibility is required by a firm in order to invest optimally.

■ VMB30

Virtual Room 30

Innovations in Services and Platforms

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Shiliang Cui, Georgetown University, Washington, DC, 20002, United States

Co-Chair: Luyi Yang, University of California-Berkeley, Berkeley, CA, 94002, United States

1 - No Panic In Pandemic: The Impact Of Individual Choice On Public Health Policy And Vaccine Priority

Guangwen Kong, Temple University, Philadephia, PA, 55455-0150, United States, Miao Bai, Ying Cui, Zhenhuan Zhang

Infectious disease outbreaks such as COVID-19 pose significant public health threats and challenges worldwide. Although public health interventions such as social distancing and lockdown can slow the disease spread, the disruption to regular economic and social activities caused by these interventions has caused significant financial losses. Strategic planning is required to optimize the timing and intensity of these public health interventions by considering individual response. We derive insightful structural properties of the optimal public health interventions and conduct numerical studies based on representative COVID-19 data in Minnesota. Moreover, we examine the vaccination priority strategy considering the trade-off between the higher mortality rate of the less active group and the higher negative externality imposed by the more active group.

2 - On Designing A Socially-optimal Expedited Service And Its Impact On Individual Welfare

Ricky Roet-Green, Simon Business School, University of Rochester, Rochester, NY, 14534-2883, United States, Aditya Shetty

Our research is motivated by the expedited security check at US airports (TSA PreCheck). We consider the problem faced by a welfare-maximizing service provider who must make a decision on how to split a fixed capacity between a standard service and an expedited service. The service is mandatory. Choosing the expedited variant requires enrollment at a fixed cost per period. Customers are strategic and have the same cost of waiting, but are heterogeneous in the rate at which they use the service. We show customers' strategic behavior in equilibrium is uniquely determined by the provider's allocation decision. We use this result to solve for the socially optimal allocation. We show that even when customers behave strategically, an expedited service offered in parallel to a standard service can not only increase overall welfare, but also do so for each customer individually.

3 - Congestion, Conflict, And Coordination: Contracting With A Food Delivery Platform

Andrew E. Frazelle, The University of Texas at Dallas, Dallas, TX, 75205-3685, United States, Pnina Feldman, Robert Swinney

In a stylized model of a restaurant as a congested service system, we explore various contractual arrangements between the parties. We find that the commonly-used, traditional revenue sharing contract, in which the platform takes a percentage cut of each delivery order, fails to coordinate the system because the platform does not internalize the effect of its pricing on dine-in revenues. By contrast, a no-contract arrangement, in which the platform pays menu price on each unit, protects the restaurant's revenue from being cannibalized by lower-margin delivery orders. Unfortunately, it too leaves potential revenue on the table. We propose an alternative, practical coordinating contract. As well as coordinating the system, our contract protects restaurant margins by ensuring that the restaurant receives no less per order on delivery than dine-in.

4 - Fulfillment by Platform: Antitrust and Upstream Market Power

Senthil Veeraraghavan, University of Pennsylvania, The Wharton School, Philadelphia, PA, 19104, United States, Jiding Zhang, Amandeep Singh

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, with concerns ranging from data usage to retail competition. We empirically examine whether mere adoption of fulfillment services offered by platforms affects competition in the upstream markets among sellers.

■ VMB31

Virtual Room 31

Empirical Research in Emerging Services

Sponsored: MSOM/Service Operations

Sponsored Session

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

Co-Chair: Shuai Ling, Tianjin University, Tianjin, 300072, China

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

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

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

2 - Westore Or Appstore: Customer Behavior Differences In Mobile Apps And Social Commerce

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

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

3 - Trips For Tips? An Investigation Of The Role Of Passengertips In Drivers' Relocation Decision-making Process

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

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

■ VMB32

Virtual Room 32

Innovative Business Models in Sustainable/Smart City Operations

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Nur Sunar, UNC, Chapel Hill, NC, 27517-7577, United States

Co-Chair: Yuexing Li, Duke University, Durham, NC, 27703-6548, United States

1 - The Environmental Impact Of The Advent Of Online Grocery Retailing

Ekaterina Astashkina, Ross School of Business, University of Michigan, Ann Arbor, MI, 77305, United States, Elena Belavina, Simone Marinesi

To study the environmental impact of the advent of online grocery retailing, we build a stylized 3-tier model of geographically-dispersed traditional and online fresh grocery retail chains. We analytically compare food waste and transportation emissions before & after the advent of online grocery retail. We isolate three key factors that drive the difference: (i) which households switch to online shopping, (ii) their shopping patterns, and (iii) how the first two factors change where inventories are held. Numerical calibration using industry and demographic data reveals that in most US cities the advent of online grocery should be beneficial, leading to an eventual 8-41% reduction in emissions.

2 - Managing Residential Energy Storage
Na Rea Cho, University of Alabama, Tuscaloosa, AL, 35405, United States, Karthik Murali, Youngsoo Kim, Mesut Yavuz

In this paper, we examine a homeowner's battery management policy when they have access to intermittent renewable energy and are connected to a grid with feed-in tariffs and time-of-use electricity prices. The cost-minimizing battery operating policy depends on the configuration of electricity prices in the market. When electricity sellback prices are lower than purchase prices from the grid, we show that a simple heuristic with a charge up to level in the off-peak period and a discharge down to level in the peak period performs extremely well relative to the optimal solution. We compare the performance and emissions reductions resulting from this recommended policy against other commonly utilized heuristics (full charge/discharge, no battery, do nothing).

3 - When Shared Autonomous Electric Vehicles Meet Microgrids: Citywide Energy-Mobility Orchestration
Mengyi Sha, University of Chinese Academy of Sciences, Beijing, China, Wei Qi, Shanling Li

We propose models and analytics to characterize the dynamics of the SAEV-microgrid service systems. We develop a space-time-energy network representation of SAEVs, and formulate linear program models to investigate the potential of operating SAEVs for improving the self-sufficiency and resilience of solar-powered microgrids. To preventatively ensure microgrid resilience, we also propose an "N-1" resilience-constrained fleet dispatch problem to cope with microgrid outages. Our results show that SAEV fleet can improve microgrid self-sufficiency via the spatial and temporal transfer of electricity. Microgrid resilience can be enhanced by SAEVs. The SAEV fleet operator can further maintain the resilience of pivotal microgrids at their maximum achievable level without significantly compromising the fleet repositioning efficiency.

4 - Subsidies/taxes Induced By An Adoption Target Or A Budget Limit: Mitigating Charging Inconvenience To Promote Electric Vehicles
Lingling Shi, University of Texas-Dallas, Richardson, TX, 75080, United States, Metin Cakanyildirim, Suresh P. Sethi

Environmental and energy independence concerns lead to government subsidies for electric vehicles. Managerial questions for a government are whether to subsidize consumers, charging stations, or both, and whether to replace the consumer subsidy with a tax. We model the interactions between the government and the charging supplier as a Stackelberg game and study the optimal structure of subsidies while incorporating charging inconvenience. We comparatively study linear (as an approximation) and quadratic charging inconveniences, and their solutions qualitatively differ when the construction cost is low. Furthermore, we show that the government provides consumer subsidy in a larger number of contexts, and that the charger builds more stations as the construction cost decreases regardless of the subsidy types. We also conduct a numerical study with real-life data.

■ VMB33

Virtual Room 33

Food Waste

Sponsored: MSOM/Supply Chain

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 - Optimal Issuing Policy For Perishables With Deteriorating Quality
Jae-Hyuck Park, The HKUST Business School, Hong Kong, 94063-4203, Hong Kong, Dan Andrei Iancu, Erica Plambeck

We consider a retailer who sells a perishable product with deteriorating quality to quality-sensitive customers over an infinite time horizon. The retailer jointly decides whether to issue the oldest (FIFO) or newest (LIFO) stock first to consumers and when to remove unsold items from shelf to maximize the objective which is a weighted sum of the immediate profit and customer welfare. The retailer and customers make optimal decisions based on their rational expectations about the customers' shopping behaviors and the quality of purchased items. We find that the optimal policy, in contrast to the industry norm that issues inventory according to FIFO and keeps inventory until it loses all of its utility, is to use LIFO and pull inventory from shelf early. We show that the LIFO issuance remains optimal even in the presence of a time stamp if the salvage value is sufficiently large.

2 - Drivers Of Food Waste At Retail Level: An Empirical Study
Nitish Jain, London Business School, London Business School Sussex Place, London, NW1 4SA, United Kingdom

Food waste in the retail sector is an urgent economic and social problem. Recent reports suggest that supermarkets in the UK throw away enough food for 190 million meals each year. This number is comparable to the total number of people undernourished in sub-saharan Africa (200 million; 2015). In order to propose solutions, it is essential to understand the underlying causes. We analyze proprietary data from a supermarket-chain in UK to understand key drivers of food wastage in retail supermarkets. We estimate the amount of "avoidable" waste, identify controllable factors and quantify the impact of each of them. We propose guidelines to store-managers and forecasters that minimize waste while maintaining service levels and revenues.

3 - Replenishment Strategies For Lost-sales Inventory Systems Of Perishables Under Demand And Lead-time Uncertainty
Sandra Transchel, Kuehne Logistics University, Hamburg, 20457, Germany, Ole Hansen, Hanno Friedrich

We develop a replenishment policy for lost-sales inventory systems of perishables under both demand and lead time uncertainty. Our model allows for order-crossing, a characteristic that is widely disregarded. We evaluate our model based on replenishment policies that ignore lead time uncertainty: First, assuming the expected lead time, and second, assuming the worst-case lead time scenario. We show that ignoring lead time uncertainty and planning based on the expected lead time either leads to unnecessary waste (under FEFO) or significantly undershoots the target service level (under LEFO). Even planning with the maximum lead time, under LEFO the achieved service level would still fall considerably below the target. We further show the value of lead time information on outstanding orders regarding generated waste.

4 - The Impact Of The Minimum Life On Receipt (MLOR) Criterion In Food Supply Chains
Sara Martins, INESC TEC, Porto, 4200-465, Portugal
Sara Martins, School of Management and Technology, Polytechnic of Porto, Portugal, Pedro Amorim, Maria João Santos, Bernardo Almada-Lobo

The Minimum Life on Receipt (MLOR) is a widely used rule that imposes the minimum remaining age a food product must be delivered by the producer to the retailer. In practice, this rule is set by retailers and it is fixed around 2/3 of the age of products regardless of their shelf life. The goal of this work is to compare the supply chain performance considering an innovative setting of optimal MLOR and the traditional setting of fixed MLOR rule. The computational results suggest that allowing flexible MLOR rules according to the shelf life of products and the operational requirements of the producer benefits both entities in the supply chain.

5 - Why Do Apples Look So Perfect? Drivers Of Cosmetic Quality Standard And Implications On Food Loss
Yangfang (Helen) Zhou, Singapore Management University, Singapore, 178899, Singapore, Pascale Crama, Jiahui Xu

A significant amount of fresh produce is wasted in the upstream of food supply chain due to the high cosmetic standard---regarding the appearance of the produce---which are set by retailers. We examine the economic incentives for retailers to adopt such high standards and their impact on food loss. A high minimum cosmetic standard of the produce enables the produce to be sold at a premium, which decreases the proportion of the produce that satisfies such standards. We show how the retailer's decision of cosmetic standard as well as food loss are affected by rejection rate due to high cosmetic standards and consumers' willing-to-pay for cosmetic-pleasing products.

■ VMB34

Virtual Room 34

Emerging Topics in Sustainable Operations

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Adem Orsdemir, University of California-Riverside, Riverside, CA, 92521-9800, United States

1 - Customization And Returns
Paolo Letizia, University of Tennessee, Knoxville, TN, United States, Gokce Esenduran, Anton Ovchinnikov

Product returns have always been considered as a necessary cost of doing business: Generous returns policies have a positive externality on demand and thus can increase the firm's profits, even though they result in a high volume of returns. When firms sell both standard and customized products, however, generous returns policies on customized products may lead to both higher profits and lower number of returns, clearly a win-win for firms.

2 - Is Adopting Mass Customization A Path To Environmentally Sustainable Fashion?
Adem Orsdemir, University of California-Riverside, Riverside, CA, 92521-9800, United States, Aydin Alptekinoglu

In high-product-variety businesses like fashion, mass production systems create environmental waste in the form of overproduction on a colossal scale. Mass customization has been proposed -- without solid evidence -- as a solution. In this paper, we analyze whether mass customization can indeed offer a win-win solution that helps both the bottom line and the environment. We also study the impact of three real policy options: promoting mass customization, charging a disposal fee for overproduction, and recycling.

3 - Evaluating The Timing Of Government Subsidy On Adopting Resource-Efficient Durable Products
Haoying Sun, Associate Professor, University of Kentucky, Lexington, KY, 40506, United States, Stephen M. Gilbert

It is common for governments to offer subsidies, such as cash rebates or tax credits, to stimulate the adoption of resource-efficient durable products by a certain date to conserve resources. While the subsidy may stimulate demand, it may interfere with a resource-efficient product manufacturer's incentive to exert effort to reduce future production costs. We investigate how the government subsidy programs' timing influences their effectiveness. Specifically, we focus on comparing three types of rebate structures: early, late, and constant rebates. We find that depending on the consumer's relative patience level and the costs of process improvement, the early rebate may backfire on the intended goal of increasing the total number of adopters. We also further characterize the regions where each rebate is more effective in stimulating more adopters than the others.

4 - Right To Repair: Pricing, Welfare, And Environmental Implications
Cungen Zhu, National University of Singapore, Singapore, Luyi Yang, Chen Jin

The "right to repair" (RTR) movement calls for government legislation that requires manufacturers to provide repair information, tools, and parts so that consumers can independently repair their own products with more ease. The initiative has gained global traction in recent years. Repair advocates argue that such legislation would break manufacturers' monopoly on the repair market and benefit consumers. They further contend that it would reduce the environmental impact by reducing e-waste and new production. However, the RTR legislation would understandably hurt manufacturers' profit, and once passed, may trigger a nuanced price response in the product market as manufacturers try to mitigate the profit loss. This paper employs an analytical model to study the pricing, welfare, and environmental implications of RTR.

■ VMB35

Virtual Room 35

Optimization Advances in Interdependent Systems

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Kai Pan, Hong Kong Polytechnic University, Kowloon, Hong Kong

1 - Optimal Planning Of Charging Facilities For The Electrification Of Bus Fleets In Public Transit Systems
Filipe Cabral, ISyE Georgia Tech, Atlanta, GA, United States, Andy Sun

The electrification of public transit systems is an important part of the transition to a zero-carbon economy. The objective of this work is to provide decision support tools for public transit authorities to optimally plan charging facilities, manage electric bus fleets and assess the impacts of transit electrification on power systems. We develop mixed-integer optimization models and solution methods and apply our methodology to the city of Atlanta to evaluate the performance of different policies over real transit data.

2 - Integration of Distribution and Transmission Markets
Golbon Zakeri, University of Massachusetts-Amherst, Amherst, MA, 01003-2210, United States

We will present a model that efficiently integrates a distribution market within a wholesale market. We will present our model, the mathematical results pertaining to this model and our numerical results based on a realistic case study.

■ VMB36

Virtual Room 36

Energy Storage and Electricity Markets

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Dirk Lauinger, EPFL, Lausanne, 1015, Switzerland

Co-Chair: Napat Rujeerapaiboon, NUS, Lausanne, 1015, Switzerland

1 - Benefits of strategically sizing wind-integrated energy storage and transmission
Shubhrajit Bhattacharjee, University of Calgary, Calgary, AB, Canada, Ramteen Sioshansi, Hamid Zareipour

We examine the behavior of a strategic firm that invests-in and operates wind, energy storage, and transmission. The capacity of the energy storage and transmission are cooptimized with the firm's wind-supply and energy-storage offers into a centrally dispatched electricity market. We employ a bilevel stochastic optimization model. The upper level determines the capacities and offering strategies to maximize the firm's expected profits. Multiple lower-level problems represent market clearing under different operating conditions, which capture uncertainties. The resulting large-scale optimization model is solved using multi-cut Benders's decomposition. The model is applied to a case study that is based on Alberta's electricity markets and the results are analyzed.

2 - The Value of Coordination in Multimarket Bidding of Grid Energy Storage
David Wozabal, Universitat Munchen, Vienna, 1170, Austria, Nils Loehndorf

We consider a storage that trades in an electricity market comprising an auction-based day-ahead market and a continuous intraday market. We show in a stylized model that a coordinated policy that reserves capacity for the intraday market is optimal. To assess the value of coordination in a realistic setting, we develop a multi-stage stochastic program for hourly trading. We show how tight upper bounds can be obtained and calculate lower bounds based on a scenario tree generation method that lends itself to deriving an implementable policy based on re-optimization. We find that coordinated bidding is most valuable for flexible storage assets with high price impact. For small assets with low price impact, participation in the day-ahead auction is less important and intraday trading appears to be sufficient. For less flexible assets intraday trading is hardly profitable.

3 - A Planner-Trader Decomposition for Multi-Market Hydro Scheduling
Napat Rujeerapaiboon, NUS, Singapore, 1015, Singapore

Peak/off-peak spreads on electricity forward and spot markets are eroding due to the nuclear phaseout and the growth in photovoltaic capacity. The reduced profitability of peak/off-peak arbitrage forces hydropower producers to recover their original profitability on the reserve markets. We propose a bi-layer stochastic programming framework for the optimal operation of hydropower plants selling energy on both the spot and the reserve markets. The outer layer optimizes end-of-day reservoir filling levels over one year, whereas the inner layer selects optimal hourly market bids within each day. Using an information restriction whereby the planner prescribes the end-of-day reservoir targets one day in advance, we prove that the inner layer reduces to a simple linear program. Experiments based on a cascade in Austria demonstrate the effectiveness of this framework.

4 - An Exponential Cone Programming Approach For Managing Electric Vehicle Charging
Li Chen, National University of Singapore, Singapore, Long He, Yangfang (Helen) Zhou

We study the EV charging management of a service provider, which faces stochastic arrival of customers and a total electricity cost including demand charges. We formulate the problem of scheduling EV charging to minimize the expected total cost as a stochastic program and solve it using exponential cone program (ECP) approximations. We first derive an ECP for the case with unlimited chargers and then extend it to the case with limited capacity using the idea from distributionally robust optimization (DRO) of employing an entropic dominance ambiguity set. We benchmark our ECP approach with sample average approximation (SAA) on numerical instances calibrated to real data. The ECP scales well and runs efficiently and consequently results in a lower mean total cost than SAA. We also use ECP to generate managerial insights for both charging service providers and policy makers.

5 - Reliable Frequency Regulation through Electricity Storage: An analytical solution
Dirk Lauinger, EPFL, Lausanne, 1015, Switzerland

Primary frequency regulation is an insurance contracted by electricity grid operators against unforeseen supply and demand mismatches. We formulate a receding-horizon optimization problem in continuous time that maximizes the expected profit of an energy storage operator selling this insurance under EU delivery guarantees. Undesired end-of-horizon effects are mitigated by a constraint on the energy reservoir's expected terminal state-of-charge. The losses during charging and discharging render the optimization problem and in particular the constraint on the expected terminal state-of-charge non-convex. The higher the spread of the mismatch distribution, the more pronounced the influence of the losses. We derive a data-driven analytical solution based on the empirical mismatch distribution and the charging and discharging losses.

■ VMB37

Virtual Room 37

Power Grid Resilience Optimization

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Erhan Kutanoglu, University of Texas-Austin, Austin, TX, 78712, United States

1 - Development Of Realistic Natural Hazard Contingencies For Synthetic Power Grids

Brent Austgen, University of Texas-Austin, Austin, TX, United States

Because real power grid specifications are usually kept private for the sake of security, power grid researchers have developed a variety of synthetic power grid datasets to use in their studies. However, these synthetic datasets omit several details that are important when assessing the impact of natural hazards on the power grid. In this work, we discuss our methods of augmenting synthetic power grids with geographic details and how this has allowed us to more easily study the effects of historical natural disasters.

2 - A Multi Stage Stochastic Optimization Approach To Electric Grid Resilience Against Storm Surge Flooding

Ashutosh Shukla, University of Texas-Austin, Austin, TX, United States, John Hasenbein, Erhan Kutanoglu

In the past 4 decades, Texas has experienced more than 80 hurricanes, including Harvey, which alone caused damages costing over $130B part of which was due to power outages. In such a scenario, it is of paramount importance to make prudent investment decisions to enhance the resilience of electric grid against such extreme events. Our proposed model in this work helps stakeholders compare different budget allocation strategies for enhancing electric grid resilience against storm-surge induced flooding. These strategies involve sequential budget allocation decisions spanning multiple years which are split into short-term (for preparedness) and medium-term (for mitigation) investments.

3 - Optimal Utilization Of Mobile Substations For Mitigating Flood Damage To An Electric Power Grid

Joshua Yip, University of Texas-Austin, Austin, TX, United States, Surya Santoso, Erhan Kutanoglu, John Hasenbein

This research work contributes a scenario-based stochastic program on the optimal utilization of mobile transformers and breakers to minimize customer outages caused by the disabling of substations during a widespread flood event, such as a hurricane. Before the event, the prepositioning of mobile resources is prescribed by the outer stage of the formulation. The inner stage concerns, supposing an event scenario is realized, the dispatch and deployment of these resources and the operation of the power system augmented with them. The formulation has been tested using the IEEE 24-Bus System.

4 - Bilevel And Trilevel Models For Power System Cyber Physical Resilience

Bryan Arguello, Sandia National Labs, Albuquerque, NM, United States

Existing bilevel interdiction models can model power system resilience to physical attacks. We present algorithms for scaling the solution of these models for use with larger power systems. Additionally, we introduce a new trilevel interdiction model for the network segmentation of a cyber physical power system for improved cyber security. Our solution techniques include bilevel branch-and-bound and a cut generation algorithm.

■ VMB38

Virtual Room 38

Energy Systems Modeling Innovations for Emerging Technologies (Macro-Energy Systems)

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Stuart Cohen, NREL

1 - Advanced Hydropower And PSH Representations In Electricity Capacity Expansion Models

Stuart Cohen, National Renewable Energy Laboratory, Golden, CO, 80401, United States, Matthew Mowers

Hydropower plays a key role in global electricity systems, providing flexibility and reliability services expected to grow in importance with increases in variable renewable generation. However, broader water management goals complicate hydropower operation, and this complexity makes hydropower difficult to model in electricity planning and operations models. This presentation describes new methods for modeling hydropower and pumped storage hydropower (PSH) operation and deployment opportunities, including long-duration storage and system upgrades. The National Renewable Energy Laboratory's Regional Energy Deployment System (ReEDS) capacity expansion model is used to demonstrate these techniques and their importance for electricity planning analysis.

2 - Operational Flexibility Of Natural Gas Combined Cycle Power Plant Coupled With Flexible Carbon Capture And Storage

Fangwei Cheng, Princeton University

Achieving net-zero economy requires affordable low carbon or carbon neutral power systems. Natural gas combined cycle (NGCC) coupled with carbon capture and sequestration (CCS) enables continuous consumption of fossil fuels for power generation with minimal CO2 emissions. In this study, we apply integer clustering and linear relaxation unit commitment (UC) to the subcomponents (e.g., gas turbine, steam turbine, absorber, and regenerator) of NGCC coupled with flexible CCS and compare the results against the conventional binary UC. Our results show integer clustering/linear relaxation UC of NGCC-CCS subcomponents leads to substantial run time reduction with marginal errors. We also study how flexible NGCC-CCS affects the economic, environmental, and generation dispatch profiles under a wide range of carbon price (0-120 $/t) and variable renewable capacity.

3 - GCAM-USA: Integrated Modeling of State and Subnational U.S. Energy, Water, and Land Systems Within a Global Framework

Matthew Binsted, Pacific Northwest National Laboratory, College Park, MD, United States

GCAM-USA represents key interactions across economic, energy, water, and land systems in a consistent global framework, with state-level detail in the United States. GCAM-USA features a detailed electricity module that simultaneously represents long-term capacity expansion and sub-annual power sector operations. This finer-scale process and temporal resolution provides more robust insights about how changes in socioeconomic drivers, technological progress, and policy impact power supply while capturing interactions with energy end-use sectors and water systems and maintaining consistency with broader national and international conditions.

4 - Energy Systems Modeling Innovations For Emerging Technologies - Transportation Sector Perspective

Matteo Muratori, NREL, Golden, CO, 80401, United States

Transportation face unprecedented potential to radically transform today's petroleum-based mobility system to rely instead on alternative fuels. However, models based on traditional analytic approaches are not equipped to fully capture all the disruptive trends and forces that are transforming transportation energy demand, and they do not fully represent emerging interconnections with the grid. NREL developed the TEMPO modeling framework to better understand: (1) potential for radical transformations of transportation demand and energy use; (2) interconnections with other sectors, particularly the electric power system; and (3) opportunities for technology/fuel adoption across various market segments. This talk will review methods and approaches used in TEMPO to model passenger and freight systems and their energy use and emissions and some sample results.

5 - The Effect Of A Changing Climate On Optimal Storage Investment And Deployment Decisions In A High Renewables Power System

Srihari Sundar, University of Michigan, Ann Arbor, MI, United States, Ashley Payne, Michael Craig

Decarbonizing power systems will likely require significant investments in variable renewable energy (VRE) and short- and long-duration electricity storage. Given worsening climate change, it is critical to understand how non-stationary climate will affect decarbonized power systems. We use an optimization-based planning model of the power system with CMIP6 climate data to quantify climate mitigation and adaptation trade-offs induced by climate change. We specifically focus on storage investment needs probing the effect of weather extremes, using subsampling techniques and climate indices.

■ VMB39

Virtual Room 39

Forecasting II

Contributed Session

Chair: Surya Shravan Kumar Sajja, IBM Research, Bangalore, 560064, India

1 - New Product Multimodal Demand Forecasting For Fashion Retail

Vijay Ekambaram, Senior Research Engineer, IBM Research, Bangalore, India, Kushagra Manglik, Sumanta Mukherjee, Surya Shravan Kumar Sajja, Satyam Dwivedi, Vikas Raykar

Fashion Industry launches substantial new products every season. Hence, accurate new product demand forecasting is vital for effective demand planning. To tackle this, we propose novel attention-based encoder-decoder models that can effectively capture the non-linear relations between product images, attributes, sales, and external regressors for robust new product forecasting. Through empirical validation on a large fashion retail dataset, we show the efficacy and interpretability of our methods as compared to existing baselines.

2 - New Product Life-cycle Forecasting With Temporal Hierarchies

Oliver Schaer, University of Virginia, Charlottesville, VA, United States, Nikolaos Kourentzes, Douglas Thomas

Extending life-cycle curves to capture seasonality can substantially increase model complexity and complicate the estimation of model parameters. To address these issues, we suggest using temporal hierarchies that use optimal suited time-series models at each aggregation level to extract model structure and subsequently combine it to increase predictive accuracy. For example, fitting a diffusion model at the quarterly level, with a long term focus, and a seasonal exponential smoothing model at the weekly level, with a short term focus. Combining these hierarchically results in a prediction that retains both aspects. We evaluate our approach on life-cycle data from a computer manufacturer.

3 - Effect Of Choice Of Forecasting Metric On Profit Margin

Brian Quanz, IBM, IBM T. J Watson Research Center, Yorktown Heights, NY, 10598, United States, Pavithra Harsha, Satyam Dwivedi, Mahesh Ramakrishna, Ali Koc, Dhruv Shah

Success in retail industry is highly correlated with the ability to accurately estimate the future demands. However, the concept of accuracy of future demands is itself unclear and identifying a metric that fits best for the problem in hand is not straightforward. In this work, we study the effect of different forecasting metrics on overall business output, in multiple simulated retail settings. We obtain forecasts for every metric by optimising it over the assumed demand distribution and use this forecast in an inventory management system to calculate overall profit over the simulated period.

4 - Privacy Preserving Explanations For Hierarchical Time Series Forecasts

Dhinakaran Vinayagamurthy, Research Scientist, IBM Research, Bangalore, India, Surya Shravan Kumar Sajja, Sumanta Mukherjee, Ankit Kumar Jain, Pankaj Dayama, Vikas Raykar

Data privacy and explainability are two important requirements for any mature AI enabled system. Local explainability for a prediction or forecast amounts to assigning credit or blame to different input features of a model responsible for that prediction. Aggregation of these predictions and explanations to higher levels of hierarchy is often met with the challenge of privacy loss as it reveals characteristics of individual data points to a wider audience. Hence, an optimal tradeoff between privacy and explainability is explored in the context of hierarchical time series forecasting.

■ VMB40

Virtual Room 40

Advances in Mining

Sponsored: ENRE/Oil/Gas/Mining

Sponsored Session

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

1 - A Decision Support System For Controlling Exceedance In Plant Parameters At An Oil Refinery

Badri N. Toppur, Associate Professor, Rajalakshmi School of Business, Chennai, India, Atanu Sanyal

For the crude oil transportation problem modelled earlier, and solved using a spreadsheet solver, we compare the results obtained from the Gurobi optimizer.

The company has also initiated a process of artificial intelligence. When there is a variance in plant parameters, the operator is required to control the manipulative variables. The reasons for variance could be complicated due to reaction kinetics. The planned AI tool will give trends of the manipulative variables and also the more complex ones, when the alarm comes. Further it will recommend appropriate control action, to support the operator's decision making process. We review the extant and recent literature in this field, as a prelude to the implementation of the AI tool.

2 - Characterizing Heat And Diesel Emissions In An Underground Mine For A Production Scheduling Model

Aaron Swift, BS, Colorado School of Mines, Golden, CO, 80401, United States

Current production scheduling models for underground mines do not consider real-time heat or emissions from diesel equipment, which can lead to unsafe conditions as heat or emissions accumulate in the working areas. Based on thermodynamic principles, this research develops a transient model for heat, emissions, and ventilation that can be infused into a short-term production scheduling model for near-term operational planning.

3 - Incorporating Ventilation, Heat, And Emissions In A Short-term Underground Mine Production Scheduling Model

John Ayaburi, MS, Colorado School of Mines, Golden, CO, 80401, United States

Mine planners utilize production schedules to determine when blocks of ore should be extracted. However, the accumulation of heat in an underground mine not only disrupts the schedule but also affects the health and safety of mine workers. We propose a large-scale, short-term production scheduling model that minimizes deviation between i) medium-and short-term schedules and ii) production goals. We correspondingly present novel techniques to improve the model tractability. Constraints such as precedence, mill and extraction capacities, heat, and diesel emissions are considered. The model produces a consistent schedule while ensuring the safety of the work environment.

■ VMB41

Virtual Room 41

Global Optimization for MINLPs and Its Applications

Sponsored: Computing Society

Sponsored Session

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

1 - Minimum Linearizations For Multilinear Programs

Carlos Jose Nohra Khouri, Visiting Research Scientist, Mitsubishi Electric Research Laboratories, Cambridge, MA, United States, Arvind Raghunathan, David Bergman

Linear Programming (LP) relaxations are widely employed in the global optimization of Multilinear Programs (MLP). The LP relaxation is derived by introducing additional variables that represent bilinear products and including concave and convex envelopes. The size of this relaxation depends on the heuristic used to identify the collection of variables to add. In this talk, we introduce the first approach for identifying the smallest size LP for MLP by investigating a Mixed Integer Program (MIP) model that solves a specialized decision diagram representation where linearizations are encoded as in-trees. Our results on a collection of benchmarks indicate that the MIP can find smaller linearizations (up to 20% reduction in number of variables) than the standard approach, and the quality of the relaxation bounds varies greatly among different minimum size linearizations.

2 - Recent Advances in EAGO.jl: A Feature-Rich Global Solver and Research Platform

Matthew D. Stuber, Assistant Professor, University of Connecticut, Storrs, CT, United States, Matthew E. Wilhelm

We review recent advances in the EAGO.jl deterministic global optimization platform. The capabilities of EAGO's standard optimizer have been improved by the incorporation of several recent advances in constructing reduced-space McCormick relaxations. Additional key new features include the introduction of an extendable modular directed acyclic multigraph backend for nonlinear formulations, direct support for hybrid modeling, and extensions to dynamic formulations, among a myriad of other features. These features allow EAGO.jl to be readily adapted by end-users without compromising performance. We illustrate this using a number of case studies taken from the literature.

3 - Uncertainty Measures And Hierarchical Acquisition Functions For Tree-based Black-Box Optimization

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

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

4 - Verifying Global Optimality Of Candidate Solutions To Polynomial Optimization Problems Using A Determinant Relaxation Hierarchy

Sikun Xu, Columbia University in the City of New York, New York, NY, United States, Ruoyi Ma, Daniel Molzahn, Hassan Hijazi, Cedric Josz

We propose an approach for verifying that a given feasible point for a polynomial optimization problem is globally optimal. The approach relies on the Lasserre hierarchy and the result of Lasserre regarding the importance of the convexity of the feasible set as opposed to that of the individual constraints. By focusing solely on certifying global optimality and relaxing the Lasserre hierarchy using necessary conditions for positive semidefiniteness based on matrix determinants, the proposed method is implementable as a computationally tractable linear program. We demonstrate this method via application to several instances of polynomial optimization, including the optimal power flow problem used to operate electric power systems.

5 - Designing Sustainable Distillation Sequences Using MINLP Techniques

Radhakrishna Tumbalam Gooty, Purdue University, West Lafayette, IN, United States, Rakesh Agrawal, Mohit Tawarmalani

Distillation, a ubiquitous process in chemical industry, is energy intensive. We develop MINLP techniques that, for the first time, use widely accepted vapor flow estimates to rigorously screen distillation configurations. We (i) describe a new formulation to model discrete decisions using multilinears, (ii) adapt the classical Reformulation-Linearization Technique (RLT) for fractional terms, and (iii) derive convex hull results for various special structures. We provide computational evidence to show that our approach significantly outperforms the state-of-the-art algorithms.

■ VMB42

Virtual Room 42

Combinatorial Optimization and Machine Learning

Sponsored: Computing Society

Sponsored Session

Chair: Philipp Baumann, University of Bern, Bern, Switzerland

1 - The Max-Cut Decision Tree: Improving on the Accuracy and Running Time of Decision Trees and Random Forests

Jonathan Bodine, UC Berkeley, United States, Dorit S. Hochbaum

The Max-Cut decision tree involves novel modifications to a standard decision tree implementation, which is a widely used method of classification. It is implemented with the novel Maximum Cut splitting metric, maximally separating observations of different classes along locally meaningful representations of the input features. Experiments show these modifications can dramatically improve classification accuracy, while significantly decreasing computational time. The Max-Cut decision tree is expected to dramatically advance decision trees, with experimental extensions to random forests.

2 - Enhancing The Performance Of Methods That Rely On Pairwise Similarities With Feature Importance

Torpong Nitayanont, University of California-Berkeley, Berkeley, CA, United States, Dorit Hochbaum

Feature importance has been widely studied and applied to many machine learning methods. One of the common approaches to discover the feature importance is done on tree-based models like CART and random forest. We employ feature importance in methods that rely on pairwise similarities by computing distances that are weighted by the importance of the features. We explore several methods to compute the feature importance based on tree models. We then demonstrate how the use of feature importance enhances the performance of models that involve pairwise similarities such as nearest neighbor classifier and Markov random field.

3 - Clustering With Weighted Must-link And Cannot-link Constraints

Philipp Baumann, University of Bern, Bern, Switzerland, Dorit Simona Hochbaum

Constrained clustering is a form of semi-supervised learning where expert knowledge is integrated through the use of constraints. We consider a clustering problem where the expert knowledge is given as weighted must-link and cannot-link constraints. The weights reflect the confidence of the expert in the respective constraints. We propose a variant of the k-means algorithm that uses mixed-binary linear programming to account for such constraint-specific weights. A feature of the proposed algorithm is a model size reduction technique based on kd-trees that considerably reduces running time. The advantages of the proposed algorithm over state-of-the-art algorithms for clustering with must-link and cannot-link constraints are demonstrated in a computational experiment.

■ VMB44

Virtual Room 44

Matching Markets

Sponsored: Auctions and Market Design

Sponsored Session

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

1 - Rank Dominance of Tie-Breaking Rules

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

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

2 - Search Approximates Optimal Matching

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

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

3 - Matching Costs in Centralized And Decentralized Markets

Naomi Utgoff, USNA, Annapolis, MD, United States

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

■ VMB45

Virtual Room 45

Human-Algorithm Interactions in Operations

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Jordan D Tong, University of Wisconsin-Madison, Madison, WI, 53706-1324, United States

1 - Algorithmic Intervention To Mitigate Inventory And Ordering Amplification In Multi-echelon Supply Chains

James Edward Paine, PhD Candidate, Massachusetts Institute of Technology, Cambridge, MA, United States

Bullwhip is a classic, yet persisting, problem with reverberating consequences in inventory management. In this work, the author develops algorithmic approaches to mitigating bullwhip using simulation modeling based on classical behavioral models, and compares the results to those obtained with a dueling network architecture reinforcement learning algorithm. The algorithmic approaches are utilized as one member within a model of a human decision makers operating within a multi-echelon supply chain with imperfect information sharing and information delays. The overall goal of this project is to develop useful, implementable, and (to the degree possible) understandable algorithms capable of mitigating bullwhip generated by real humans when placed into an actively evolving inventory management crisis in-progress.

2 - The Impacts Of Algorithmic Work Assignment On Fairness Perceptions And Productivity: Evidence From Field Experiments

Bing Bai, Washington University-St Louis, St. Louis, MO, United States, Hengchen Dai, Dennis Zhang, Fuqiang Zhang, Haoyuan Hu

The growing concern that algorithms may reproduce or even magnify the inequality historically exhibited by humans calls for research on how people perceive the fairness of algorithmic decisions (vs. human-based decision-making) and consequently, adjust their work motivation. We study how algorithmic (vs. human-based) task assignment processes change workers' fairness perceptions and productivity. In two field experiments with Alibaba where warehouse picking workers received tasks either from an algorithm or a human, the algorithmic assignment process was perceived as fairer and yielded productivity gains, despite that the two processes used the same underlying rule to allocate tasks. We showed via online experiments that people in the U.S. also viewed algorithmic task assignment as fairer, especially among people with a strong equality motive.

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

Park Sinchaisri, Assistant Professor, Haas School of Business, UC Berkeley, Berkeley, CA, 19104, United States,
Hamsa Sridhar Bastani, Osbert Bastani

Workers spend a significant amount of time learning how to make good decisions. Evaluating the efficacy of a given decision, however, is quite complicated as decision outcomes are often long-term and relate to the original decision in complex ways. We propose a novel machine-learning algorithm for extracting "best practices" from trace data and inferring interpretable tips that can help workers improve their performance in sequential decision-making tasks. To validate our approach, we design a virtual kitchen-management game in which participants learn to minimize service time. Our experiments show that the tips generated by our algorithm are effective at improving performance, significantly outperform tips generated by human experts and a baseline algorithm, and successfully help participants build on their own experience to discover additional strategies.

4 - Does Algorithm Aversion Exist In The Field? An Empirical Analysis Of Algorithm Use Determinants In Diabetes Self-management

Wilson Lin, University of Southern California, Arcadia, CA, United States, Jordan D. Tong, Song-Hee Kim

Advancements in algorithms hold promise to better operations by improving users' decision-making. However, humans may exhibit so-called "algorithm aversion," which would be a barrier to achieving such improvements -- though these claims are based primarily on laboratory experiments. Using the decision-support algorithm behavior in over 230,000 bolus insulin dosing decisions from diabetes self-management, we contribute field analysis to identify drivers of algorithm use. We precisely define dynamic algorithm aversion -- an asymmetric usage response to performance feedback that favors humans over algorithms -- as one key hypothesis from the experimental literature. We then reject this hypothesis, instead finding that patients respond to performance feedback asymmetrically, but in favor of the algorithm.

5 - Algorithm Use In The Service Setting

Clare Snyder, University of Michigan, Ann Arbor, MI, United States, Samantha Keppler, Stephen Leider

Computer algorithms can improve human recommendations by providing accurate advice quickly. Prior research shows however that they often do not, because people are reluctant to accept algorithms' suggestions when recommendation quality alone is incentivized. We experimentally study the use of algorithms in a service context where servers have incentives for both recommendation quality and service time. We hypothesize that high time pressure (represented by higher customer arrival rates) will induce subjects to follow the algorithm's recommendation. We find that under higher arrival rates, people are indeed more likely to follow the algorithm's recommendation, especially with experience.

■ VMB46

Virtual Room 46

Leveraging AI in Healthcare

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Tongxin Zhou, University of Washington, Seattle, WA, 98105, United States

1 - Disregarding, Modifying, and Adopting: How Medical Experts Incorporate AI Recommendations Into Patient Care Decisions

Jeffrey Clement, University of Minnesota, Minneapolis, MN, United States, Yuqing Ren, Shawn P. Curley

AI Clinical Decision Support Systems (AI CDSS) can generate personalized recommendations to improve patient care, but it is unclear how healthcare professionals incorporate these recommendations into their care decisions. We employ mixed methods with semi-structured interviews and a pair of computer-based experiments with experienced organ transplant clinicians to examine the factors that influence trust of AI CDSS. Our results indicate that the process of incorporating AI recommendations into clinical decisions is not explained by the theories explaining trust in other recommender systems; notably, providing explanations does not seem to increase trust in the recommendations.

2 - Personalizing Healthcare Intervention Options To Users: A Deep-Learning And Diversity-Enhanced Bandit Approach

Tongxin Zhou, University of Washington, Seattle, WA, 98105, United States, Yingfei Wang, Lu (Lucy) Yan, Yong Tan

In this study, we take a design science perspective to propose a recommendation framework that helps users to select healthcare interventions. Our approach is built on multi-armed bandit (MAB) framework, which is able to balance between exploiting users' past behavior histories and discovering users' diverse and evolving healthcare needs. In addition, two design components are incorporated to improve recommendation performance in the healthcare contexts: a customized deep-learning-based feature engineering procedure, and a diversity promotion constraint. We apply our approach to an online weight management context and evaluate it rigorously through a series of experiments. Our results demonstrate the superiority of our model as compared to a variety of state-of-the-art recommendation systems.

3 - Purchasing Algorithms For Human-machine Collaborative Decision Making: When Machines Will Take Over Or Will They?

Mehmet Eren Ahsen, University of Illinois at Urbana-Champaign, Champaign, IL, 61874, United States

We study the optimal acquisition of AI algorithms for cost-effective service design and propose a collaboration strategy that allocates tasks between human experts (i.e., radiologists) and machines (i.e., AI algorithms). We use data from a recent crowdsourced deep-learning mammography challenge to demonstrate the value of the optimal selection of AI algorithms and our proposed allocation strategy.

4 - Evidence-Based Medicine Through Few-Shot Deep Learning

Rong Liu, Stevens Institute of Technology, Hoboken, NJ, United States, Jingjing Li, Marko Zivkovic

Evidence-Based Medicine (EBM) optimizes clinical decision making through judicious use of the current best scientific evidence. However, EBM's benefits are often hindered by the unscalability of its enabling method - systematic review (SR) - a manual process that collates and consolidates evidence from medical literature. Motivated by humans' impressive capability to learn from limited examples (compositionality), we propose a principled, flexible and generalizable few-shot learning framework - FastSR - to extract heterogeneous medical data elements from full-text articles through very small training data. We instantiate and evaluate FastSR in two SR projects: supporting phase III clinical trials for Wilson disease and extracting risk factors for COVID-19. Our experiments demonstrate FastSR-aided SR reports are comparable to those generated manually.

5 - The Effect Of Using Decision Support Systems In Nursing

Yuankun Luo, Southern University of Science and Technology, Shenzhen, China, Ye Liu, Weiling Ke, Yong Tan

In recent years, decision support systems are widely used in health care services. Most previous research focuses on the effect of DSS on physicians in the choice of treatments. This study investigates how DSS affects nursing in the inpatient setting. Particularly, most previous studies view the effect of DSS as a whole, while we consider the effect of different features of DSS from the perspective of task-technology fit theory. We also consider the heterogeneity of the disease in different departments and how it affects the use of DSS.

■ VMB47

Virtual Room 47

Digital Finance

Sponsored: Finance

Sponsored Session

Chair: Agostino Capponi

1 - Bitcoin Mining And Electricity Consumption

Min Dai, National University of Singapore, Singapore, 119076, Singapore, Steven Kou, Shuaijie Qian, Ling Qin

We propose an economic model for the co-movements of computing hash power and electricity consumption of Bitcoin network. Our model is rich enough to include technology innovation, endogenous miners' options of exit and entry. The model is calibrated to the empirical data of the electricity consumption. Due to the exit option and technology innovation, the model implies that electricity consumption cannot go up indefinitely and will reach a steady state.

2 - Presenter

Tarun Chitra, Gauntlet Networks, Inc., New York, NY, United States

Constant function market makers (CFMMs) such as Uniswap, Balancer, and Curve make up some of the largest decentralized exchanges on Ethereum and other blockchains. These protocols provide computational benefits for automated market makers in compute constrained environments such as blockchains. As the amount of capital and trading volume in these protocols grows past tens of billions of dollars, improving the efficiency of these systems has becomes more important. To describe what efficiency means in this context, we start with the theory of CFMMs and describe how it is closely tied to convex duality. This relationship is then related to classic payoff replications (e.g. Carr-Lee, El Karoui), which can be realized by optimized trading functions. We will describe how payoffs replicated by CFMMs can be designed to optimize capital efficiency and minimize fees.

3 - Presenter

Mohammadreza Bolandnazar, NY, United States

4 - StableFees: A Predictable Fee Market for Cryptocurrencies
Soumya Basu, Cornell University, Ithaca, NY, 14850, United States

Blockchain-based cryptocurrencies must solve the problem of assigning priorities to competing transactions. The most widely used mechanism involves each transaction offering a fee to be paid once the transaction is processed, but this first-price mechanism fails to yield stable equilibria with predictable prices. We propose an alternate fee setting mechanism, StableFees, that is based on second-price auctions. We prove that our proposed protocol is free from manipulation by users and miners as the number of users and miners increases and show empirically that gains from manipulation are small in prac- tice. We show that StableFees reduces the fees paid by users and reduces the variance of fee income to miners. Data from December 2017 shows that, if implemented, StableFees could have saved Bitcoin users $272,528,000 USD in transaction fees while reducing the variance of miner's fee income, on average, by a factor of 7.4. We argue that our fee protocol also has important social welfare and environmental benefits. (joint work with David Easley, Maureen O'Hara, and Emin Sirer)

■ VMB48

Virtual Room 48

Social Media and Digital Commerce

Sponsored: eBusiness

Sponsored Session

Chair: Ying Liu, UMASS-Amherst, Amherst, MA, 01003, United States

1 - The Real Deal: Return Policies Against Review Manipulation
Xiangjing Chen, Arizona State University, Tempe, AZ, 85282, United States, Yi-Jen (Ian) Ho, Shengjun Mao

Review manipulation (RM) is pervasive on online platforms, undermining market fairness and harming social welfare. Though various fake-review-detection technologies have been developed, RM remains rampant due to the lack of economic incentives from a platform's perspective. We, thus, explore the economic incentives via return policies. We craft a game-theoretic model, endogenizing a platform's and sellers' strategies, given heterogeneous consumers in taste. Our results show that a full-refund policy can be a powerful but double-edged sword that either inhibits or enhances RM. We further identify a return-manipulation paradox - the platform prefers the policy that encourages RM. To resolve the paradox, we find that an alternative autonomous scheme could lower overall RM and increase social welfare compared to the platform's dictatorial return scheme.

2 - Building Resilience During Crises: A Big Data Empowered Reinforcement Learning Approach For Airline Insurance
Jingyuan Yang, Assistant Professor, George Mason University, Fairfax, VA, 22030-4422, United States, Jingjing Li, Yuan Qu

The COVID-19 pandemic has led to a devastating impact on the airline industry, resulting in an unprecedented demand plummet and revenue loss. This impact also disturbs the travel insurance industry by reducing purchases (hence the transactional data) and shifting consumer preferences (e.g., COVID coverage). Consequently, traditional insurance recommendation models that rely on extensive training data and an offline (static) modeling framework are no longer resilient during crises. This paper proposes a Big data Empowered Reinforcement Learning (BERL) framework that can effectively learn heterogeneous and dynamic user preferences in a data deficient environment. The resulted recommendation model is evaluated on two major US airlines during the pandemic, demonstrating preliminary results for a data-driven business resilience strategy.

3 - The Effect Of Quarantine On Multiplayer Game Popuations
Zachary Sheffler, University of Massachusetts-Amherst, Amherst, MA, 01003-9310, United States

The COVID-19 pandemic in early 2020 caused a number of abrupt changes in the lives of nearly everyone around the world. One of the chief disruptions was to the ability of people to socialize and otherwise satisfy relatedness needs (Deci and Ryan 2000). While remote work, layoffs, and restrictions on gatherings diminished the ability of people to satisfy their relatedness needs, they could satisfy those needs would be through online games. In this paper, we will investigate evidence of virtual socialization in online video games as a substitute for in-person socialization.

4 - The Impact Of Providing Hospital Quality Scores On Hospital Online Reputation
Lianlian Jiang, University of Houston, Houston, TX, 77056-6448, United States, Jinghui Hou, Xiao Ma

To further improve the usefulness of online reviews for hospitals, it is suggested that reviews could be paired with other more verifiable measures of quality, like patient readmissions or mortality rates. While most of prior research concentrates on establishing the relationship between Yelp-style review ratings and other traditional quality care measures, our research investigates how the disclosure of traditional quality care measure of hospitals on review platforms influence hospital ratings. After reviews for hospital have been collected from an popular review platform, difference-in-differences analysis's results show that hospital quality care disclosure decreased the ratings of hospitals with above average Yelp ratings and above average maternity care scores as one type of traditional indicator of quality care.

■ VMB49

Virtual Room 49

MCDM

Sponsored: Multi Criteria Decision Making

Sponsored Session

Chair: Roman Slowinski, Poznan University of Technology, Poznan, 60-965, Poland

1 - An Integrated Simulation-ml-mcdm Framework To Select The Optimal Ppc Method In A Manufacturing System: A Case Study
Aida Esmaeilidouki, University of British Columbia, Kelowna, BC, Canada, Bryn. J Crawford, Amir Ardestani-Jaafari, Abbas. S. Milani

Nowadays, energy planning has turned into a challenging task in sustainable development due to multiple criteria such as social, economic, and environmental impacts (EI). The present study presents a novel hybrid framework, as integration of simulation, Machine Learning (ML), and Multi-Criteria Decision Making (MCDM) techniques, to optimize costs, time, energy consumption, and EI imposed on manufacturing systems. We investigate the performance of our proposed framework on a real manufacturing system case.

2 - A Multi-Objective Rolling Horizon Personnel Routing And Scheduling Algorithm For Large-Scale Natural Disasters
Istenc Tarhan, Lancaster University, Lancaster, United Kingdom, Konstantinos G. Zografos, Juliana Sutanto, Ahmed Kheiri

We study the disaster response personnel routing and scheduling problem considering different types of emergency response services with precedence relations and optimizing efficiency, fairness and transportation risk objectives, subject to personnel resting requirements and synchronization constraints. A matheuristic algorithm with tabu search is developed and adapted to the multi-objective and multi-period problem environment. The proposed algorithm is tested in the context of evacuation and medical services in 2018 Lombok Earthquake, Indonesia.

3 - Reliability And Risk Evaluation Of Manufacturing Execution System Baesd On FMEA
Jiajie Wang, Tongji University, Shanghai, China, Chunyan Duan, Zhangfan Xia

Failure mode and effects analysis (FMEA) has been widely utilized in reliability and risk evaluation. This paper constructs an improved FMEA model by using LINMAP and VIKOR methods to analyze the reliability and risk evaluation of Manufacturing Execution System (MES). Results indicate the improved FMEA provides a useful and reliable method for reliability and risk evaluation of MES.

■ VMB50

Virtual Room 50

Simulation-I

Sponsored: Simulation Society

Sponsored Session

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

1 - Sample Average Approximation For Shape-Constrained Function Estimation
Dashi I Singham, Naval Postgraduate School, Monterey, CA, 93943-5219, United States, Henry Lam

We develop a method for solving infinite-dimensional simulation optimization problems when the decision variable is a function over the space of the random variable used to model the uncertainty in the formulation. We use sample average approximation to transform the infinite-dimensional problem to a finite-dimensional one. Empirical process theory exists for convergence over function spaces and we make the connection to sample average approximation, which traditionally has focused on finite spaces. Examples include acceptance/rejection and distributionally robust optimization.

2 - Probability Maximization Via Minkowski Functionals: Convex Representations And Tractable Resolution

Uday V Shanbhag, Pennsylvania State University, University Park, PA, 16803, United States, Ibrahim Bardakci, Afrooz Jalilzadeh, Constantino Lagoa

In this paper, we consider the maximization of a probability distribution function over a closed and convex set X, a special case of the chance-constrained optimization problem. We show that in two distinct settings, by leveraging recent findings in the context of non-Gaussian integrals of positively homogenous functions, this function can be expressed a the expectation of a suitably defined integrand with respect to an appropriately defined Gaussian density (or its variant). Aided by a recent observation in convex analysis, we then develop a convex compositional representation of the original problem. We provide a variance-reduced stochastic approximation schemes, amongst the first schemes for computing approximate solutions of such problems in finite time. This is joint work with Ibrahim Bardakci, Afrooz Jalilzadeh, and Constantino Lagoa.

3 - Confidence Sets For Parameters Estimated From Time Series

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

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

■ VMB51

Virtual Room 51

Healthcare and Service Operations Management

Sponsored: Service Science

Sponsored Session

Chair: Seokjun Youn, University of Arizona, Tucson, AZ, 85721-0087, United States

1 - Does Competition Improve Service Quality? The Case Of Nursing Homes Where Public And Private Payers Coexist

Bingxiao Wu, Rutgers University, New Brunswick, NJ, 08854-5452, United States, Susan F. Lu, Konstantinos Serfes, Gerard Wedig

Competition plays an ambiguous role in nursing home markets where public and private payers coexist. Using U.S. nursing home data with a wide range of market structures, we find a U-shaped relationship between competition and service quality when nursing homes serve a mix of public and private segments, and a monotonically increasing relationship when nursing homes mostly serve the public, price-regulated, segment. The outcomes can be explained by the interplay of two opposing effects of competition: the reputation building effect whereby competing firms choose high quality to build a good reputation and the rent extraction effect whereby competition hinders investment for quality improvements by eliminating price premia. These observations are consistent with a repeated game model that incorporates public and private payer segments.

2 - Analysis On Costs And Benefits Of Machine Learning-based Early Hospitalization Prediction

Eunbi Kim, Korea University, Seoul, Korea, Republic of, Kap-su Han, Taesu Cheong, Sung-Woo Lee, Sujin Kim, Joonyup Eun

Overcrowding is often derived from boarding time delays of ED patients to wards. If we predict a patient's hospitalization early enough and accurately in the ED, an inpatient bed for the patient can be prepared in advance. We predict an ED patient's hospitalization and compare the performances between models. Based on the prediction results, we estimate how much time is saved in an ED. We also estimate time costs of beds to be kept as being empty for patients to be hospitalized in wards. According to the analysis, we provide the linkage between prediction performances, costs, and benefits.

3 - Does Information Sharing Enforcement Come To Fruition To The Marketplace?

Seokjun Youn, The University of Arizona, Tucson, AZ, 85721-0087, United States, Yeongin Kim, Kyung Sung Jung, Young Kwark

Online retailers are aggressively expanding own-brand businesses, directly competing with sellers in their marketplaces. Regulators recently unveil plans to oblige the giant retailer to share data with the smaller rivals. Using an analytical modeling framework, we study whether and when such data-sharing enforcement is effective, to help small sellers and alleviate antitrust issues. Surprisingly, sharing enforcement is not always the best decision. We find that the decision hinges on the value of the shared information and how the seller perceives it. A ban on sharing, rather than sharing, should be enforced if the retailer's information is not of high quality and the seller thinks too highly of its value. Our results provide the requisites for the successful intervention of the regulators and conditions for effective data-sharing for the marketplace participants.

■ VMB53

Virtual Room 53

Media and Social Media

Sponsored: Social Media Analytics

Sponsored Session

Chair: Z. Jessie Liu, Johns Hopkins, United States

1 - Digital Platforms and Race-Related Classroom Curriculum: Evidence from Black Lives Matter

Ananya Sen, Carnegie Mellon University, Pittsburgh, PA, United States

We study whether digital platforms can be a force for equality in the context of systemic racism. We use requests made by teachers on DonorsChoose.org as a measure of demand for race-related conversations in the classroom. We use the precise timing of high-profile police brutality events to identify the effect on race-related requests. We find a significant increase in race-related requests with the effect being driven by the killing of George Floyd in 2020. These requests are related to books written by Black authors and those that have Black protagonists. There are significant spillovers related to other minority communities such as Asians and Hispanics. The impact is higher for schools that witnessed a protest in the city. We find no polarization on the platform with requests coming from both Republican and Democratic zip-codes.

2 - Intensified Online Opinion Clashes With Group Bias

Mantian Hu, Chinese University of Hong Kong, Shatin, Hong Kong, Xintong Han

We collect the data from Hong Kong's major news media Facebook pages from 2019 to 2020 to examine the opinion clashes on social media platform. We find that specific writing habits signify users' background and elicit readers' group segregation cues. Compared to Traditional Chinese comments, the increase of pro-police comments in Simplified Chinese induced a more polarized reaction from the opposite side with more anti-police comments and demand for regional independence. Counter-intuitively, contents generated by suspected bots alleviate the clashes. The results demonstrate the need for debiasing intervention and regulation in social media platforms.

3 - Implications Of Revenue Models And Technology For Content Moderation Strategies

Yi Liu, Wharton, Philadelphia, PA, United States

This paper develops a theoretical model to study the economic incentives for a social media platform to moderate user-generated content. We show that a platform can use content moderation as a marketing tool to achieve its positioning as a moderate or extreme content platform. The optimal content moderation strategy differs for platforms with different revenue models, advertising or subscription. We also show that a platform's content moderation strategy depends on its technical sophistication. Because of imperfect technology, a platform may optimally throw away the moderate content more than the extreme content. Furthermore, we show that a platform under advertising does not necessarily benefit from a better technology for content moderation, but one under subscription does. Finally, we draw managerial and policy implications from our insights.

4 - The Production And Consumption Of Social Media

Apostolos Filippas, Fordham University, New York, NY, 10009-5280, United States, John Joseph Horton

We model social media as collections of users producing and consuming content. Users value consuming content, but doing so uses up their scarce attention, and hence they prefer content produced by more able users. Users also value receiving attention, creating the incentive to attract an audience by producing valuable content, but also through attention bartering—users agree to become each others' audience. Attention bartering can profoundly affect the patterns of production and consumption on social media, explains key features of social media behavior and platform decision-making, and yields sharp predictions that are consistent with data we collect from #EconTwitter.

■ VMB54

Virtual Room 54

Community-Based Operations Research

Sponsored: Public Sector OR

Sponsored Session

Chair: EunSu Lee, New Jersey City University, Jersey City, NJ, 07304-4048, United States

1 - Designing A Community-engaged Learning Using Public OR
EunSu Lee, Ph.D., New Jersey City University, Jersey City, NJ, 07311, United States

This presentation discusses the community-engage learning (CEL) using the public OR. The case studies will be presented and introduce a sample syllabus and student project. The key takeaways include how to design CEL utilizing the public OR, lessons learned from the cases, and things to consider. The audience will be able to actively participate in the discussion during the presentation.

2 - Market Response of Amazon Warehouse Operation to North Dakota: Example in Fargo, ND
Mingwei Guo, Ph.D., Valley City State University, Valley City, ND, United States

The development of e-commerce is changing everything, especially in the pandemic. As the biggest city in North Dakota, Fargo has accepted the move of FedEx and UPS hubs to its territory. In 2021, a new addition of Amazon warehouse made its settlement in the city, and how the market and community will respond remains interesting.

As a pioneer research, this analysis will be used as a portion for the new picture of Last-Mile Delivery (LMD) from crowd sources and provide insights on how residents will adapt to the change and operation of the new tech giant.

3 - Presenter
Poyraz Kayabas, Purdue University Fort Wayne, Fort Wayne, IN, 46835-3289, United States

■ VMB55

Virtual Room 55

Analytics for Migration and Resettlement

Sponsored: Public Sector OR

Sponsored Session

Chair: Buket Cilali, The University of Oklahoma, Norman, OK, 73069-5703, United States

1 - Multi-stage Stochastic Programming For Long-term Refugee Resettlement Planning
Buket Cilali, University of Oklahoma, Norman, OK, 73069-5703, United States, Kash Barker, Andres David Gonzalez

Most studies in refugee resettlement assume that capacity/demand within a fixed time interval is given. However, refugee resettlement is not a one-time event. On the contrary, it is an ongoing and long-term process with dynamic parameters. To deal with the current conflict-based resettlement problem, as well as future climate-driven variants of the long-term displacement problem, we take a stochastic approach and adapt the supply change management framework. To this end, we address issues related to the nature of resettlement (e.g., cost of opening new locations to service, penalties/incentives for unmet demand, dynamic capacity/demand management, socio-cultural impact of the resettlement process).

2 - Refugee Migration Networks and Regulations: A Multiclass, Multipath Variational Inequality Framework
Anna B. Nagurney, University of Massachusetts-Amherst, Isenberg School of Management, Amherst, MA, 1003, United States, Patrizia Daniele, Ladimer S. Nagurney

In this paper, we take up the timely topic of the modeling, analysis, and solution of refugee migration networks. We construct a general, multiclass, multipath model, determine the governing equilibrium conditions, and provide alternative variational inequality formulations in path flows and in link flows. We also demonstrate how governmental imposed regulations associated with refugees can be captured via constraints. We provide qualitative properties and then establish, via a supernetwork transformation, that the model(s) are isomorphic to traffic network equilibrium models with fixed demands. Illustrative examples are given, along with numerical examples, inspired by a refugee crisis from Mexico to the United States, which are solved using the Euler method embedded with exact equilibration. The work sets the foundation for the development of additional models and algorithms and also provides insights as to who wins and who loses under certain refugee regulations.

3 - Prescriptive Machine Learning For Public Policy: The Case Of Immigration Enforcement
Mohammad Fazel-Zarandi, Massachusetts Institute of Technology, Cambridge, MA, 02114, United States, Dimitris Bertsimas

Historically, machine learning applications have focused on making predictions by discovering complex patterns in data. In this talk, we demonstrate that successful implementations of data-driven policies entail going beyond machine learning predictions by carefully connecting such predictions to decisions. Specifically, we show that a crucial component of the prediction-decision interaction is accounting for both observed and unobserved factors in the data-generating process. We present a framework that embeds machine learning predictions into a quasi-experimental design to allow for an unbiased evaluation of an algorithm's recommendations. We apply this framework to design a national immigration policy that prevents crime. After accounting for unobserved confounders, we show that our algorithm reduces severe crimes by 26%.

4 - Refugee Resettlement With A Time-evolving Minimum Cost Problem Approach
Deniz Emre, University of Oklahoma, Norman, OK, United States, Buket Cilali, Kash Barker, Andres David Gonzalez

The literature in refugee relocation focuses generally on short-term planning, but such problems are continuous and require long-term planning. Inspired by the long-term nature of the problem, we consider temporal networks, a special case of multi-layered networks in which time is incorporated with layers. With this snapshot representation of time for the resettlement problem such that each layer is a static representation of the network at a different point in time, we create a network of temporal layers. Our aim is to solve a minimum cost flow problem from the first to final layers while synchronously solving a resettlement facility location problem in each layer and managing the temporal opening or expansion of resettlement locations.

5 - Endogenous Network Restoration Under Uncertainty
Seyma Guven-Kocak, Amazon.com Inc., Istanbul, Turkey, Pinar Keskinocak

We study Endogenous Network Restoration under Uncertainty (ENRU), motivated by post-disaster debris clearance problem, where the connections between the nodes are lost due to disrupted edges, and the goal is to restore some of the edges to connect all nodes. The restoration activities are endogenous, depending on previous restorations, and the restoration times are stochastic. We model ENRU as a Partially Observable Markov Decision Process (POMDP) and propose alternative solution methods: Mixed Integer Programming model, Monte Carlo Search Tree (MCST) based heuristic, and a greedy heuristic. We show that the MCST heuristic has high performance and computational efficiency in large instances.

■ VMB56

Virtual Room 56

Emerging Topics in Agricultural Supply Chains

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Somya Singhvi, MIT, Cambridge, MA, 02139-4230, United States

1 - Integrated Optimization of Cultivation and Fertilizer Application: Implications for Farm Management and Food Security
Lusheng Shao, University of Melbourne, Melbourne, 3000, Australia, Onur Boyabatli, Helen Zhou

This paper studies a farmer's joint cultivation and fertilizer (a representative farm-input) application decisions facing uncertainties in both crop margin and farm yield where yield is stochastically increasing in the fertilizer application rate. We develop a stochastic program that captures the trade-offs facing a farmer growing a single crop in a single season to maximize the expected profit. We characterize the optimal decisions and also how these decisions and the resulting expected harvest volume (a measure of food security) are affected by (fertilizer and cultivation) costs and (crop margin and farm yield) uncertainties. We find that the effects of costs and uncertainties can be counterintuitive due to joint optimization; specifically when they induce the farmer to change the cultivation volume and fertilizer application rate in opposite directions.

2 - Yield Improvement Through Smallholder Farmer Certifications: Price And Profit Implications
Utku Serhatli, Nova School of Business and Economics, Lisbon, Portugal, Guillaume Roels

In agricultural-intensive economies, manufacturers often help smallholder farmers improve their yields through training and certification programs. However, and perhaps paradoxically, some farmers feel that these programs can lower their profit, in part due to a decrease in commodity prices. Using a Cournot model, we show that a) certification programs can push prices down, which may indeed decrease profits of some farmers, b) the objectives of minimizing market prices and protecting farmer well-being might be conflicting and c) certifying low-cost farmers performs well in terms of both individual and aggregate farmer well-being.

3 - Does Agent-choice In Last-mile Delivery Of Public Programs Increase Welfare?

Rakesh Allu, Cornell University, Ithaca, NY, United States, Maya Ganesh, Sarang Deo, Sripad K. Devalkar

Last-mile delivery of entitlements in most public programs is executed through agents pre-assigned to beneficiaries. Such pre-defined beneficiary-agent mapping coupled with weak government monitoring may lead to several inefficiencies such as poor service quality and rent extraction. We examine the welfare impact of replacing the agent pre-assignment with unconditional agent-choice. Using a natural experiment across two neighboring states in India's food security program, we estimate a 4.5% increase in average monthly uptake of subsidized rice per household. Further, we find that increase in uptake is higher in regions with large concentrations of temporary workforce and higher density of agents.

4 - Seasonality And The Spatial Configuration Of Palm Oil Processing In West Africa

Casey Maue, Stanford University, Stanford, CA, United States

A distinguishing feature of West African palm oil supply chains is that modern export-oriented industrial palm oil processing mills tend to be surrounded by small-scale informal mills that use rudimentary technology to produce palm oil for local consumption. To understand this phenomenon, we develop a spatial model to evaluate the efficiency of various configurations of different types of processing mills. Returns to scale incent the social planner to develop large and efficient industrial mills. However, when the rate of fruit production is seasonal, high costs of transporting fruit to industrial mills creates a niche for small, low-cost, low-productivity firms to increase the aggregate efficiency of the sector by processing otherwise unused fruit. This result highlights the potential limitations of industrial palm oil development in the African context.

■ VMB58

Virtual Room 58

Electric Fleet Operations

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Zhichen Liu, University of Michigan

1 - Dynamic Crowdsourced Delivery with Rental Electric Vehicles

Zhiwei Zhang, Chongqing University, Chongqing, China, Shu Zhang

We investigate a parcel delivery problem for online retailers, where deliveries are made via rental electric vehicles driven by crowdsourced drivers. We consider uncertainties in the arrival of orders as well as crowdsourced drivers and their availabilities. We model the problem as a Markov decision process and focus on developing approximate dynamic programming schemes to obtain high quality policies

2 - Dynamic Inventory Relocation for a One-way Electric Car Sharing System with Uncertain Demand

Rui Liu, Chongqing University, ChongQing, 400044, China, Shu Zhang, Ping Chen

We investigate a stochastic inventory relocation problem for a one-way electric car sharing system. We present a Markov decision process formulation and develop approximate value iteration algorithm to solve the problem. We have identified conditions under which certain actions can be eliminated to reduce action space. Our algorithm is tested with real-world dataset from GoFun, a car-sharing operator in China.

3 - Dynamic Pickup and Delivery Problem with Shared Electric Vehicles

Yutong Gao, School of Economics and Business Administration, Chongqing University, Chongqing, China, Shu Zhang

We introduce a pickup and delivery problem where an operator dynamically dispatches a fleet of shared electric vehicles to transport passengers and freight. All requests arrive stochastically through time and both passengers and freight might be carried by the same vehicle. We model the problem as a Markov decision process and develop reinforcement learning algorithms to solve the problem.

4 - Reducing Carbon Emissions In Ridesourcing System

Zhichen Liu, University of Michigan, Ann Arbor, MI, United States, Yafeng Yin

This study examines regulatory policy options to electrify a ridesourcing system to reduce carbon emissions per vehicle mile traveled in an effective and cost-efficient manner. In response to a policy, ridesourcing platforms may hire more electric vehicles (EVs) and differentiate EVs in their matching process. This study develops a general modeling framework to capture those responses to analyze the ridesourcing market under an electrification policy. The framework is then used to examine and compare the effects of potential regulatory policies.

5 - Combining Predictive And Prescriptive Techniques For Optimizing Electric Vehicle Fleet Charging

Ehsan Mahyari, PhD Student, The University of Alabama, Tuscaloosa, AL, United States

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

■ VMB59

Virtual Room 59

TSL FRT Virtual

Sponsored: TSL/Freight Transportation

Sponsored Session

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

1 - A Location-Inventory-Routing Model for the Post-Disaster Last-Mile Distribution of Emergency Supplies

Qingyi Wang, Sichuan University, Chengdu, 610064, China, Xiaofeng Nie

We propose a location-inventory-routing model for post-disaster last-mile distribution, which incorporates dynamically locating points of distribution (PODs), allocating emergency supplies from local distribution centers to PODs, and choosing delivery routes. With a case study, we obtain managerial insights and highlight that the flexibility of location, inventory, and routing is vital for improving post-disaster last-mile distribution.

2 - A Policy And Infrastructure Evaluation Model Of Commodity Flows Through Inland Waterway Ports

Sanjeev Bhurtyal, University of Arkansas, Fayetteville, AR, United States, Sarah Vavrik Hernandez, Sandra D. Eksioglu, Manzi Yves

The purpose of the study is to formulate the two-stage stochastic optimization model to determine which inland waterway ports to invest in to provide expanded commodity-specific handling capacity given changes to commodity-specific demand. Calibration and validation of the two-stage optimization model is carried out in Arkansas River. To overcome the computational burden from large size mixed-integer linear programming model, Benders decomposition algorithm is used. The results from the model serve to prioritize inland waterway port infrastructure and equipment capacity expansion investment decisions under scenarios of commodity growth/decline.

3 - Assigning A Commodity Dimension To Vessel Trips Derived From Ais Data On An Inland Waterway Network

Magdalena Asborno, PhD, Applied Research Associates, Inc., Vicksburg, MS, United States, Sarah Vavrik Hernandez

Quantifying commodity flow on inland waterways is important to make investment and planning decisions, but publicly available data does not identify inter-port commodity flows. Automatic Identification System data may disaggregate freight-flows to the port level, but lacks commodity information. Uniquely, this work quantifies and describes by commodity vessel trips mapped to an inland waterway network from publicly available data. The methodology, applied to the Arkansas River, consists of a multi-commodity assignment model solved via optimization. A stochastic scenario approach handles uncertainty in cargo-to-vessel ratios. Aggregated model predictions differ from observations by only 2% by commodity and lock. Applications of this work are: data-driven prioritization of investments, and integration of waterborne freight into multimodal modeling.

4 - Strategic Capacity, Deployment And Mutual-aid Of An Emergency Vehicle Fleet

Yossi Luzon, Afeka Tel Aviv Academic College of Engineering, Tel Aviv, Israel, Opher Baron, Oded Berman, Vedat Verter

This study considers a data-driven Emergency Vehicle Fleet (EVF) model that considers the trade-off between the cost incurred for holding vehicles idle in an emergency fleet and the one incurred when waiting for service. We find the optimal number of vehicles, their deployment, and the collaboration among EVF stations using a queueing model. This model incorporates important performance measures such as response times and capacity. We apply the EVF model to the Toronto fire services' data set.

■ VMB60

Virtual Room 60

Advances in Analytics for Military and Security Applications II

Sponsored: Military and Security

Sponsored Session

Chair: Trevor Bihl, Air Force Research Laboratory, Air Force Research Laboratory, Wheelersburg, OH, 45694, United States

1 - Meta-heuristic Optimization Methods For Quaternion-valued Neural Networks

Jeremiah Bill, Air Force Institute of Technology, Wheelersburg, OH, United States

Real-valued neural networks have demonstrated promising, and often striking, results across a broad range of domains. This has driven a surge of applications utilizing high-dimensional datasets. While many techniques exist to alleviate issues of high dimensionality, they all induce a cost in terms of network size or computational runtime. This work examines the use of quaternions in neural networks. The constructed networks demonstrate the ability of quaternions to encode high-dimensional data in an efficient manner while reducing the number of total trainable network parameters compared to their real-valued equivalents. Finally, this work introduces a novel training algorithm using a meta-heuristic approach that bypasses the need for a quaternion chain rule and analytic quaternion loss or activation functions.

2 - Rightsizing The Design Of A Hybrid Microgrid

Daniel Reich, Naval Postgraduate School, Monterey, CA, 93943, United States, Giovanna Oriti

Selecting the sizes of distributed energy resources is a central planning element when designing a microgrid. We introduce a method for rightsizing capacity that presents a range of potential microgrid design solutions, allowing decision-makers to weigh their upsides and downsides based on a variety of measurable factors. We decouple component-specific modeling assumptions, energy management system logic and objective measurements from our simulation-based nested binary search method for rightsizing to meet power loads. In doing so, we develop a flexible, customizable and extensible approach to microgrid design planning.

3 - Analogical Reasoning: A Comparison Of Algorithms

Kara Combs, Wright State University, Dayton, OH, 45322, United States

A significant limitation of Artificial Intelligence (AI) is the inability of it to learn new information from what it currently knows. Analogical reasoning (AR), whereby learning by analogy is conducted, has been proposed as one method to achieve this end goal. Current AR models have their roots in symbolism, connectionist, or hybrid types indicating how analogies are evaluated. Limited studies compare AR algorithms. This study compares five connectionist and one hybrid AR algorithms are compared on multiple-choice word-based analogy problems.

4 - Artificial Intelligence And Autonomy

Trevor Bihl, Air Force Research Laboratory, Wheelersburg, OH, United States

Autonomous systems are in development with promises to revolutionize everything from cars to commerce to government. To be autonomous, systems must sense and extract meaning from their surroundings, and take actions to achieve their goals. This involves a considerable amount of intelligence and the fields of autonomy and artificial intelligence (AI) are necessarily heavily intertwined. This talk will present a discussion of what is autonomy, what is AI, how they are related, and what the future holds.

■ VMB61

Virtual Room 61

Airline Operations Recovery

Sponsored: Aviation Applications

Sponsored Session

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

1 - Reinforcement Learning In Improving Sequencing For Airline Recovery

Keji Wei, Sabre, Grapevine, TX, 76051, United States, Yichen Yang, Xianfei Jin, Sureshan Karichery

Reinforcement Learning in Improving Sequencing for Airline Recovery Abstract: Airline recovery is always modeled as Time-space network problem and Mixed MILP is widely used to solve it. However, many issues like connection-based turn times and minimum connection ground times make that airline recovery network hard to construct. The time spent on addressing that issue takes a large percentage of total run time. Instead of solving in a traditional way, we propose a

reinforcement learning method by treating that as a combinatorial problem. Particularly, we train the graph attention network and use that to solving the sequencing problem before constructing Time-space network. The experiments results show that our new method can dominate the previous way by a large margin: computational time reduced by 10-80% with equivalent or better solution quality.

2 - Airline Recovery Using Machine Learning And Optimization
Ahmet Esat Hizir, Massachusetts Institute of Technology, Cambridge, MA, 02139-4953, United States, Cynthia Barnhart, Vikrant Vaze

Due to the irregular nature of flight operations, airlines need to take a range of actions to recover their aircraft and crew schedules. The limited time frames prevent airlines from using a full-scale optimization approach. Consequently, airlines usually apply recovery solutions that are far from being optimal. This study proposes a practical method that combines machine learning and optimization to find better solutions for the recovery problems than alternative approaches. The developed procedure is based on the idea that the most effective constraints (cuts) to add to the recovery models without sacrificing the solution quality can be determined in advance by leveraging the similarities between disruptions. Conducted experiments show that this approach can accelerate the optimization significantly while keeping the solution quality close to the optimality.

3 - Presenter
Manuel Fuentes

■ VMB62

Virtual Room 62

Mario Vanhoucke session

Informs Special Session: Scheduling and Project Management

Informs Special Session Session

Chair: Mario Vanhoucke, Ghent University, Ghent, 9000, Belgium

1 - Automated Design of Priority Rules for Resource-Constrained Project Scheduling Problem Via Surrogate Assisted Genetic Programming
Jingyu Luo, Ghent University, Ghent, Belgium, Mario Vanhoucke, Jose Coelho

The training process is the most time-consuming part of the genetic programming (GP) approach. In this research, we propose two types of surrogate models for the resource-constrained project scheduling problem on which the priority rules can be designed via GP with a low training time. The first model approximates the fitness of a rule according to its behavior under a set of situations, while the second model directly simplifies the problem. The performance and efficiency of the proposed models are compared with the standard GP, and the best surrogate model is indicated for future use.

2 - A Comparative Study of Machine Learning Methods to Detect the Best Performing Component for the Resource-constrained Project Scheduling Problem
Weikang Guo, Ghent University, Ghent, Belgium, Mario Vanhoucke, Jose Coelho

The branch-and-bound (B&B) procedure is traditionally used to find the optimal solution for the resource-constrained project scheduling problem (RCPSP). However, project managers often do not know which components of the B&B method should be used for their specific project. This research presents five Machine Learning (ML) methods to classify and detect the best performing component of the B&B method for the RCPSP. The performance of the proposed models is assessed by means of a large and topologically diverse dataset and is benchmarked against any single component.

3 - Metaheuristic Solution Procedures for Multi-project Scheduling: Key Insights and Best Practices
Dries Bredael, Ghent University, Ghent, Belgium, Mario Vanhoucke

Scheduling multiple projects under various goal functions, project deadline settings and diverse problem instance characteristics uncovers valuable insights into the multi-project scheduling problem. By benchmarking a series of existing solution procedures on a novel dataset and a variety of evaluation criteria, effective scheduling practices are demonstrated. The impacts of optimisation criteria, specific problem characteristics and metaheuristic building blocks are examined to develop a general best-performing metaheuristic solution procedure for any type of instance and criterion.

4 - Solution Improvement for Resource-constrained Project Scheduling Problem with Alternative Subgraphs
Rojin Nekoueian, Ghent University, Ghent, Belgium, Mario Vanhoucke, Tom Servranckx

Resource-constrained project scheduling problem with alternative subgraphs (RCPSP-AS) is the problem of selecting one alternative among existing alternatives to execute subsets of activities that are affiliated to work packages. Then, selected activities of each work package should be scheduled considering constrained resources. In this paper, we are going to improve the current benchmark of solution for RCPSP-AS. We employ a Genetic Algorithm associated with local and neighborhood searches for a dataset of problem instances to provide a high-quality solution for RCPSP-AS.

5 - Analytical Analysis of the Impact of Changes in the Mean and Variance of Individual Activities on the Mean and Variance of the Project Completion Time
Forough Vaseghi, Ghent University, Ghent, Belgium, Mario Vanhoucke, Annelies Martens

Due to risk and uncertainty, the project completion time is uncertain, and its distribution stems from the project network structure and the distribution of activity durations. In this study, the behavior of the project distribution is investigated when individual activity duration distributions are changed (e.g., activity crashing) for different network topologies and distributions. Based on this analysis, the project activities can be ranked based on their importance and influence on the project completion time to select the right activities for corrective actions during project execution.

■ VMB63

Virtual Room 63

Recent Advances in Dynamic Treatment Regime/reinforcement Learning/recommender Systems

Sponsored: Data Mining

Sponsored Session

Chair: Zhengling Qi, George Washington University, Arlington, VA, 22202-2850, United States

1 - Query-Argumented Active Learning
Yujia Deng, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Yubai Yuan, Haoda Fu, Annie Qu

In this talk, we propose an active metric learning method for clustering with pairwise constraints. The proposed method actively queries the label of informative instance pairs, while estimating underlying metrics by incorporating unlabeled instance pairs, which leads to a more accurate and e cient clustering process. In particular, we augment the queried constraints by generating more pairwise labels to provide additional information in learning a metric to enhance clustering performance. Furthermore, we increase the robustness of metric learning by updating the learned metric sequentially and penalizing the irrelevant features adaptively. In addition, we propose a novel active query strategy that evaluates the information gain of instance pairs more accurately by incorporating the neighborhood structure.

2 - Does The Markov Decision Process Fit The Data: Testing For The Markov Property In Sequential Decision Making
Chengchun Shi, LSE, London, United Kingdom, Runzhe Wan, Rui Song, Wenbin Lu, Ling Leng

The Markov assumption (MA) is fundamental to the empirical validity of reinforcement learning. In this paper, we propose a novel Forward-Backward Learning procedure to test MA in sequential decision making. The proposed test does not assume any parametric form on the joint distribution of the observed data and plays an important role for identifying the optimal policy in high-order Markov decision processes and partially observable MDPs. We apply our test to both synthetic datasets and a real data example from mobile health studies to illustrate its usefulness.

3 - Data-Driven Compositional Optimization in Misspecified Regimes
Ethan Xingyuan Fang, Pennsylvania State University, University Park, PA, 16802-2112, United States

As systems grow in size, scale, and intricacy, the challenges of misspecification become even more pronounced. In this paper, we focus on parametric misspecification in regimes complicated by risk and nonconvexity. When this misspecification may be resolved via a parallel learning process, we develop data-driven schemes for resolving a broad class of misspecified stochastic compositional optimization problems. Our numerical experiments support the theoretical findings based on the resolution of a three-level compositional risk-averse optimization problem.

4 - Distribution-Free Contextual Dynamic Pricing
Will Wei Sun, Purdue University, West Lafayette, IN, United States, Yiyun Luo, Yufeng Liu

Contextual dynamic pricing aims to set personalized prices based on sequential interactions with customers. At each time, a customer who is interested in purchasing a product comes to the platform. The customer's valuation for the product is a function of contexts, including product and customer features, plus some random market noise. The seller does not observe the customer's true valuation, but instead needs to learn the valuation by leveraging contextual information and historical binary purchase feedbacks. Existing models typically assume full or partial knowledge of the noise distribution. In this talk, I will discuss contextual dynamic pricing with unknown random noise. Our distribution-free pricing policy learns both the contextual function and the market noise simultaneously. A key ingredient of our method is a novel perturbed linear bandit framework.

■ VMB64

Virtual Room 64

Optimization with Noisy Intermediate-Scale Quantum 2

Sponsored: OPT/Global Optimization

Sponsored Session

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

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

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

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

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

3 - Globally Optimizing QAOA Circuit Depth For Constrained Optimization Problems
Rebekah Herrman, United States

In this talk, we will discuss a global variable substitution method that reduces n-variable monomials in combinatorial optimization problems to equivalent instances with monomials in fewer variables. We apply this technique to 3-SAT and analyze the optimal quantum circuit depth needed to solve the reduced problem using the quantum approximate optimization algorithm. For benchmark 3-SAT problems, we find that the upper bound of the circuit depth is smaller when the problem is formulated as a product and uses the substitution method to decompose gates than when the problem is written in the linear formulation, which requires no decomposition.

4 - Quantum Approximate Optimization Algorithm for the 0-1 Knapsack Problem
Ka Wa Yip, Lehigh University, Bethlehem, PA, United States

Recent technological progress has enabled the development of many experimental platforms for quantum information processors (QIPs) and has ushered in the era of Noisy Intermediate-Size Quantum (NISQ) devices. Variational quantum algorithms (VQAs) have been proposed as a classical-quantum hybrid approach to perform computations within the limitations of NISQ devices, whereby a quantum state is prepared on the QIP using a parameterized quantum circuit and measurement outcomes are used to feed a classical optimization algorithm that then updates the parameters of the circuit. The Quantum Approximate Optimization Algorithm (QAOA) is an example of a VQA for finding approximate solutions of combinatorial optimization problems. We derive a QAOA-knapsack algorithm that is easily implemented in gate-based NISQ devices, and introduce some techniques to improve its performance in a noisy environment and NISQ devices.

■ VMB65

Virtual Room 65

Chance Constraints, Theory and Application

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Narges Sereshti, HEC Montreal, Montreal, QC, H3S2V7, Canada

1 - Locating Electric Vehicle Fast-charging Stations Under Uncertain Power Consumption: A Chance-constrained Programming Approach
Céline Gicquel, Université Paris Saclay, Paris, France, Mouna Kchaou-Boujelben

We seek to locate fast-charging stations enabling electric vehicles to carry out long-distance trips in aroad network and consider uncertainties on the power consumption on a road segment. We model this facility location problem using a series of joint chance-constraints, each one limiting the probability of running out of fuel when carrying out a trip. We propose a solution approach based on a partial sample approximation of the stochastic parameters and compare its performance with the one of an approach based on Bonferroni's inequality. Our results show that the proposed solution approach outperforms the Bonferroni approach in terms of solution quality.

2 - Chance-constrained Multi-stage Stochastic Lot Sizing Problem With Substitution
Narges Sereshti, HEC Montreal, Montreal, QC, H3S2V7, Canada, Merve Bodur, Jim R. Luedtke, Raf Jans, Yossiri Adulyasak

We consider the lot sizing problem with stochastic demand and the possibility of product substitution. Considering different production costs, the use of substitution can increase the revenue and customer satisfaction specially when the demand is uncertain. The goal is to minimize the total expected cost while satisfying a predetermined service level. In our model, we consider the service level which limits the probability of stock outs, defined as a chance constraint. We investigate different solution policies for this chance-constrained multi-stage stochastic model and derive some managerial insights for the problem.

3 - A Chance-Constrained Two-Echelon Vehicle Routing Problem With Stochastic Demands
Natasja Sluijk, Eindhoven University of Technology, Eindhoven, Netherlands, Alexandre Florio, Joris Kinable, Nico P. Dellaert, Tom Van Woensel

Two-echelon distribution systems are often considered in city logistics to maintain economies of scale and satisfy the emission zone requirements in the cities. In this work, we formulate the two-echelon vehicle routing problem with stochastic demands as a chance-constrained stochastic optimization problem, where the total demand of the customers in each second-echelon route should fit within the vehicle capacity with high probability. We propose two efficient solution procedures based on column generation. To ensure that the chance constraints are met, we use statistical inference techniques. Additionally, we employ feasibility bounds on the stochastic demands to reduce the number of times we have to verify the chance constraints. The results show the value of the stochastic formulation in terms of improved solution cost and guaranteed feasibility of the routes.

■ VMB66

Virtual Room 66

Mixed-integer Optimization in Defense Applications

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Robert Mark Curry, United States Naval Academy, Annapolis, MD, 21403-4616, United States

1 - Optimizing Brigade Reorganization at the United States Naval Academy
Joseph Carl Foraker, Permanent Military Professor, United States Naval Academy, Annapolis, MD, 21409-5480, United States

The U.S. Naval Academy is the undergraduate college of our country's naval service. There are approximately 4500 Midshipmen at the Naval Academy who are organized into 30 different companies. A decision was made during the spring semester of 2021 to randomly redistribute Midshipmen from the current freshman and sophomore classes. One of the goals of the reorganization was to reduce variability across companies using the following metrics: gender, race, academic and military performance, physical readiness test scores, prior enlisted service, and participation in varsity athletics. We discuss a binary integer programming model developed to assist with this reorganization effort.

2 - Robust Minimum-Cost Flow Problems Under Multiple Ripple Effect Disruptions

Mehdi Ansari, Oklahoma State University, Stillwater, OK, United States, Juan Sebastian Borrero, Leonardo Lozano

We study multi ripple effect disruptions over a network as a defender-attacker optimization problem. The defender acts on an uncertain objective function whose parameters are determined by the attacker who operates multi disruptions on the network. A cutting generation algorithm is presented to find the robust optimal solution of the bilevel programming. The attacker solves a mixed-integer programming on an uncertainty set to identify the worst realization of parameters. In this regard, two different cost functions are proposed and the formulation of the subproblem has been modified to enhance the performance of the method. The algorithm has been tested on generated grid networks and real-world datasets. The results help decision-makers to react immediately after severe disruptions like earthquakes in the populated urban areas.

3 - Integer Programming Models For Optimal Naval Placement In Contested Waters

Robert Mark Curry, United States Naval Academy, Annapolis, MD, 21403-4616, United States

Territorial claims in contested maritime settings have long been disputed. Some actors proceed by claiming previously unoccupied islands and creating massive artificial islands in order to make significant progress in expanding financial and military control over these waters. In order to halt this expansion, we assume a country's naval forces are able to fortify islands either already occupied or currently occupied by an ally force. We explore a variety of methods for determining the valuation of islands in contested waters. We next formulate and solve an integer program to build a tree of islands that maximizes the total value of occupied islands. We then analyze the sensitivity of our solutions to determine their efficacy under varying parameters. Finally, we explore a novel interdiction problem in which the adversary reacts optimally to our naval placement decision.

■ VMB67

Virtual Room 67

Nonlinear Combinatorial Optimization

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Richard Forrester, Dickinson College, Carlisle, PA, 17013, United States

Co-Chair: Lucas Waddell, Bucknell University, Lewisburg, PA, 17837-1846, United States

1 - The Linearization Problem Of A Binary Quadratic Problem Andits Applications

Hao Hu, Ph.D., University of Waterloo, ON, Canada

We provide several applications of the linearization problem of a binary quadratic problem. We propose a new lower bounding strategy, called the linearization-based scheme, that is based on a simple certificate for a quadratic function to be non-negative on the feasible set.Each linearization-based bound requires a set of linearizable matrices as an input. We also present a polynomial-time algorithm for the linearization problem of the quadratic shortest path problem on directed acyclic graphs. Our algorithm gives a complete characterization of the set of linearizable matrices for the quadratic shortest path problem. This is a joint work with Prof. Renata Sotirov.

2 - Fractional 0-1 Programming And Submodularity

Shaoning Han, University of Southern California, Los Angeles, CA, 90089-3606, United States, Andres Gomez, Oleg A. Prokopyev

In this note we study multiple-ratio fractional 0-1 programs, a broad class of NP-hard combinatorial optimization problems. In particular, under some relatively mild assumptions we provide a complete characterization of the conditions, which ensure that a single-ratio function is submodular. Then we illustrate our theoretical results with the assortment optimization and facility location problems, and discuss practical situations that guarantee submodularity in the considered application settings. In such cases, near-optimal solutions for multiple-ratio fractional 0-1 programs can be found via simple greedy algorithms.

3 - Stochastic Power System Resilience Optimization

Nathan Stewart, Sandia National Laboratories, Albuquerque, NM, United States, Matthew Hoffman

In wide-area emergencies, a power system may rapidly experience multiple failures, leading to major dynamics, protective device tripping, and potentially cascading failure. Quasi-static modeling assumptions and/or constraints that preclude abnormal (protection-tripping) system states are prevalent in resilience optimization literature but inappropriate for this hazard class. We propose stochastic resilience optimization with coupled planning and recourse stages explicitly incorporating dynamic physics and protective logic, posing a difficult non-convex MINLP. We discuss progress to date in NLP stochastic preventive-corrective control optimization, and progress towards the full MINLP wide-area emergency resilience optimization problem. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525

4 - A Polyhedral Characterization Of Solvable Cases Of The Quadratic Assignment Problem

Lucas Waddell, Bucknell University, Lewisburg, PA, 17837-1846, United States

The quadratic assignment problem (QAP) is an NP-hard combinatorial optimization problem that has been extensively studied for over 50 years. We examine various readily-solvable special cases and show how they can be explained and unified in terms of the dual region to the continuous relaxation of the level-1 RLT representation. These explanations allow for simplifications and/or generalizations of the conditions defining the special cases.

5 - Advanced Greedy Algorithms For The 0-1 Cubic Multiple And Multidimensional Knapsack Problems

Richard Forrester, Dickinson College, Carlisle, PA, 17013, United States

In this talk we focus on the 0-1 cubic multidimensional knapsack problem and the 0-1 cubic multiple knapsack problem, which are generalizations of the classic linear and quadratic versions of these knapsack problems. Greedy algorithms have been a mainstay of methods for multi-constraint knapsack problems. We investigate variants of greedy algorithms, called advanced greedy algorithms, for tacking these problems. In addition, we consider a graduated-probe strategy and strategic oscillation metaheuristics. Computational tests demonstrate the effectiveness of our techniques.

■ VMB68

Virtual Room 68

Methods And Software For Nonlinear Optimization

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Giampaolo Liuzzi, Sapienza University of Rome

1 - On The Use Of Inexact Restoration In Finite-Sum Minimization

Benedetta Morini, University of Florence, Firenze, 50134, Italy

Finite-sum minimization is a relevant problem in many contexts, such as classification in machine learning and sample average approximation of objective functions formulated as mathematical expectation. We address finite-sum minimization via trust-region methods where the models are of order one and random since subsampled functions and derivatives are employed. The issue of choosing the sample size for approximating functions and gradients is delicate and several strategies have been proposed in the literature. In this talk we discuss a new strategy where the sample sizes change dynamically along the iterations and are adjusted by a deterministic rule inspired by the inexact restoration method for constrained optimization. We provide the complexity analysis of our procedure and its numerical validation on a set of convex and nonconvex classification problems.

2 - Minimization Over The L1-ball Using An Active-set Non-monotone Projected Gradient

Marianna De Santis, Sapienza University of Rome, Roma, 44227, Italy

In this talk, we focus on optimization problems defined over the l1-ball.

We propose an active-set algorithm to handle the presence of sparse solutions efficiently. At each iteration, the method first sets to zero the variables that are guessed to be zero at the final solution. This is done by means of a tailored active-set estimate that aims at identifying the manifold where the stationary points of problem lie. Then, the remaining variables, i.e. those variables estimated to be non-zero at the final solution, are moved along a feasible first-order direction. We show the practical performances of our algorithm on two class of problems frequently arising in data science and machine learning: LASSO and l1-constrained logistic regression problems.

3 - A New Derivative-free Interior Point Method For Constrained Black-box Optimization

Giampaolo Liuzzi, Sapienza University of Rome, Rome, Italy, Andrea Brilli, Stefano Lucidi

Black-box optimization problems are characterized by objective and/or constraint functions that are only known through their input-output behavior. Thus, typically, first order derivatives cannot be used. Frequently in such applications, constraints are hard in the sense that functions cannot be computed (or they could not even be defined) outside of the feasible region. In such situations, it is customary to use an extreme or dead penalty approach in which an extremely high value is assigned to the objective function outside of the feasible region. However, such an approach frequently causes numerical difficulties. In this talk, we approach the problem by means of an interior penalty function. We propose an algorithm and study its theoretical convergence properties. Further, we also present preliminary numerical results which show viability of the proposed method.

4 - A Derivative-free Optimization Approach for Multiobjective Mixed-integer Problems and Application to Emergency Department Management

Tommaso Giovannelli, Lehigh University, Bethlehem, PA, United States, Giampaolo Liuzzi, Stefano Lucidi, Francesco Rinaldi

Multiobjective optimization problems with black-box functions frequently arise in many real-world applications that require the adoption of a Discrete Event Simulation model. Solving these problems is even more challenging when both continuous and integer variables are involved. We first describe a linesearch-based method that guarantees global convergence towards a set of Pareto stationary points. Then, we test the performance of the proposed approach on a simulation-based optimization problem related to the management of low-complexity patients in a large Italian emergency department.

5 - Embedded Nonlinear Programming For Autonomous Systems Using FORCESPRO

Mads Rystok Bisgaard, Embotech AG, Zurich, Switzerland, Alexander Domahidi

Real-time control based on numerical optimization is one of the key technologies used to automate systems today. In this talk we present FORCESPRO, a software tool to easily generate custom optimization solvers for embedded optimal control and MPC applications. We present novel features such as custom ODE integrators and specialized SQP algorithms. These allow users to deploy our solvers on increasingly low-level hardware without losing performance or robustness. We will show benchmark results from embedded applications such as autonomous driving and rocket landing.

■ VMB69

Virtual Room 69

Risk Management for Clean Power Grids

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 - Performance Metrics For Load, Wind And Solar Monte Carlo Scenarios

Rene A. Carmona, Princeton University, Dept of Oper Res & Fin Eng, Princeton, NJ, 8544, United States

Spatial and temporal correlations between renewable generators are important factors in the output statistics of Unit Commitment (UC) and Economic Dispatch (ED). Using old and new statistical forecasts performance metrics, we demonstrate the importance of these correlations in the design and implementation of Monte Carlo simulation methods for day-ahead and intra-day load, and wind and solar generation.

2 - Designing Firm Renewables Structures

Glen Swindle, Scoville Risk Partners LLC, United States

Firm renewables delivery at short time scales is desired by an increasing number of electricity consumers. To date, solutions have been large, bespoke transactions. Here I will describe how short-term high-dimensional simulation methods for large sets of renewables assets being designed as part of the PERFORMS effort, suitably modified, may prove to be useful in designing structures that will bring firm delivery to more end-users.

3 - From Stochastic Weather Data to Probabilistic Energy from Renewable / Intermittent Sources in the Electric Power

Richard D. Tabors, President, Tabors Caramanis Rudkevich, Boston, MA, 02116-3941, United States, Mark Gildersleeve, Aleksandr Rudkevich

Renewable / intermittent technologies such as wind and solar operating at the electric utility scale introduce a high level of uncertainty into the operational planning from days ahead to real time. These technologies are inherently driven by weather. Increased sophistication in weather forecasting that now allows for both high spatial granularity (4km by 4km) and with ensemble models, the development of probability forecast of individual weather variables will allow the power industry to stochastically evaluate the availability of energy from intermittent resources both temporally and spatially. The current paper, undertaken as a portion of the Stochastic Nodal Adequacy Platform (SNAP) under the ARPA-E PERFORM Program discussed in detail the modeling and analytics of "weather to energy."

4 - Using Parallel Computing For Assessing Nodal Resource Adequacy Of A Power Network

Aleksandr Rudkevich, President, Newton Energy Group LLC, Newton, MA, 02116, United States, Evgeniy (John) Goldis, Charles R. Philbrick

Inadequacy is defined as an event within the electrical grid under which the power balance cannot be maintained due to a system-wide shortage of supply or overloading of transmission facilities. Such events could be caused by probabilistic weather-driven factors affecting electricity demand, availability of renewable generation, i.e., wind or solar, random outages of conventional generation and transmission facilities. We use Monte Carlo based simulations and optimal power flow modeling under stochastic scenarios representing those probabilistic factors. Statistical analysis of results are summarized in a set of nodally defined and computed adequacy indices. Computations use the ENELYTIX platform built within AWS and utilize PSO simulation engine. Emphasis is placed on the efficient design of parallel architecture and power flow modeling algorithms.

■ VMB70

Virtual Room 70

Decision Making Under Uncertainty for Large-scale Problems Using ADP/RL

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Amin Asadi, University of Arkansas, Fayetteville, AR, 72701-4033, United States

1 - ADP/RL Methods For Decision Making Under Uncertainty: Applications To Managing Operations In Electric Vehicle And Drone Battery Swap Stations.

Amin Asadi, University of Arkansas, Fayetteville, AR, 72701, United States, Sarah G. Nurre Pinkley, Amin Asadi

We introduce a novel class of stochastic scheduling, allocation, and inventory replenishment problem (SAIRP) to find the best sequential decisions for recharging/discharging and replacing batteries in an Electric Vehicle and drone battery swap station. Our Markov Decision Process model for SAIRPs suffers from the curse of dimensionality. We prove the value function of SAIRPs has a monotone structure, which has a linear relationship with the model's parameters. We use a high-performance monotone approximate dynamic programming with regression-based initialization to solve large-scale SAIRPs.

2 - Spatial Dynamic Pricing For Shared Transport Systems

Ibrahim El Shar, University of Pittsburgh, Pittsburgh, PA, United States, Daniel Jiang

Inspired by the growing popularity of shared transport systems, we study dynamic pricing of a fixed number of rental units to serve price-sensitive customers over a network of locations. One of the main challenges faced by these systems is dealing with imbalanced rental units resulting from spatially imbalanced demand. A dynamic pricing framework offers a natural approach to modulate the demand. We formulate the problem as a finite horizon stochastic dynamic program and analyze the structure of the optimal policy, which allows the use of efficient approximate dynamic programming algorithms.

3 - Risk Bounds And Rademacher Complexity In Batch Reinforcement Learning

Yaqi Duan, Princeton University, Princeton, NJ, United States

We consider batch Reinforcement Learning (RL) with general value function approximation. Our study investigates the minimal assumptions to reliably minimize Bellman error, and characterizes the generalization performance by (local) Rademacher complexities of general function classes. Concretely, we view the Bellman error as a surrogate loss for the optimality gap, and prove: (1) In double sampling regime, the excess risk of Empirical Risk Minimizer (ERM) is bounded by the Rademacher complexity of the function class. (2) In the single sampling regime, sample-efficient risk minimization is not possible without further assumptions, regardless of algorithms. However, with completeness assumptions, the excess risk of FQI and a minimax style algorithm can be again bounded by Rademacher complexities. (3) Fast statistical rates can be achieved by using localization.

4 - Approximate Dynamic Programming For Condition-based Node Deployment In A Wireless Sensor Network

Nicholas T. Boardman, University of Arkansas, Fayetteville, AR, 72703-3280, United States, Kelly Sullivan

Wireless sensor network performance declines over time as a result of sensor failures, frequently attributed to a limited power supply supporting sensor operations. Extending network lifetime is possible by deploying new sensors in the network, and is commonly concerned with a single stage deployment to restore a network coverage or communication measure. We introduce and discuss condition-based deployment policies (CBDPs) in which sensors are deployed over a series of missions, and formulate a Markov decision process model to maintain a reliable WSN with respect to region coverage. Due to the resulting high dimensional state and action space, we explore approximate dynamic

programming methodology in the search for high quality CBDPs. We conclude with a discussion on CBDPs in a range of test instances, and compare the performance to alternative deployment strategies.

■ VMB71

Virtual Room 71

Yards and Terminals

Sponsored: Railway Applications

Sponsored Session

Chair: Roger William Baugher, TrAnalytics, LLC, Johns Creek, GA, 30097-8510, United States

1 - Flat Yard Simulation using AnyLogic

Roger William Baugher, MBA, Northwestern; MSCE, University of Illinois, TrAnalytics, LLC, Duluth, GA, 30097, United States

Choosing the correct sequence for switching cars in a flat yard can be a complex challenge. Such yards may not have dedicated tracks for arriving or building trains, may be switched from both ends, may have multiple switch jobs with conflicting movements, may have the mainline running through the middle and other complicating factors. A simulation of the switching process can provide insight for training, analysis and process improvement. The presentation will demonstrate the simulation of flat switching operations at a terminal railroad using AnyLogic, a software package capable of depicting railroad movements.

2 - Development of Yard Planning Systems

Jeremiah Dirnberger, MSCE, University of Illinois, Wabtec Corporation, Jacksonville, FL, United States

The decisions being made in a typical classification yard include Inbound train-to-track assignment, Block-to-track assignment, Pull-back/Build sequence, etc. For the majority of the industry, these decisions are being made manually using data contained in various inventory management systems. Efforts to automate these decisions with the development of yard planning systems are starting to bear fruit. In this session, we will review the decisions that lend themselves to automation, the potential approaches and other factors that need to be considered in building these advanced planning systems.

3 - Machine Learning Algorithms for Yard Departure Prediction

Niloofar Minbashi, KTH Royal Institute of Technology, Stockholm, Sweden, Markus Bohlin

Increasing the predictability of yard departures impacts on improving the reliability of rail freight services. Yard operations are complex and dependent on human decisions; most of the previous analytics and simulation approaches have not been entirely capable of including these aspects of yard operations to develop models for yard departure prediction. Machine learning techniques can be used to capture implicitly interrelationships between different yard operational parameters to predict yard departures. We intend to evaluate these techniques on yard departure prediction by combining different yard operational data sources comprising wagon connection, punctuality, and train feature data.

4 - Thoughts on Improving Yard Representation in Line Simulation from a Field Perspective

Tim Robinson, Canadian National Railroad, AB, Canada

Line Simulation has been a mainstay in the North American Class 1 Scene since at least the 1970s for studying infrastructure requirements and new service patterns, but what happens in a high growth environment? In this presentation, the author examines some of the underlying assumptions of common railway line simulators, and how those can break down under high traffic regimes, rendering the line simulations invalid. Specifically the author will describe field observations pertaining to terminal capacity, traffic segregation, dynamic prioritization, and hours of service, as well as environmental considerations, obtained from working in a Class 1 railway simulation office, and then as a line and terminal transportation manager (train master) in a sub-arctic, high growth railway environment.

5 - Hump Yard Simulation using AnyLogic

Jiaxi Zhao, University of Illinois at Urbana-Champaign, Urbana, IL, 61801-2350, United States

On North American freight railways, railcars spent majority of their transit time in classification (marshalling) yards waiting for being sorted and classified to their destination. The congestion of one yard could promote mainline train delay and further affect down stream yards and then decrease the railway level of service. However, few research has focused on the interaction of yards and mainline with the impact of vast volume and schedule variability. This study conducted a series of simulation experiments to quantify the interaction of inbound and outbound traffic and schedule variability among yards with a novel AnyLogic hump yard model. A few yard performance metrics are collected to reveal the propagation and transformation of the variability from upstream yards to downstream yards.

■ VMB72

Virtual Room 72

The Emerging Integration of Operations Research, Data, Machine Learning and Artificial Intelligence with Industry

Sponsored: Data Mining

Sponsored Session

Chair: Shouyi Wang, University of Texas at Arlington, Arlington, TX, 76019-1000, United States

1 - Panelist

Eren Yilmaz, Stanley Black & Decker, Harford, CT, United States

2 - Panelist

Matheus Scuta, Ford Motor Company, Detroit, MI, United States

3 - Panelist

Mike Testani, Binghamton University, Binghamton, NY, United States

4 - Panelist

Kahila Mokhtari, IBM, San Diego, CA, United States

5 - Panelist

Jeff Daniels, Lockheed Martin Corporation, Fort Worth, TN, United States

■ VMB73

Virtual Room 73

Decision Analysis Applications I

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Pawan Chowdhary, IBM Research, San Jose, CA, 95120-6001, United States

1 - Multialternative Neural Decision Processes

Fabio Angelo Maccheroni, Universita Bocconi, Milan, Italy, Carlo Baldassi, Simone Cerreia-Vioglio, Massimo Marinacci, Marco Pirazzini, Giuseppe Savare

Based on eye-tracking evidence for fast moving consumer goods, and on the known limitations of short term memory, we introduce an algorithmic decision process for multialternative choice that combines binary comparisons and Markovian exploration. We show that a preferential property, transitivity, makes it tractable and testable.

2 - Ensembles Of Judgmental Forecasts In Dynamic Environments Containing Structural Breaks

Shijith Kumar Payyadakkath Meethale, Assistant Professor, Solbridge International School of Business, Daejeon, Korea, Republic of, Matthias Seifert, Yun Shin Lee

We study the effectiveness of judgmental forecasts in time series environments involving structural breaks. We propose two ensemble methods, to aggregate trimmed individual judgments based on forecasters' empirically elicited or inferred belief that the underlying data series has been subject to structural shift. We test the predictive performance of our models using judgments obtained from two online experiments and by studying analysts' forecasts in real world contexts. Our findings indicate the superior accuracy of our ensemble method using inferred beliefs about shifts as the aggregation criterion, outperforms other aggregation rules including symmetric trimming and simple averages.

3 - Learning Manipulation Through Information Dissemination

Xinyuan Zhang, Sauder School of Business, University of British Columbia, Vancouver, BC, Canada, Jussi Keppo, Michael Jong Kim

We study optimal manipulation of a Bayesian learner through adaptive provisioning of information. The problem is motivated by settings in which a firm can disseminate biased information at a cost, to affect the public's belief about a hidden parameter related to the firm's payoffs. For example, firms advertise to sell products. We study a dynamic optimization model where the firm designs the signals sent to the public, aiming to maximize its profits. We solve the associated DP equations, and characterize the optimal manipulation policy in closed-form. We also extend our analysis to consider the public as partially-Bayesian social learners who use public reviews to resist manipulation.

4 - Extracting The Wisdom Of A Smaller Crowd From Dependent Quantile Judgments

Yuanyuan Lei, Tsinghua University, Beijing, China,
Chen Mavis Wang

When aggregating, experts are likely to have similar professional backgrounds, so that much information is shared by all and only some is uniquely held by specific experts. Here we focus on making predictions about a continuous uncertain quantity by multiple experts. We propose a linear forecasting model in which the predictive quantile function is represented by a Gaussian process. Inspired by matrix factorization in recommendation, we extract the latent information cues and expert weights by decomposing multiple experts' forecasts for various variables. Then we inquire correlations between judgments, and pick a reduced number of experts on weight clustering to represent the wisdom of a crowd.

5 - Demand Driven Workforce Balance

Pawan Chowdhary, IBM Research, San Jose, CA, United States,
Shubhi Asthana, Rodrigo Silva, Taiga Nakamura

Balancing workforce, especially in the support organization, is important to serve the customer request onetime with high quality. This requires understanding the upcoming demand and corresponding ticket fulfillment time to able to recommend the staffing needs. We will discuss in brief time series forecast model and downward propagation of error and other analytics in support of balancing the workforce.

■ VMB74

Virtual Room 74

Advances in Stochastic Dynamic Programming

Sponsored: Decision Analysis Society

Sponsored Session

Chair: David Brown, Duke University, Durham, NC, 27708-9972, United States

1 - Near-optimality For Restless Bandits With Many Arms: Beating The Central Limit Theorem

Xiangyu Zhang, Cornell University, Ithaca, NY, United States,
Peter Frazier

Restless bandit problems play an important role in recommender systems, active learning, and revenue management. In the finite-horizon restless bandit, we study the growth of the optimality gap for practically-computable policies as the number of arms N grows large, where a constant fraction of these arms can be pulled per period. Central Limit Theorem suggests that this should grow like O(sqrt N) for fluid-approximation based policies and previous results justify this. Mysteriously, simulation studies show that, sometimes the optimality gap is O(1). Our work solves this mystery. We characterize a non-degeneracy condition and a wide class of novel practically-computable policies, called fluid-priority policies, in which the optimality gap is O(1). We also show that, when this non-degeneracy condition does not hold, the optimality gap is nevertheless O(sqrt N).

2 - Joint Inventory And Pricing Control For A One-Warehouse Multi-Store Problem With Lost Sales

Sheng Liu, University of Toronto, Toronto, ON, Canada,
Murray Lei, Stefanus Jasin, Andrew Vakhutinsky

We consider a joint inventory and pricing problem in the setting with Poisson demand, one warehouse and multiple stores. We assume that unmet demand is lost, delivery lead time is zero, and there is no transshipment across stores. We propose a heuristic that is asymptotically optimal in the setting with large annual market size. The construction of our heuristic combines four ideas: (1) order-up-to control, (2) dynamic pricing with linear rate adjustment, (3) replenishment batching, and (4) random errors averaging. We also analyze the performance of popular heuristics that directly implement the solution of the deterministic approximation. We show that simple re-optimization of the deterministic problem may yield a poor performance by causing a ``spiraling down" movement in price trajectory, which in turn yields a ``spiraling up" movement in expected lost sales quantity

3 - Dynamic Programs With Shared Resources And Signals: Dynamic Fluid Policies And Asymptotic Optimality

Jingwei Zhang, Duke University, Durham, NC, United States,
David Brown

We consider a sequential decision problem involving shared resources and signals in which a decision maker repeatedly observes some exogenous information (the signal), modeled as a finite-state Markov process, then allocates a limited amount of a shared resource across a set of projects. In this paper, we develop a Lagrangian relaxation and a DP formulation of the corresponding fluid relaxation -- a dynamic fluid relaxation -- that provide upper bounds on the optimal value function as well as a feasible policy. We develop an iterative primal-dual algorithm for solving the dynamic fluid relaxation. Our performance analysis implies, under mild conditions, that the dynamic fluid relaxation bound and feasible dynamic fluid policy are asymptotically optimal as the number of projects grows large. We demonstrate the model and results in two applications.

4 - Sequential Search With Bidding

Cagin Uru, Duke University, Durham, NC, United States,
David Brown

We consider a sequential search problem in which a decision maker sequentially explores and bids on a set of disappearing alternatives with a priori unknown values to obtain the best alternative. This problem can be formulated as a stochastic dynamic program, but it is difficult to solve as the state space is both high-dimensional and continuous. In this paper, we study a relaxation with an infinite number of alternatives and obtain a threshold policy that does not recall any previously explored alternative. Analyzing its performance in the original problem, we not only show that the threshold policy is asymptotically optimal for problems with many alternatives but also characterize the convergence rate. For problems where calculating the threshold is challenging, we propose an approximation scheme based on the discretization of the state space and prove its convergence.

■ VMB75

Virtual Room 75

OR/ML in Practice

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Ignacio Aravena, Lawrence Livermore National Laboratory, Livermore, CA, 94550, United States

1 - Catching Toll Dodgers On German Motorways

Elmar Swarat, Zuse Institute Berlin, Berlin, D-14195, Germany,
Thomas Schlechte

We present an optimization approach on the enforcement of a distance-based truck toll on German motorways. It is partly conducted by spot-checks of mobile control inspectors. In an on-going research and development project with the control authority we are aiming at optimal control tours and crew rosters of the inspectors. The major task is to find a compromise between quality and quantity of controls as well as providing fair roster schedules. Starting from a simple MIP model, we will discuss how we mastered the challenge to bring our tool into production.

2 - A Cloud-based Decision Support System For Optimal Tea Purchasing And Blending

Z. Caner Taskin, Bogazici Universitesi, Istanbul, 34342, Turkey,
Zehra Melis Teksan, Cavide Tekin

We investigate the optimal tea purchasing and blending problem at a global FMCG company. The company purchases tea leaves from various markets around the world and processes them in its global network of blending facilities. Tea leaves have different attributes such as taste, color and scent that vary depending on the producer and the season, and can be purchased at different price levels subject to market conditions. Leaves are mixed in blending facilities in appropriate quantities to achieve desired attributes of tea blend products. We formulate the optimal tea purchasing and blending problem as a multi-objective optimization problem. We also describe our experience in building a cloud-based decision support system based on our optimization model, which is used by the company on a weekly basis.

3 - Optimizing Power System Blackstart Under Uncertain Component Damage

Ignacio Aravena, Lawrence Livermore National Laboratory,
Livermore, CA, 94550, United States

Power systems blackstart after a major outage is often approached as a deterministic problem where the sequence of component energizations that would put the system back to normal can be planned with certainty. In reality, however, operators only have partial information on the damage of components while planning blackstart operations. Actual damage is only revealed after attempting to energize these uncertain components. We study the problem of deciding these energization sequences optimally using stochastic dynamic programming. We propose a stochastic look-ahead policy based on relaxations of the network constraints at each stage, where scenario trees are built using valid bounds for the remaining time to energize uncertain components. We present a benchmark of our policy against confidence bounds for realistic instances, demonstrating its effectiveness.

■ VMB76

Virtual Room 76

Artificial Intelligence II

Contributed Session

Chair: Mohammad Bisheh, Kansas State University, Manhattan, 66506, United States

1 - Transformer Model For Vehicle Trajectory Prediction Of Congested And Heterogeneous Traffic
Yufei Xu, CEE Georgia Tech, 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.

2 - Blood Pressure Prediction Based On Deep Learning With Photoplethysmography And Electrocardiogram Signal Data
Junwon Park, Chungnam National University, Daejeon, Korea, Republic of, Wonkeun Jo, Hogeun Koo, HyungTaik Oh, Kyuhyup Oh, Dongil Kim

Blood pressure (BP) is one of the most important indicators to monitor and predict diseases. However, there needs additional efforts and costs with the conventional BP measurement processes. In this study, we propose a deep learning-based method to predict BP using photoplethysmography (PPG) and electrocardiogram (ECG) data. The PPG and ECG data with their the first and second derivitives were used to train multiple deep learning models. Experimental results including two real-world datasets showed that the proposed method could predict BP accurately: 2~4 of the mean squared error and over 0.9 of the R2.

3 - Practical Tabular Learning And Interpretation For Predictive Approach In Largescale Semiconductor Manufacturing
Seongjin Bang, Kwangwoon University, Seoul, Korea, Republic of, Haeji Ko, Sangmin Lee

This study aims at resolving a real-world planning problem in largescale plants. Currently, the semiconductor chip shortage is prolonged worldwide, so major manufacturers are focusing on increasing productivity. To deal with this with high uncertainties, the predictive approach is necessary to promote the effectiveness and efficiency of production systems. We here propose a practical hybrid approach combining tabular-learning(TabNet) and model-agnostic(SHAP) methods. Experiments show the outperformance of the proposed approach with that of other competitive algorithms.

4 - Image-based Characterization Of Laser Scribing Quality Using Transfer Learning
Mohammad N. Bisheh, Kansas State University, Manhattan, KS, United States, Shing Chang, Xinya Wang, Shuting Lei, Jianfeng Ma

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

■ VMB77

Virtual Room 77

Competition, Collaboration, and Incentives

Informs Special Session: New Product Development

Informs Special Session Session

Chair: Panos Markou, Darden School of Business, Charlottesville, VA, 22903-1760, United States

Co-Chair: Antoine Feylessoufi, University of Cambridge, Cambridge, CB2 3BU, United Kingdom

1 - The Effect Of Routine Communication Within And Across Teams Of Knowledge Workers
Fabian J. Sting, University of Cologne, Köln, 50931, Germany, Matthias Heinz, Johannes Schleef

How does routine communication within and across teams of knowledge workers affect their problem solving quality? Our study is based on a randomized controlled trial at a kitchen manufacturer, that is, in the context of complex, mass customized products. Here, knowledge workers virtually meet and discuss quality improvements with frontline colleagues of their team or with other teams in online quality circles. We measure effects on individual quality performance.

2 - Patent Grant Delays And Future Innovative Activities
Param Pal Singh Chhabra, Georgia Institute of Technology, Atlanta, GA, 30308-1149, United States, Manpreet Singh Hora, Karthik Ramachandran

Patent grant delays have the potential of negatively affecting future patenting activities of inventors. We formulate an inventor's resource allocation model to divide her efforts between innovative and routine activities in multiple periods with belief updating about the probability of patent grant delays in a Bayesian framework. Utilizing patent application data from USPTO, spanning more than four decades, we find support for our hypothesis that patent grant delays negatively affect the inventor's future innovative activities. Additionally, we also evaluate the moderating role of the inventor and industry characteristics.

3 - Did The Millercoors Joint Venture Strengthen The Craft Beer Revolution?
Xabier Barriola, IESE Business School, Barcelona, 8034, Spain, José Azar

In this paper, we study the effect of the MillerCoors joint venture on craft Brewers in the United States. Using a detailed scanner data set, which covers 1,739 grocery stores located in 33 cities, we track the assortment and the market share of craft beers that were offered from 2001 until 2011. After separating the markets into two groups, most affected and least affected by the merger in terms of concentration, and using an augmented synthetic control methodology, we find that the number of craft beers and their market share significantly increased after the event. In particular, assortment increased by 27.5% and revenue shares by 1% in the treatment group, relative to the synthetic control group. This shows that smaller firms were able to enter into highly concentrated markets, and that entry was stronger in the markets that were most affected by the consolidation of large firms.

4 - Spaces For Creativity: On-line Experiments On Creative Problem Solving
Manuel E. Sosa, Professor, INSEAD, Singapore, 138676, Singapore, Sunkee Lee

We report results of our on-line experiments to complement our study investigating how two contrasting physical spaces (visually "quiet" vs. visually "stimulating") influence the two most widely recognized types of creative thinking: convergent and divergent creative thinking. Our findings shed light on the role that creative workspaces may play on fostering creative problem solving in both physical and on-line environments.

■ VMB78

Virtual Room 78

NSF Rapids Related to Covid

Committee Choice: Committee's Choice

Committee Choice Session

Chair: Julie L Swann, North Carolina State University, Raleigh, NC, 27695, United States

1 - Tracking Vaccine Distribution As An Extreme Logistics Operation
Sharika J. Hegde, Northwestern University, Evanston, IL, United States, Hani S. Mahmassani, Karen Smilowitz

Given the unprecedented and fast-moving nature of the Covid-19 vaccine distribution operation, it is imperative to track its development and deployment. We documented the evolution of vaccine distribution in the United States through a real-time dashboard to monitor the state of the Covid 19 vaccine supply chain, including vaccination rates over time and space. Data from this effort allows us to extract lessons learned and principles for the robust design and resilient operation of future extreme logistics deployments, including health-related crises and disaster response situations.

2 - Toward Understanding Vaccine Supply Chain: Distribution And Administration Challenges
Leila Hajibabai, North Carolina State University, Raleigh, NC, 27695-7906, United States, Ali Hajbabaie, Julie L Swann

The rollout of vaccine in the COVID-19 pandemic is one of the largest efforts in public health history. We collect spatiotemporal data on vaccine allocation, shipment and distribution, administration, inventory, and policies in the US. This study performs analyses to explore the (i) number and distribution of vaccine doses and providers with respect to each state's population, (ii) distribution of vaccine doses across states and territories, pharmacies, and other vaccine awardees, (iii) time-variant shipment amount of vaccine doses from manufacturers to providers throughout the study period, (iv) cumulative percentage of vaccine doses for individuals of different age groups over time for a selection of states, (v) vaccination rate of doses by state and by race/ethnicity to individuals of various age groups, and (vi) amount of vaccine wastage revealed at each provider.

3 - Presenter
Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States

■ VMB79

Virtual Room 79

Sustainability Issues in Agriculture

Informs Special Session: Agriculture

Informs Special Session Session

Chair: Deishin Lee, Ivey Business School at Western University, London, ON, N6G 0N1, Canada

1 - Impact Of Increased Drought Intensity In California On Supply Chain Configuration: Broccoli In The United States
Miguel Gomez, Cornell University, Cornell University, Ithaca, NY, 14853, United States, Bingyan Dai

California is the largest producer vegetable products in the US. Recent extreme weather events are likely to shift vegetable cultivation to areas with more available water and less production risks. An important question is: where are viable and optimal supply locations to increase crop acreage if severe drought events increase in key production areas and what are the economic and environmental implications of the land and production reallocation? To do this, we quantify the impact of increased drought intensity in California broccoli output. We than develop a mathematical optimization model of U.S. fresh broccoli to simulate drought intensity increase scenarios and examine supply-chain costs, product flows and food miles.

2 - Research Agenda Setting In Seafood Supply Chain Management: Whats Under The 'c' In Scm
Madeleine E. Pullman, Portland State University, Portland, OR, 97232, United States

There are few areas more neglected in supply chain management research than sustainability issues related to the sea and its ecosystem. This dearth of research is surprising given that more than 80% of the global trade travels by ship, seafood is the most widely traded food item on a global scale, 3 billion people depend on it as their primary source of protein and there are no longer plenty of fish in the sea. In this research, we critically examine the existing sustainability problems and proposed solutions. Our goal is to understand current approaches to improving sustainability in seafood supply chains from more ecology focused theories as well as from a research activism and critical perspective.

3 - Resilience of Fluid Milk Supply Chains: Northeast U.S. and Ontario, Canada
Jury Gualandris, Ivey Business School at Western University, London, ON, 6NG 2H2, Canada, Deishin Lee, Miguel Gomez, Charles Nicholson

What are the key operational and organizational differences between the fluid milk supply chains in Northeast United States and Ontario, Canada? How do these differences affect the ability of the respective supply chains to respond to various types of disruptions? Our study maps these dairy supply chains by triangulating primary and secondary data sources and then simulates their different responses to similar demand and supply shocks during the COVID-19 pandemic. Our study contributes new mechanisms of supply chain resilience and sustainability, with important implications for policy making.

■ VMB80

Virtual Room 80

INFORMS TutORials - Surrogate-Based Simulation Optimization

Tutorial Session

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

1 - Surrogate-Based Simulation Optimization
Xiaowei Zhang, HKU Business School, Hong Kong, Jeff Hong

Simulation models are widely used in practice to facilitate decision-making in a complex, dynamic and stochastic environment. But they are computationally expensive to execute and optimize, due to lack of analytical tractability. Simulation optimization is concerned with developing efficient sampling schemes—subject to a computational budget—to solve such optimization problems. To mitigate the computational burden, surrogates are often constructed using simulation outputs to approximate the response surface of the simulation model. In this tutorial, we provide an up-to-date overview of surrogate-based methods for simulation optimization with continuous decision variables. Typical surrogates, including linear basis function models and Gaussian processes, are introduced. Surrogates can be used either as a local approximation or a global approximation. Depending on the choice, one may develop algorithms that converge to either a local optimum or a global optimum. Representative examples are presented for each category. Recent advances in large-scale computation for Gaussian processes are also discussed.

■ VMB81

Virtual Room 81

Emerging Topics in Food and Grocery Delivery Services

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Qi Luo, Clemson University, Clemson, SC, 29634, United States

Co-Chair: Zhengtian Xu, The George Washington University, Ann Arbor, MI, 48105-2540, United States

1 - The Vertical Spillover Effect Of Online Ratings On Platform Competition: An Empirical Investigation
Yulia Vorotyntseva, Saint Louis University, Saint Louis, MO, 19102-4325, United States, Aleksi Aaltonen, Subodha Kumar, Paul Pavlou

The familiar 'five-star' ratings system makes it easy for consumers to use product evaluations across competing platforms to choose a product or service. The average rating for the same product can vary across platforms for reasons unrelated to quality, including pure randomness. We argue that such diverging evaluations can give rise to a vertical spillover effect, that is, the evaluations of a product represented on a platform may affect the consumer's choice between the platforms. To study this, we conduct a series of experiments in a restaurant food delivery setting. Our results show that consumers indeed tend to choose the platform where their chosen restaurant is rated higher, even when they know they will receive exactly the same service. This may imply that in face of competition a platform may find it disadvantageous to counter vendors' rating inflation.

2 - Dine In Or Take Out? Trends On Restaurant Service Demand Amid The Covid-19 Pandemic
Linxuan Shi, The George Washington University, Washington, DC, United States, Zhengtian Xu

The outbreak of COVID-19 pandemic has caused unprecedented damage to restaurant dine-in services, given the concerns of exposure to coronavirus. In contrast, online food ordering and delivery services, represented by DoorDash, Grubhub, and Uber Eats, filled in the vacancy and achieved explosive growth. The restaurant industry is experiencing a drastic change under the crossfire of these two driving forces. However, due to the lack of first-hand data, we are not fully exposed to the underlying changes, let alone understand the potential impacts and launch targeted policies. To address such a pressing need, this study proposes to leverage the foot-traffic data to effectively keep track of the rapidly evolving demand for restaurant businesses. Data based on 0.8 million cellphone users and 10 thousand restaurants in the DC area is applied for demonstration and analysis.

3 - A Profit-Maximizer Courier Positioning Problem
Elise Miller-Hooks, George Mason University, Fairfax, VA, United States, Hossein Fotouhi, Weiwen Zhou

Couriers must determine a best location at which to preposition themselves while waiting for anext job to maximize their opportunity for future, profitable jobs. This presentation introducesthe Profit-maximizer Courier Positioning Problem. The problem is formulated as a MarkovDecision Problem (MDP) and a machine-learning algorithm using concepts of deepreinforcement learning is applied for its solution.

4 - Drone Dispatch Policy To Fulfill Uncertain Customer Demands In A Delivery Network
Zhenyu Zhou, Wayne State University, Detroit, MI, 48201-1111, United States

We present a dynamic vehicle routing problem encountered in the design of an on-demand meal delivery network. Through subscription contracts each customer has the right to order a meal a day which will be delivered in, e.g., 20 minutes, by a drone. Customer locations are aggregated and represented by demand nodes in the network. In a delivery trip, a drone will start from a depot node, visit the demand node and return to (the same or a different) depot node. Not every demand node is reachable all depots. The drone dispatch is performed periodically, e.g., once every 10 minutes. The time slot in which a customer makes the order is uncertain. We present a stochastic dynamic programming model to maximize the total expected number of demands fulfilled by the end of the day. Reasonable state space reduction schemes will be presented to address the representation and computation challenges.

5 - Modeling The Downtown Parking Of Crowdsourced Deliverers

Xiaotong Sun, The Hong Kong University of Science and Technology (Guangzhou), Guangzhou, 48109-2125, China, Zhengtian Xu

The past year's pandemic has spurred the explosive demand for online food ordering and delivery services, fulfilled by an enlarging group of crowdsourced deliverers. To pick up goods from merchants or drop them off to customers, deliverers have to leave their cars for handover in person. Such a nature of the delivery process results in a stream of deliverers searching and competing for curbside parking due to the lack of dedicated spaces, especially in populated downtown areas. Compared to regular curbside parkers, deliverers park for a significantly shorter time, with the parking durations mainly dictated by the walking distance to/from target locations. In this study, we build up a stylish model to analyze the impacts of crowdsourced delivery services on downtown parking and examine different management means to improve the efficiency of curbside parking utilization.

■ VMB82

Virtual Room 82

Robotized Warehouses

Sponsored: TSL/Facility Logistics

Sponsored Session

Chair: Banu Ekren, Yasar University, Turkey, Dept. of Industrial Engineering

Co-Chair: Tone Lerher, University of Maribor, Honolulu, United States

1 - A Novel Automated Storage And Retrieval System Technology Under Deadlock And Collision Prevention Operating Policies

Melis Kucukyasar, Yasar University, Izmir, Turkey, Boris Jerman, Banu Yetkin Ekren, Tone Lerher

This work studies a novel autonomous vehicle-based storage and retrieval system technology with movable lifts. In the proposed robotic technology, there are aisle-captive lifts that are able to travel along the warehouse aisle to position themselves at the target storage column location to lift up/down automated guided vehicles to store/retrieve loads. In this study, we provide performance analysis for this novel robotic system design working under smart collision and deadlock operating policies.

2 - Robotic Order-picking Automated Vehicle Storage and Retrieval Systems

Tone Lerher, University of Maribor, Celje, Slovenia, Jakob Marolt, Boris Jerman

This study presents a numerical model to calculate the cycle times and throughput performance of robotized Automated Vehicle Storage and Retrieval Systems (AVS/RS). The proposed model considers a robotic order-picking shuttle carrier that performs the picking process using a robotic arm. The proposed model allows calculating the expected cycle time for multiple command cycles, which can be used to evaluate the performance of AVS/RS with robotic order-picking shuttles.

3 - Throughput Analysis Of Automated Vehicle Storage And Retrieval System Following The Depth-first Relocation Strategy With Predefined Zones

Jakob Marolt, University of Maribor, Cejie, Slovenia, Tone Lerher

This paper presents a novel relocation strategy in multiple-deep automated vehicle storage and retrieval systems (AVS/RS). As there are multiple depths in the storage system, a relocation cycle occurs whenever a blocking SKU is in front of the ordered SKU. The new approach selects a suitable empty storage slot from a predefined zone. By varying the size of the predefined zone, different performance characteristics were obtained. The strategy was evaluated by computing the shuttle carrier's dual command cycle with a discrete event simulation. The new approach results were compared with three existing storage and relocation strategies combinations.

■ VMB83

Virtual Room 83

Logistics II

Contributed Session

Chair: Xiaofeng Nie, Texas A&M University, College Station, TX, 77843, United States

1 - A Med Device Network Design Decision Support Model

Tan C Miller, Director and Professor Global Supply Chain Program, Rider University, Lawrenceville, NJ, United States, Renato De Matta, Emmanuel Peters

The medical device industry is one of the largest segments in the field of healthcare. We propose and develop new methodologies utilizing mathematical optimization and simulation models to improve the design of the physical networks, and to make insource vs outsource distribution decisions for medical device manufacturers.

2 - A Decision Making Tool For The Last Mile Delivery Strategy

Raghavan Srinivasan, North Dakota State University, Fargo, ND, United States, Joseph Gerard Szmerekovsky, Satpal Singh Wadhwa

Last mile delivery has experienced growing interest in utilizing the available capacity from logistics services offered by local people of a region, i.e. crowd logistics. The objective here is to provide a decision-making tool, to determine the optimal balance of deliveries by full time employees, part time employees, and crowd sourcing. A newsvendor type solution is derived for a stylized model incorporating seasonal demand, available capacity, and delivery cost to determine the optimal cost of last mile delivery using full time, part time and crowd sourcing logistics. A heuristic approach based on the stylized model is then provided to determine the optimal last-mile delivery strategy.

3 - Vehicle Platooning Problem With Time Varying Traffic Congestion

Jae Seok Choi, Yonsei University, Seoul, Korea, Republic of

The vehicle platooning problem aims to minimize fuel consumption in logistics systems through appropriate planning of vehicles' route and time schedule considering platooning in which vehicles travel in a queue behind each other within close proximity. We develop a mathematical optimization model considering time varying traffic congestion in the vehicle platooning problem. Impact of time varying congestion and some important aspects of the problem are analyzed. A novel path finding based search algorithm is also proposed to solve the problem more efficiently.

4 - Stochastic Fleet Composition With Overflow Shipping Options

Xiaofeng Nie, Texas A&M University, College Station, TX, United States, Yue Wang, Joseph Geunes

We study the fleet composition problem with random and bounded periodic demand that must be fulfilled via a combination of internal truckload (TL) capacity and less-than-truckload (LTL) shipments via an external carrier. Assuming a fixed ownership cost per truck, as well as fixed and variable costs per shipment using internal capacity, in addition to a variable LTL cost, we demonstrate the convexity of the expected cost as a function of the internal fleet size for a given value of standard internal truck capacity. We further explore properties of the optimal internal capacity level.

■ VMB84

Virtual Room 84

Daniel H. Wagner Prize for Excellence in the Practice of Advanced Analytics and Operations Research: II

Award Session

Chair: Margret V Bjarnadottir, University of Maryland, College Park, MD, 20742, United States

1- Increasing Chip Availability Through a New After-Sales Service Supply Concept at ASML

Douniel Lamghari-Idrissi, ASML and Eindhoven University of Technology, Veldhoven, 5507 NW, Netherlands, Rob Basten, Geert-Jan van Houtum

ASML is the market leader in the photolithography sector. A joint project of ASML and Eindhoven University of Technology began in January 2017 to reform ASML's service supply concept driven by the increased focus of its customers on extreme long downtimes. Changes were made to the service measure and the planning approach. They resulted in a new service concept rolled out to ASML's complete installed base worldwide after successful pilots. The new concept resulted in a yearly benefit of 1.5 Billion euros across the semiconductor industry and increased sustainability.

2 - Collaborating with Local and Federal Law Enforcement for Disrupting Sex Trafficking Networks

Nickolas K Freeman, University of Alabama, Tuscaloosa, AL, 35405-9618, United States, Burcu B. Keskin, Gregory J. Bott

In the U.S., 95% of human trafficking cases are associated with sex trafficking, and the majority of these cases were facilitated by the use of the internet, in the form of classified sexual service ads. Collaborating with the West Alabama Human Trafficking Task Force, Department of Homeland Security, and Long Island Police Department, UA researchers developed an analytical tool to surveil multiple websites, differentiate fake and real ads, detect sex trafficking networks, and plan interdiction operations. The tool used in undercover stings and led to identifying victims and several arrests.

Monday, 7:45AM - 8:30AM

■ VMB86-01

Virtual Room 86

Technology Tutorial: Turning Models Into Applications– GAMS Engine and GAMS Transfer

Technology Tutorial

1 - Turning Models Into Applications- GAMS Engine and GAMS Transfer

Steven Dirkse, GAMS Development Corporation, Fairfax, VA, United States, Adam Christensen

The right tools help you deploy your GAMS model and maximize the impact of your decision support application. GAMS Engine is a powerful tool for solving GAMS models, either on-prem or in the cloud. Engine acts as a broker between applications or users with GAMS models to solve and the computational resources used for this task. Central to Engine is a modern REST API that provides an interface to a scalable Kubernetes-based system of services, providing API, database, queue, and a configurable number of GAMS workers. GAMS Transfer is an API (available in Python, Matlab, and soon R) that makes moving data between GAMS and your computational environment fast and easy. By leveraging open source data science tools such as Pandas/Numpy, GAMS Transfer is able to take advantage of a suite of useful (and platform independent) I/O tools to deposit data into GDX or withdraw GDX results to a number of data endpoints (i.e., visualizations, databases, etc.).

Monday, 8:00AM - 8:30AM

■ VM85-3

Virtual Room 85

Technology Showcase: Radical Simplification for the Creation of Optimization Models

Technology Showcase

1 - Radical Simplification for the Creation of Optimization Models

Segev Wasserkrug, IBM Reserach Lab, Haifa, Israel, Dharmashankar Subramanian

We will demonstrate a unique technology being developed by IBM to radically simplify and speed up the creation of optimization models. This is done through a combination of data driven and simplified modeling techniques, thereby also creating end-to-end data to decisions pipelines.When you interact with IBM, this serves as your authorization to INFORMS or its vendor to provide your contact information to IBM in order for IBM to follow up on your interaction. IBM's use of your contact information is governed by the IBM Privacy Policy

■ VMB86-2

Virtual Room 86

Technology Tutorial: This IS IT! Interactive Smart Textbooks for the Modern Program!

Technology Tutorial

1 - This IS IT! Interactive Smart Textbooks for the Modern Program!

Jaret Wilson, MyEducator, Orem, UT, United States, Scotty Pectol

This is modern higher education! An affordable alternative to OER with up-to-date content from world-class author teams. Created by professors for professors, MyEducator smart interactive textbooks and learning resources are ideal for any classroom setting and work within live technology environments so your students don't just learn, they do! Our approach enhances student engagement, improves learning outcomes, instructors receive better teaching evaluations, and students have more fun in the classroom. Each smart learning resource is hosted on our intuitive platform with auto-graded assessments, ample instructor material, robust analytics, all with seamless single sign-on LMS integration, low student cost, lifetime access, and best-in-class service. Full access will be given to any book on our platform to attendees.

Monday, 9:00AM - 9:30AM

■ VM85-4

Virtual Room 85

Technology Showcase: The Application of Simio Scheduling in Industry 4.0

Technology Showcase

1 - The Application of Simio Scheduling in Industry 4.0

Eric Howard, Simio LLC, Sewickley, PA, 15143, United States, Adam Sneath

Simulation has traditionally been applied in system design projects where the basic objective is to evaluate alternatives and predict and improve the long term system performance. In this role, simulation has become a standard business tool with many documented success stories. Beyond these traditional system design applications, simulation can also play a powerful role in scheduling by predicting and improving the short term performance of a system. In the manufacturing context, the major new trend is towards digitally connected factories that introduce a number of unique requirements which traditional simulation tools do not address. Simio has been designed from the ground up with a focus on both traditional applications as well as advanced scheduling, with the basic idea that a single Simio model can serve both purposes. In this paper we will focus on the application of Simio simulation in the Industry 4.0 environment.

Monday, 9:45AM - 10:45AM

■ Plenary 01

CC - Ballroom E /Virtual Theater 5

Plenary: From Learning to Optimize to Learning to Explore

Plenary Session

1 - Plenary: From Learning to Optimize to Learning to Explore

Yoshua Bengio, University of Montreal, Montreal, QC, H3C 3J7, Canada

We consider a discrete combinatorial space and a given objective function where the goal is not to find the maximum of the objective function but rather to discover its main modes, which can be turned into the question of sampling values with probability proportional to the objective function. By taking a power of the objective function, that formulation can smoothly transform the problem of finding the leading modes (with more or less emphasis on the really larger ones) into focussing on just the argmax of the objective. This problem comes up in drug discovery and material discovery tasks, where the objective function is only a proxy (e.g. from a simulator, or imperfect assays) for what we really care about (e.g., more expensive assays, like with mice models, or even clinical trials). Finding a diversity of good solutions is therefore important, because the single argmax solution may not in the end be appropriate. Although MCMC methods can in principle be used for that, we present an alternative approach based on deep generative models seen as policies sampling a sequence of discrete actions and that has the potential to use the power of systematic generalization in order to guess the presence of isolated modes of the objective function. This avoids the mode mixing issue which often comes up with MCMC in high-dimensional spaces where local search methods get stuck and even annealing is not enough, but instead relies on the potential of machine learning to generalize out-of-distribution, a rapidly expanding area of research in deep learning.

Monday, 10:00AM - 10:30AM

■ VMB85-5

Virtual Room 85

Technology Showcase: Turning Models Into Applications– GAMS Engine and GAMS Transfer

Technology Showcase

1 - Turning Models Into Applications- GAMS Engine and GAMS Transfer

Steven Dirkse, GAMS Development Corporation, Fairfax, VA, United States, Adam Christensen

The right tools help you deploy your GAMS model and maximize the impact of your decision support application. GAMS Engine is a powerful tool for solving GAMS models, either on-prem or in the cloud. Engine acts as a broker between applications or users with GAMS models to solve and the computational resources used for this task. Central to Engine is a modern REST API that provides an interface to a scalable Kubernetes-based system of services, providing API, database, queue, and a configurable number of GAMS workers. GAMS Transfer is an API (available in Python, Matlab, and soon R) that makes moving data between GAMS and your computational environment fast and easy. By leveraging open source data science tools such as Pandas/Numpy, GAMS Transfer is able to take advantage of a suite of useful (and platform independent) I/O tools to deposit data into GDX or withdraw GDX results to a number of data endpoints (i.e., visualizations, databases, etc.).

■ VMC01

CC - Ballroom A / Virtual Theater 1

INFORMS TutORial - Good and Bad Optimization Models: Insights from Rockafellians

Tutorial Session

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

1 - Good and Bad Optimization Models: Insights from Rockafellians

Johannes Royset, Naval Postgraduate School, Monterey, CA, 93943-5285, United States

A basic requirement for a mathematical model is often that its solution (output) shouldn't change much if the model's parameters (input) are perturbed. This is important because the exact values of parameters may not be known and one would like to avoid being misled by an output obtained using incorrect values. Thus, it is rarely enough to address an application by formulating a model, solving the resulting optimization problem and presenting the solution as the answer. One would need to confirm that the model is suitable, i.e., "good," and this can, at least in part, be achieved by considering a family of optimization problems constructed by perturbing parameters as quantified by a Rockafellian function. The resulting sensitivity analysis uncovers troubling situations with unstable solutions, which we referred to as "bad" models, and indicates better model formulations. Embedding an actual problem of interest within a family of problems via Rockafellians is also a primary path to optimality conditions as well as computationally attractive, alternative problems, which under ideal circumstances, and when properly tuned, may even furnish the minimum value of the actual problem. The tuning of these alternative problems turns out to be intimately tied to finding multipliers in optimality conditions and thus emerges as a main component of several optimization algorithms. In fact, the tuning amounts to solving certain dual optimization problems. In this tutorial, we'll discuss the opportunities and insights afforded by Rockafellians.

■ VMC02

CC - Ballroom B / Virtual Theater 2

Hybrid - Fair Optimization and Learning under Uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Qing Ye, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Weijun Xie, Virginia Tech, Blacksburg, VA, 24061, United States

1 - A Stochastic Alternating Balance K-means Algorithm For Fair Clustering

Suyun Liu, Lehigh University, Bethlehem, PA, 18015-3749, United States, Luis Nunes Vicente

In the application of data clustering, the clustering outcome might discriminate against people in different demographic groups, leading to unfairness. A natural conflict occurs between the clustering cost and the balance, leading to a nonconvex and nonsmooth biobjective problem. To determine the complete trade-off between the two competing goals, we design a novel stochastic alternating fair k-means (SAfairKM) algorithm consisting of alternating k-means updates and swap updates. Moreover, we propose a novel companion algorithm, the stochastic alternating biobjective gradient descent algorithm, which can handle a smooth version of the biobjective fair k-means problem. A sublinear convergence rate is established under strong convexity for the determination of a stationary point of a weighted-sum function parameterized by the number of updates on each function.

2 - Fair and Interpretable Decision Rules for Binary Classification

Connor Lawless, Cornell University, Ithaca, NY, United States, Oktay Gunluk

In this talk we consider the problem of building Boolean rule sets in disjunctive normal form (DNF), an interpretable model for binary classification, subject to fairness constraints. We formulate the problem as an integer program that maximizes classification accuracy with explicit constraints on two different measures of classification parity: equality of opportunity, and equalized odds. Column generation framework, with a novel formulation, is used to efficiently search over exponentially many possible rules. When combined with faster heuristics, our method can deal with large data-sets. Compared to other fair and interpretable classifiers, our method is able to find rule sets that meet stricter notions of fairness with a modest trade-off in accuracy.

3 - Learning Fair Optimal Classification Trees

Sina Aghaei, University of Southern California, Los Angeles, CA, 90007, United States, Jack Benson, Andres Gomez, Phebe Vayanos

The increased use of machine learning (ML) in high stakes domains has created an urgent need for ML algorithms that are fair and interpretable and that leverage the available data to its full extent to yield the most accurate predictions. In this paper, we propose a versatile framework for learning optimal and fair classification trees based on mixed integer optimization technology. Our framework is flexible to capture arbitrary fairness notions from the literature such as statistical parity, conditional statistical parity, etc. We evaluate our method on numerous datasets from the literature and investigate the trade-off between accuracy and fairness. We provide an R package that is freely distributed for academic and non-profit use.

4 - A Statistical Test For Probabilistic Fairness

Bahar Taskesen, EPFL, Lausanne, Switzerland

Algorithms are now routinely used to make consequential decisions that affect human lives. While algorithms empower us to harness all information hidden in vast amounts of data, they may inadvertently amplify existing biases in the datasets. This concern has sparked increasing interest in fair machine learning. Machine learning models should undergo intensive tests to detect algorithmic biases before being deployed at scale. We use ideas from the optimal transport theory to propose a statistical hypothesis test for detecting unfair classifiers. The test statistic quantifies the distance of the empirical distribution supported on the test samples to the manifold of distributions that render a pre-trained classifier fair. We develop a rigorous hypothesis testing mechanism for assessing the probabilistic fairness of any pre-trained logistic classifier.

5 - Unbiased Subdata Selection For Fair Classification: A Unified Framework And Scalable Algorithms

Qing Ye, Virginia Tech, Blacksburg, VA, United States, Weijun Xie

Fair classification concerns the biases in the classical machine learning models. Due to high nonconvexity of fairness measures, existing methods often approximate fairness measures via convex programs. This paper fills the gap by developing a unified framework to incorporate fairness measures precisely. In the proposed framework, when the classification outcomes are known, the resulting problem, termed unbiased subdata selection, can be used to enhance the classification fairness by selecting more representative data points. This motivates us to develop an iterative refining strategy (IRS) to improve the classification accuracy and conduct the unbiased subdata selection in an alternating fashion. We prove approximation guarantee of IRS and numerically demonstrate that the proposed framework can yield better fair classification outcomes than existing ones.

■ VMC03

CC - Ballroom C / Virtual Theater 3

Hybrid - APS Special Session on 'Causal Inference'

Sponsored: Applied Probability Society

Sponsored Session

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

1 - Tutorial On Causal Inference In Medicine And Public Health
Miguel Hernan, Harvard University, Boston, MA, United States

This session will provide an introduction to causal inference, including the definition of causal effects, key conditions for their identifiability and methods for their estimation. These concepts will be illustrated with several real world applications to study interventions for the treatment and prevention of disease.

■ VMC04

CC - Ballroom D / Virtual Theater 4

Hybrid - Emerging Issues in Supply Chain Finance and Risk Management Practice

Sponsored: MSOM/iForm

Sponsored Session

Chair: Gill Eapen, Decision Options, LLC, Groton, CT, 06340, United States

Co-Chair: Selvaprabu Nadarajah, Information and Decision Sciences, University of Illinois at Chicago, Woodridge, IL, 60517, United States

1 - Emerging Issues in Supply Chain Finance and Risk Management Practice
Gill Eapen, Decision Options, LLC, Groton, CT, 06340, United States

This panel explores emerging topics at the interface of finance, operations, and risk management. The increasing number of shocks (e.g., COVID, weather events) on integrated supply chains has placed a premium on quantifying their impact on physical and financial flows, as well as the need for forward looking design. Thought leaders from academia and industry will discuss this burgeoning theme by considering the interactions between financial and operating risks, the role of risk management, and the value of recent technologies (e.g., blockchains and digital platforms) and practices.

2 - Panelist
Volodymyr O. Babich, Georgetown University, Washington, DC, 20057, United States

3 - Panelist
John R. Birge, University of Chicago, Chicago, IL, 60637-1656, United States

4 - Panelist
Aurelien Ouattara, Amazon Luxenburg, Luxenburg, Germany

5 - Panelist
Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA, 15213-3815, United States

■ VMC05

CC - Ballroom E / Virtual Theater 5

Hybrid - TSL Award II

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137-5246, United States

Monday, 11am-12:30pm

■ VMC01

Virtual Room 01

Advances in Customers Behavior Analytics and Modeling

Sponsored: Data Mining

Sponsored Session

Chair: Yichen Ding, University of Iowa, Iowa City, IA, 52246-2872, United States

1 - Understanding Road Users' Behavior from Egocentric Video Data
Yichen Ding, University of Iowa, Iowa City, IA, 52246-2872, United States

Based on road users' trip record data, we use deep learning methods to model and forecast their responses to the various traffic conditions and reactions in the complex road environment. Furthermore, we provide some case studies to generate insights on how to keep these road users safe and bring inspiration to facilitate the behavioral studies.

2 - From Favorited to Fear: An Empirical Investigation of Customer Emotions and Behavior of Online Customers After Data Breaches
John N. Angelis, University of Maine, Orono, ME, 24504, United States, Rajendran Murthy, Tanya Beaulieu, Joseph Miller

Previous empirical papers on data theft crimes often ask respondents to imagine that a well-known company has been hacked and then measures their response. We improved this design by first having respondents pick a favorite free or paid website and then presenting them with a data breach scenario involving their account or the entire site. Using automated textual analysis, we discover that only fear has a significant effect on breached customer behavior, and the customers who most likely to express positive sentiment pre-breach do not significantly differ in their post-breach behavior.

3 - Behavioral Analysis Of Consumer Return Policy Decisions
Han Oh, Mays Business School, Texas A&M University, College Station, TX, United States, Huseyn Abdulla, Rogelio Oliva

We investigate consumer return policies recognized and studied by operations management scholars as an important managerial decision in a retail environment. Our research investigates, through randomized experiments, the behavioral aspects of return policy decisions and their interaction with other operational decisions.

4 - Variety Seeking In High Frequency Consumption: New Implications For Targeted Marketing
Fan Zhang, UC Berkeley, Haas School of Business, Berkeley, CA, United States, Carol Lu

In this project we study consumers' variety seeking behavior on a food ordering platform and explore the benefits of using purchase history data for targeted marketing from a new angle. We find that consumers have heterogeneous tastes for variety which provides rich room for targeted marketing. We find that consumers seek variety in high frequency consumption. Holding price, ranking positions and match values fixed, consumers are willing to pay 5.45 CNY (0.8 USD) more for switching to a different seller, which is about 15% of the average payment per order. Our findings have important implications on targeted marketing, including targeted ranking and targeted pricing.

■ VMC02

Virtual Room 02

Data Analytics in Service Operations

Sponsored: Data Mining

Sponsored Session

Chair: Shuai Hao, University of Illinois at Urbana-Champaign, Champaign, IL, United States

1 - Learning From Driving Behaviors: A Deep Learning Approach For Predicting Retail Visits And The Privacy Tradeoffs Of Tracking Consumers
Unnati Narang, University of Illinois at Urbana Champaign, Urbana, IL, 77840, United States, Fernando Luco

U.S. drivers record 3.2 trillion miles driven each year. Granular information about their movement is constantly tracked by apps on their smartphones. This information can be useful for retailers to interact with consumers real-time. However, collecting these granular data also leads to privacy concerns. Thus, such tracking introduces a trade-off between the value of the data and privacy

concerns for firms. Furthermore, modeling spatio-temporal driving data is challenging because they are computationally intensive and high dimensional. We propose a deep learning algorithm that combines a convolutional neural network (CNN) and long short-term memory model (LSTM) using individual driving trajectories in order to predict retail visits and quantify value-privacy trade-offs. Our research can guide privacy policies of firms given the current regulatory environment.

2 - Lower-Tier Products: Friends or Foes? The Impact of Carpool on Ride-hailing Platforms

Tingting Nian, University of California, New York, NY, 10012, United States, Vidyanand Choudhary, Jinan Lin, Rambo Tan, Cheng Gong

The introduction of a new product to existing product lines typically gives rise to two opposing effects to the firm - market expansion and cannibalization. In this study, we seek to understand and evaluate the causal impacts of introducing carpool rides on both riders' and drivers' welfare. In doing so, we use a unique dataset with fine-grained trip-level information provided by a leading ride-hailing platform, and exploit a natural experiment of the introduction of carpool rides. We are among the first studies investigating how new product introduction affects their ecosystems and revenues.

3 - An Empirical Analysis of Sequential Diagnostic Decisions for Bike Returns

Hailong Cui, University of Minnesota, Minneapolis, MN, 55455-0438, United States, Guangwen Kong, Sampath Rajagopalan

We study diagnostic decisions for bike maintenance in which a judge and a worker sequentially decide whether to replace or repair a part of a bike. We examine the impact of decisions on repair or replacement of parts on bike return and find factors that impact repair or replacement choice

4 - Establishing The Link Between Overtreatment And Bad Debt In The Healthcare System

Shi Qiu, University of Illinois Urbana-Champaign, Urbana, IL, 61801-1024, United States, Yuqian Xu, Michael Freeman

Unnecessary health care, also known as overuse or overtreatment, is increasingly being recognized as a cause of patient harm and excess costs. However, it has not been studied whether overtreatment effect could contribute to patients' increasing bad debt. This paper aims to examine the relationship between overtreatment and bad debt, and the underlying moderators.

■ VMC03

Virtual Room 03

Big Data Applications in Global Operations and Management

Sponsored: Data Mining

Sponsored Session

Chair: Xiaojin Liu, Virginia Commonwealth University, Trier, VA, United States

Co-Chair: Pankaj Kumar, Virginia Polytechnic Institute and State University, Virginia Polytechnic Institute and State Universit, Blacksburg, United States

1 - Social Learning In Prosumption: Evidence From A Randomized Field Experiment

Ravi Bapna, University of Minnesota, Minneapolis, MN, 55410-1846, United States

In this study, we ask whether and how social learning, the act of showing creations made by other customers to the focal customer, can ameliorate frictions in co-creation. In close collaboration with an e-commerce platform specialized in customized photo products, we examine the effectiveness of social learning by means of a large-scale in-vivo randomized field experiment. We exogenously vary both the availability of others' design and the characteristics of images shown to the treated users. We develop a novel 'honest-bagging' approach guided by principles of causal forests to personalize the high-dimensional treatment around which images to show to what types of users.

2 - Topological Data Analysis And Organizational Research

Russell Funk, University of Minnesota, North Oaks, MN, 55127, United States

The growing availability of large scale, high-dimensional digital data creates tremendous opportunities for advancing scholarship on organizations, but not without analytical challenges. To date, organizational scholars have chiefly approached the analysis of "big data" using dimension reduction techniques from machine learning and related fields. In this talk, I will introduce an alternative approach to the analysis of large scale, high-dimensional data, discussing the value emerging techniques from the field of topological data analysis. These tools are particularly useful for their ability to provide rich, qualitative descriptions of high-dimensional data. Examples of how topological data analysis can shed new light on the study of innovation are discussed.

3 - Employee Performance and Communication in a Hybrid Remote Workplace: Evidence from a Field Experiment

Prithwiraj Choudhury, Harvard Business School, Boston, MA, 02163, United States

We report evidence from an intrafirm field experiment on hybrid-remote work conducted in 2020. Following a government mandated four-month lockdown due to COVID-19, we randomized the list of workers allowed back in office on any given day. We exploit this allocation protocol and use data on emails exchanged among employees in the pre-lockdown, lockdown and post-lockdown (i.e. treatment) periods to study intra-firm communication. Our results suggest that email communication is a complement of physical colocation, rather than a substitute. By applying topic modeling to the content of employees' email communication, we also demonstrate that discussion topics differ with colocation.

4 - AI and Big Data Analytics for Customer Services and Employee Coaching

Xueming Luo, Temple University, Philadelphia, PA, 19122-6105, United States

In this presentation, I will focus on integrating artificial intelligence, big data machine learning, and field experiments to model, explain, and optimize customer behaviors and company strategies. I leverage text/audio/image/video/Links big data and cutting-edge AIML algorithms to research business decisions on marketing, customer service, sales support, dynamic product offerings, online advertising, brand equity management, new product discovery, customer experience, employee coaching, worker skills training and HR support, employee emotions, transformational leadership, executive personality, and top management team synergy creation. These AIML algorithms range from deep neural nets of RNN CNN and LSTM, natural language processing BERT Transformer, textmining, graph neural nets, to reinforcement learning dynamic optimization.

■ VMC04

Virtual Room 04

Data Driven Modeling for Urban Shared Mobility

Sponsored: Data Mining

Sponsored Session

Chair: Xiaodong Qian, University of California-Davis, Davis, CA, 95616-3752, United States

1 - Modelling Mode Choice And Substitution Patterns Between Shared Micro-mobility, Public Transport And Private Modes.

Daniel J. Reck, ETH Zürich, Zürich, Switzerland, Henry Martin, Kay W. Axhausen

Shared micromobility services (e-scooters, e-bikes) rapidly expand worldwide. Yet, we do not comprehensively understand which transport modes they replace and why - two topics fundamental to effective transport planning. Here, we estimate a first comprehensive choice model using 3 months of GPS tracks of ~550 travellers. We find that shared e-scooters/e-bikes tend to replace more sustainable modes while personal e-scooters/e-bikes replace the car more often, overall reducing CO2 emissions. Trip distance and access distance are the most important variables to understand travellers' choices.

2 - A Macroscopic Model Of Dockless Bike Sharing Systems

Hongyu Zheng, Northwestern University, Evanston, IL, United States, Kenan Zhang, Yu (Marco) Nie

This paper studies the design of a dockless bike sharing (DBS) system in a city using a parsimonious spatial model, in which the DBS service competes with walking and a generic motorized mode. Travelers choose one of the three modes according to their utility, which may depend on trip duration, access time and monetary cost. We show the access time to DBS is determined by the number of unique bike locations in the city, which is a function of the bike fleet size. The model defines a supply-demand equilibrium that may be controlled by choosing the service price and the fleet size of the DBS system. We calibrate the model against empirical data collected in Chengdu, China, and test three counterfactual strategies: (i) profit maximization; (ii) market share maximization with non-negative profit; and (iii) social optimum.

3 - Laws Of Accessibility, Bike-sharing Station Distribution, And Equity In Cities

Zhiwei Chen, University of South Florida, 5182 Sunridge Palms Dr, Tampa, FL, 33617-1428, United States, Xiaopeng Li

Bike-sharing is a promising approach to improve transportation equity by offering affordable mobility solutions to underserved communities. Yet, it is an open question of how accessibility, bike-sharing station distribution, and urban form interplay with one another to achieve equity. This study collects data for multiple US cities to empirically investigate this interplay. Results will inform bike-sharing system planners of how to distribute bike-sharing stations within cities to improve accessibility equitably for all.

■ VMC05

Virtual Room 05

Causal Inference Analysis for Information Retrieval

Sponsored: Data Mining

Sponsored Session

Chair: Da Xu, United States

1 - Towards Robust Off-policy Learning for Runtime Uncertainty

Yuting Ye, SUSTech, Shenzhen, China

Off-policy learning plays a pivotal role in optimizing and evaluating policies prior to the online deployment. However, during the real-time serving, we observe varieties of inter- ventions and constraints that cause inconsistency between the online and offline setting, which we summarize and term as runtime uncertainty. Such uncertainty cannot be learned from the logged data due to its abnormality and rareness nature. To assert a certain level of robustness, we perturb the off-policy estimators along an adversarial direction in view of the run- time uncertainty. It allows the resulting estimators to be robust not only to observed but also unexpected runtime uncertainties. Leveraging this idea, we bring runtime-uncertainty robustness to three methods, the inverse propensity score method, the reward-model method, and the doubly robust method. We theoretically justify the robustness of our methods to runtime uncertainty, and demonstrate their effectiveness using both the simulation and the real-world online experiments.

2 - Ranking Grocery Items with Quality Constraints using Counterfactual Modelling

Chuanwei Ruan, Instacart, Santa Clara, CA, United States

Observational data with transparent intervention mechanism is usually impractical for real-world applications. However, there exists abundant feedback data from unknown interventions - any recommendation made by the system potentially changes the environment for users' decision making. It is therefore a timely topic to understand if and how the black-box interventions can assist causal discoveries and drive more effective recommendations.

3 - Using Auction Throttling to Measure the Effect of Online Advertising

Fengshi Niu, UC Berkeley, Berkeley, CA, United States

Causally identifying the effect of digital advertising is challenging, because experimentation is expensive, and observational data lacks random variation. This paper identifies a pervasive source of naturally occurring, quasi-experimental variation in user-level ad-exposure in digital advertising campaigns. It shows how this variation can be utilized by ad-publishers to identify the causal effect of advertising campaigns.

4 - Towards the Modern Experiment Framework Design for E-commerce

Zenan Wang, JD.Com, Berkeley, CA, United States

The classical experiment framework expects analysis to be done after expected sample size is reached. However, peeking at the result is prevalent among practitioners running the online experiment. This talk will discuss some possibilities to address issues for continuous monitoring. First, what proper adjustment is needed to prevent type I error inflation. Second, how to deal with delayed responses.

■ VMC06

Virtual Room 06

Analytics and Machine Learning Solutions for Financial Sector

Sponsored: Data Mining

Sponsored Session

Chair: Meisam Soltani-koopa, Queen's University, Toronto, ON, M4P 1K4, Canada

1 - Capital Structure Optimization

Amir Emami Gohari, Kingston, ON, Canada, Mikahil Nediak

One of the most crucial concepts in a corporation's financial decisions is the question of Capital Structure. What capital structure suits a company best?What is the rationale behind the decisions of companies in determining their capital structure?Although this question has been around for decades and has led to valuable insights in the form of theories such as M&M and Pecking Order, up to this day there has not been a ubiquitous answer that justifies companies' behavior in practice.In this work, we try to take a novel approach to an old question via more practical definitions, modeling and techniques.

2 - Using Reinforcement Learning To Maximize Customer Profitability And CLV At Financial Institutions

Meisam Soltani-koopa, PhD Candidate, Queen's University, Kingston, ON, M4P 1K4, Canada, Hootan Kamran, Mikhail Nediak, Anton Ovchinnikov

Customer Lifetime Value, CLV, is a popular measure to understand the future profitability of customers to allocate resources in more efficient ways to keep the company alive during difficult economic situations. We use machine learning tools to predict the expected revenue from each customer during one year of his/her relationship with the institution as the CLV of the customer. The approach is implemented on two datasets from two international financial institutions. Different feature engineering techniques were applied to improve the prediction power of the model. We used two stage or three stage prediction models. In the second phase, we train a reinforcement learning algorithm based on the history of marketing activities and the CLV as the state of customers to determine the optimum marketing action for customers in each state to maximize their profitability.

3 - Acquisition.ai: Customer Acquisition Optimization Powered By Data And Ai

Anis Sharafoddini, PhD, Deloitte, Toronto, ON, Canada

Marketing practitioners in the financial services industry are using diverse models to help their institutes achieve objectives of acquiring new customers. However, these traditional models have been disrupted and rapid changes in the market due to the Covid-19 pandemic have proven a need for dynamic models. With the increased adoption of digital channels by customers, more data is becoming available. Financial intuitions are now more interested in leveraging this abundant data to make more informed decisions. Acquisition AI is a Deloitte tool that uses trusted third-party data to enrich the data financial institutes already have on customers. This data is then being processed by an AI algorithm to target new customers, identify growth areas and optimize growth campaigns. Acquisition.AI has a proven track record of success in the market.

■ VMC07

Virtual Room 07

Statistical Learning for Decision Analytics in Complex Systems

Sponsored: Data Mining

Sponsored Session

Chair: Victoria C. P. Chen, The University of Texas at Arlington, Arlington, TX, 76019-0017, United States

1 - Optimizing The Performance Of Analytical Chemistry Instrumentation

Srividya Sekar, The University of Texas at Arlington, Arlington, TX, 76012, United States, Jay M. Rosenberger, Victoria C.P. Chen, Kevin A. Schug, Shouyi Wang, Chen Kan

Optimal parameter settings play an important role in the efficiency of analytical chemistry instrumentation. The research focusses on developing a surrogate optimization methodology that globally optimizes the surrogate to obtain parameter settings for a run of the instrument. It uses a Multivariate Adaptive Regression Splines (MARS) metamodel and a Mixed Integer Quadratically Constrained Program (MIQCP) for the optimization. The algorithm will provide knowledge about the system, reduce the sample preparation time and the trial-and-error runs needed to achieve the optimal and efficient extraction of the analysis.

2 - Machine Learning Framework Fornonlinear And Interaction Relationships Involving Categorical And Numerical Features

Shirish Rao, University of Texas-Arlington, Arlington, TX, 76019, United States, Victoria C. P. Chen, Jay Michael Rosenberger, Shouyi Wang, Atefe Makhmalbaf

Certain applications like sustainability assessment in green building have a mix of categorical and numerical features. The relation between response and features in these applications can be highly nonlinear in behavior. Moreover, interactions between features impact sustainability metrics, and addressing interaction modeling for this mix of feature types is another challenge. While some of these challenges have been addressed individually in the literature, there is no methodology which handles these complexities simultaneously. We propose a method combining multivariate adaptive regression splines with group LASSO to screen relevant features and model terms. Using experimental design, we uncover causal understanding and show that models fitted with our methodology have improved prediction capability

3 - Lasso Based State Transition Modeling With Interactions In Adaptive Interdisciplinary Pain Management

Amith Viswanatha, University of Texas-Arlington, Arlington, TX, 76013, United States, Victoria C. P. Chen, Jay Michael Rosenberger

The McDermott Center for Pain Management at The University of Texas (UT) Southwestern Medical Center at Dallas provides a two-stage interdisciplinary pain management program, where a holistic, integrated approach is employed in treating patients with chronic pain to improve their pain outcomes. Patient data from the McDermott Center includes state variables related to the patient's past and current health, treatment history, and current treatments. It is important to identify the true underlying features and the interactions between the state and treatment variables for building state transition and outcome models that are employed within a two-stage stochastic programming-based treatment optimization. In this study, we evaluate different LASSO based interaction modelling approaches on a simulated case study in identifying the true features and interactions.

4 - Online Quality Assurance Of Additively Manufactured Honeycomb Structures

Yujing Yang, University of Texas-Arlington, Arlington, TX, United States, Zehao Ye, Xin Liu, Chen Kan

Despite the rapid maturation of additive manufacturing (AM), geometric imperfections often exist in AM products. As a result, mechanical properties of the printed part will be affected, especially those with complex structures, like honeycomb. In this study, a new representation learning scheme is developed for online quality assurance of honeycomb structures. With a structured-light scanner, a representative boundary profile of honeycomb cells will be obtained, which is further characterized using the recurrence plot. Moreover, an unsupervised deep learning model is leveraged to project recurrence plots onto a latent space, where the distance between feature vectors preserves the similarity of recurrence plots. Finally, a control chart is constructed for layer-wise monitoring and detection of significant geometric imperfections.

■ VMC08

Virtual Room 08

Data Analytics In Semiconductor Manufacturing

Sponsored: Data Mining

Sponsored Session

Chair: Kim Dohyun, Korea, Republic of

1 - A Framework For Process Parameter Optimization Based On Deep Generative Model

YoungGeun Ahn, Myongji University, Yongin-si, Korea, Republic of, Dohyun (Norman) Kim, Minyoung Park

There are many process parameters that affect the process yield in the semiconductor process, and it is very important to find an optimized value of parameters to maximize the process yield. However, complex nonlinear correlations between parameters make their optimization difficult. Therefore, in this study, we propose a framework for optimizing the process parameters that maximize the process yield using deep generative model.

2 - Deep Learning-based Clustering Algorithm Considering Outliers

Somi Ha, Myong-ji Univ., Gyeonggi-do, Korea, Republic of, Sungwoo Kim, Dohyun (Norman) Kim

Most clustering algorithms perform clustering without considering outliers. However, when performing clustering, outliers often degrade performance. Therefore, in this study, a clustering algorithm that simultaneously performs clustering and outlier detection has been proposed. The proposed deep learning-based algorithm identifies outliers using the predicted class distribution and performs clustering based on only normal data.

3 - Analysis Of Tabular Data Based On Graph Neural Network

Seungyeon Lee, Myongji University, Yongin-si, Korea, Republic of, Minyoung Park, Dohyun (Norman) Kim

In many applications in the industry, tabular data are the most commonly used data type. Machine learning methods for dealing with tabular data are classified into two categories: similarity-based approach and feature-based approach. Feature-based models are easy to understand and intuitive to use and deploy but generally cannot utilize the relationships between observations. Similarity-based models are most suited for exploiting the relationships among observations, but their availability is usually limited. In order to take advantage of both aspects of tabular data, we propose an algorithm to combine feature-based and similarity-based approaches using graph neural network. Experimental results show that the proposed method provides more precise results for classification tasks, implying that it may improve the generalization capability.

4 - Unsupervised Representation Learning Based On Triplet Loss For Wafer Map Pattern Analysis

Hyungu Kang, Sungkyunkwan University, Suwon, Korea, Republic of, Seokho Kang

Analyzing the defect patterns of wafer maps(WMs) is crucial for investigating the root causes in the semiconductor fabrication process. Manually annotating thousands of WMs with their defect patterns is laborious and time-consuming. Thus, we present an unsupervised method for analyzing WM patterns. We note that the rotation of a WM generally preserves its pattern. Discriminative representations of unlabeled WM patterns are learned using a triplet loss function which minimizes the distance between a WM and its rotation, while maximizes the distance between two different WMs. We demonstrated the effectiveness of the proposed method through visualization of the learned representations.

■ VMC09

Virtual Room 09

2021 Pierskalla Award Session - INFORMS HAS

Sponsored: Health Applications Society

Sponsored Session

Chair: Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

Co-Chair: Agni Orfanoudaki, Massachusetts Institute of Technology, Cambridge, MA, 02142-1339, United States

1 - Toward a Liquid Biopsy: Greedy Approximation Algorithms for Active Sequential Hypothesis Testing

Kyra Gan, Carnegie Mellon University, Pittsburgh, PA, 15205, United States, Su Jia, Andrew Li, Sridhar Tayur

This paper addresses a set of active learning problems that occur in the development of liquid biopsies via the lens of active sequential hypothesis testing (ASHT). In the problem of ASHT, a learner seeks to identify the true hypothesis from among a known set of hypotheses. The learner is given a set of actions and knows the random distribution of the outcome of any action under any true hypothesis. Given a target error $\delta>0$, the goal is to sequentially select the fewest number of actions so as to identify the true hypothesis with probability at least $1 - \delta$. Motivated by applications in which the number of hypotheses or actions is massive (e.g., genomics-based cancer detection),we propose efficient (greedy, in fact) algorithms and provide the first approximation guarantees for ASHT, under two types of adaptivity. Both of our guarantees are independent of the number of actions and logarithmic in the number of hypotheses. We numerically evaluate the performance of our algorithms using both synthetic and real-world DNA mutation data, demonstrating that our algorithms outperform previously proposed heuristic policies by large margins.

2 - Novel Pooling Strategies for Genetic Testing, with Application to Newborn Screening

Hussein El Hajj, University of Waterloo, Waterloo, ON, 24061-1019, Canada, Ebru Bish, Douglas Bish, Denise Kay

Cystic fibrosis (CF) is one the most prevalent genetic disorders in newborn screening. For cost-effectiveness, CF screening starts with a biomarker test, followed by a more expensive and accurate genetic test or mutational panel (MP) for newborns with elevated biomarker levels. To overcome the cost barriers to expanded genetic testing, we explore a pooled approach for MP testing. This leads to a novel pooling problem that involves selection of mutational variants for screening, potential partition of the selected variants into multiple panels, and selection of pool size for each panel. We establish key structural properties of optimal pooled MP designs; develop an exact algorithm that generates a family of optimal pooled MP designs, along with their corresponding budgets; and characterize the conditions under which a one-panel versus a multi-panel design is optimal.

3 - An Inverse Optimization Approach to Measuring Clinical Pathway Concordance

Nasrin Yousefi, University of Toronto, Toronto, ON, M4Y1R5, Canada, Timothy Chan, Yusuf Shalaby, Maria Eberg, Katharina Forster, Claire Halloway, Luciano Ieraci

Clinical pathways outline standardized processes in the delivery of care for a specific disease. Clinical pathway concordance (CPC) refers to the degree of alignment between the actual care patients receive and the ideal care described in a clinical pathway. Measuring CPC is essential in monitoring variations in the healthcare system, identifying bottlenecks, and providing data-driven evidence to inform health policy decisions. We develop a general methodology for measuring CPC based on inverse optimization, apply our novel concordance metric to a real dataset of colon cancer patients, and show that it has a statistically significant association with survival.

4 - Improving Tuberculosis Treatment Adherence Support: The Case for Targeted Behavioral Interventions

Justin J. Boutilier, University of Wisconsin-Madison, Madison, WI, 53706-1603, United States, Jonas Oddur Jonasson, Erez J. Yoeli

: Tuberculosis (TB) is a global health priority and lack of patient adherence to treatment protocols is a main barrier to reducing the global disease burden of tuberculosis. In this talk, we will study the operational design of a treatment adherence support (TAS) platform that requires patients to verify their treatment adherence on a daily basis. To do this, we partner with a TB TAS provider in Kenya and use data from a completed randomized controlled trial. Our analysis establishes that patient engagement can be increased by personal sponsor outreach and that patient behavior data can be used to identify at-risk patients for targeted outreach.

5 - Deploying a Reinforcement Learning System for COVID-19 Testing at the Greek Border

Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States, Kimon Drakopoulos, Vishal Gupta, Jon Vlachogiannis, Christos Hadjicristodoulou, Pagona Lagiou, Gkikas Magiorkinis, Dimitrios Paraskevis, Sotirios Tsiodras

Throughout the COVID-19 pandemic, countries relied on a variety of ad-hoc border control protocols to allow for non-essential travel while safeguarding public health: from quarantining all travelers to restricting entry from select nations based on population-level epidemiological metrics such as cases, deaths or testing positivity rates. Here we report the design and performance of a reinforcement learning system, nicknamed "Eva." In the summer of 2020, Eva was deployed across all Greek borders to limit the influx of asymptomatic travelers infected with SARS-CoV-2, and to inform border policies through real-time estimates of COVID-19 prevalence. In contrast to country-wide protocols, Eva allocated Greece's limited testing resources based upon incoming travelers' demographic information and testing results from previous travelers. By comparing Eva's performance against modeled counterfactual scenarios, we show that Eva identified 1.85 times as many asymptomatic, infected travelers as random surveillance testing, with up to 2-4 times as many during peak travel, and 1.25-1.45 times as many asymptomatic, infected travelers as testing policies that only utilize epidemiological metrics. We demonstrate that this latter benefit arises, at least partially, because population-level epidemiological metrics had limited predictive value for the actual prevalence of SARS-CoV-2 among asymptomatic travelers and exhibited strong country-specific idiosyncrasies in the summer of 2020. Our results raise serious concerns on the effectiveness of country- agnostic internationally proposed border control policies that are based on population-level epidemiological metrics. Instead, our work represents a successful example of the potential of reinforcement learning and real-time data for safeguarding public health.

■ VMC10

Virtual Room 10

Machine Learning for Health Systems Engineering

Sponsored: Health Applications Society

Sponsored Session

Chair: Anil Aswani, UC Berkeley, Berkeley, CA, 94720-1731, United States

1 - Local Water Inventory Management For The Developing World

Yoon Lee, UC Berkeley, Berkeley, CA, 94720, United States, Yonatan Mintz, Anil Aswani, Zuo-Jun Max Shen, Cong Yang

Cities in the developing world often lack water distribution networks that provide clean water throughout the day. This leads to water being stored for long durations, thereby exposing people to substantially increased bacterial and viral contamination. We consider the stochastic optimization problem of deciding how much water to store each day in the system, as well as determining when to completely empty the tank, in order to trade off: the financial costs of the water, the health costs implicit in long durations of storing the same water, the potential for a shortfall in the quantity of stored versus demanded water, and water wastage when emptying the system. Our results present sufficient conditions that ensure the optimal policy has an easily interpretable four-threshold structure that generalizes the (s, S) policy for classical inventory management problems.

2 - Regret Analysis For Adaptive Model Predictive Control

Ilgin Dogan, Ph.D. Candidate, University of California, Berkeley, CA, 94707-2017, United States, Zuo-Jun Max Shen, Anil Aswani

The exploration/exploitation trade-off is an inherent challenge in data-driven and adaptive control. Though this trade-off has been studied for multi-armed bandits, reinforcement learning for finite Markov chains and linear control systems; it is less well-studied for adaptive control of nonlinear systems. A significant challenge in nonlinear setting is that there is no explicit characterization of an optimal policy for a given set of parameters. We propose a new regret notion with respect to a finite-horizon oracle controller with full knowledge of parameters and develop a new class of learning-based policies in the context of adaptive model predictive control. We conduct statistical analyses to prove finite sample concentration bounds for the estimation step, and then we perform theoretical analyses to show the closed-loop stability and low regret of our policy.

3 - A Pilot Study Using Machine Learning To Predict Treatment Outcomes In Patients With Neovascular Age-related Macular Degeneration Using Phase 2 Trial Data

Yusuke Kikuchi, University of California-Berkeley, Berkeley, CA, 94709-1181, United States, Michael G. Kawczynski, Neha Anegondi, Jian Dai, Carlos Quezada Ruiz

In this study, we developed machine learning models to predict treatment outcomes in patients with nAMD using baseline (BL) characteristics and optical coherence tomography (OCT) data from patients treated with faricimab in the phase 2 AVENUE trial.185 faricimab-treated eyes were included. Age, gender, best-corrected visual acuity (BCVA), central subfield thickness (CST), low-luminance visual acuity, and OCT images on study day 1, together with treatment assignment, were included in the model. Regression and binary classification models were developed to predict BCVA at month 9 and CST reduction of >35% at month 9, respectively. Symbolic models (linear model and extreme gradient boost tree) were trained on BL characteristics, and deep neural networks were trained on OCT images. Image data and BL characteristics were merged using and a model averaging approach.

■ VMC11

Virtual Room 11

Stochastic Modeling and Analytics in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: Hossein Piri, University of British Columbia-Sauder School of Business, Vancouver, BC, V6B 1X9, Canada

1 - Individualized Dynamic Patient Monitoring Under Alarm Fatigue

Woonghee Tim Huh, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada, Hossein Piri, Steven Shechter, Hudson Darren

Hospitals are rife with alarms, leading to alarm fatigue. We develop a partially observable Markov decision process (POMDP) model for recommending dynamic, patient-specific alarms in which we incorporate the undesirable cry-wolf feedback-loop of repeated false alarms. Our model takes into account patient heterogeneity in safety limits and learns a patient's safety limit by performing Bayesian updates during a patient's hospital stay. We find that the optimal alarm policy may not be monotone with respect to the patient's vital sign measurement nor with respect to the count of prior false positive alarms. However, we show that the optimal policy does have a threshold structure with respect to the belief about the patient's safety limit. As a case study, we simulate patient monitoring in an intensive care unit (ICU) using clinical data.

2 - Derivers Of The Physician's Referral Networks

Saeede Eftekhari, Tulane University, New Orleans, LA, 14260-4000, United States

Referrals from primary care physicians to specialists are an integral part of the healthcare system. Thi study aims at exploring the factors that impact primary care physician's referral network and studying whether the participation of the specialists in Health Information Exchanges (HIEs) platform impact the formation of referral networks among physicians. We apply Exponential Random Graph Modeling (ERGM) to analyze the referrals from primary care physicians to specialists using the observational referral data. The study contributes to the literature of the referrals by revealing the factors that impact the formation of the referral network and has important managerial implications for the HIEs platforms.

3 - Optimal Decentralization Of Innovative Diagnostic Technologies For Pediatric HIV In Resource-limited Settings

Melike Yildirim, Harvard Medical School, Boston, MA, 30332, United States

HIV and AIDS are major public health issues in Zimbabwe. In 2019, 5,200 new HIV infections occurred among children. Early HIV diagnosis and prompt initiation of antiretroviral treatment (ART) can dramatically reduce infant mortality; therefore, it is essential to optimize the use of scarce resources. We used an integer programming-based optimization model to identify the optimal locations for point-of-care (POC) early infant diagnoses (EID) machines at healthcare facilities in Matabeleland South, with the goal of maximizing the proportion of infants with HIV who initiate ART. We first identified the optimal placement of the 12 currently available POC EID machines and next identified the optimal placement of increasing numbers of additional POC devices. Preliminary input parameters (used for model development) were derived from routine program data.

4 - Investigating The Effect Of Communication Between Patients And Physicians In Online Consultations

Ye Liu, University of Washington, Seattle, WA, United States, Weiling Ke, Yuankun Luo, Yong Tan

After the pandemic of covid-19, online consultation becomes a popular choice for patients because of convenience. Previous research shows the result of how online consultations affect patients' future offline consultations. However, the involvement of physicians in online consultations is largely neglected. We argue that any decision of a patient should be derived from a shared decision-making process between the patient and the physician. Therefore, we investigate the effect of the communication between patients and physicians during online consultations on the patients' future decisions of care-seeking and treatment. We also investigate how physicians make treatment in reaction to their 'perceived' communication.

5 - Estimating Heterogeneous Treatment Effects With Modern Mixed Integer Programming Formulations

Zilong Wang, Georgia Institute of Technology, Atlanta, GA, United States, Zhaowei She, Turgay Ayer, Shihao Yang

The recent data driven approach paradigm at identifying and solving problems has reignited interest amongst policy makers, businesses, and physicians in shifting away from a "one-size-fits-all" mentality to a more tailored approach. Estimating heterogeneous treatment effects (HTEs) is thus of great import in many fields such as personalized medicine, marketing, and policy evaluation. State of the art techniques, are either based on highly restrictive classifiers or too complex to interpret. In this paper, we unify and generalize these approaches under a Generalized Method of Moments (GMM) estimation framework, and formulate it as a Mixed Integer Program (MIP). This estimation framework presents a "best-of-both-worlds" approach which simultaneously achieves interpretability and flexibility in classification problems based on treatment effect heterogeneity.

■ VMC12

Virtual Room 12

Improving Patient Outcomes Through Technology and Standardization

Sponsored: Health Applications Society

Sponsored Session

Chair: Seungyup Lee, Vanderbilt University Medical Center

Co-Chair: Vikram Tiwari, Vanderbilt University Medical Center, Nashville, TN, 37221-4346, United States

1 - Healthcare Technology Sourcing Management And Technical Debt

Vikram Tiwari, Vanderbilt University Medical Center, Nashville, TN, 37221-4346, United States, Seung-Yup Lee, Sriram Narayanan

We study how hospitals' previous decisions and investments in healthcare information technology (IT) infrastructure and work processes generate a legacy of technical debt (i.e., cumulative buildup of technical obligations/costs), and impact performance. We analyze a large national hospital-level IT dataset to provide insights into implications of IT integration pathway and the resultant IT platform ecosystem on performance outcomes.

2 - Service Chains' Operational Strategies: Standardization Or Customization?

Lu Kong, University of South Florida, Sarasota, FL, United States, Kejia Hu, Rohit Verma

In this research, we investigate within a customer-recognizable service chain, how standardization and customization across chain-belonging units impact that chain's performance outcomes. We study this question in the nursing home industry. Using rich archival data, we study the Degree of Standardization (DoS) in three operational dimensions: customer mix, service offering, and service delivery, and its impact on three nursing home outcomes: financial outcome, clinical outcome, and resident welfare. We also discuss the implication of our results during a public crisis such as the COVID-19.

3 - Patient-Centered Assortment Planning and Stocking of Implantable Medical Devices

Renato E. de Matta, University of Iowa, Iowa City, IA, United States

As hospital revenues have been constrained and Medicare reimbursements have decreased, hospitals are looking to find cost savings in their implantable medical device (or IMD) purchases. In this study, we find the IMD assortment that maximizes the total revenue that is realized when a hospital considers the expressed IMD preferences of surgeons in consultation with patients, and orders the right amounts of those IMDs at minimum cost. We formulate the problem as a stochastic programming model. Preliminary computational results and managerial insights are presented.

■ VMC13

Virtual Room 13

Health Care III

Contributed Session

Chair: Hao Jiang, Dallas, TX, 75206, United States

1 - Hospital-physician Integration And Cardiac Surgery Outcomes: A U-shaped Relationship?

Hui Jia, University of Tennessee-Knoxville, Knoxville, TN, United States

We utilize patient-visit level information for Florida patients hospitalized for coronary artery bypass graft (CABG) to test hypotheses that posit a U-shaped association between integration and care outcomes such as patient length of stay (LOS), in-hospital mortality risk, and readmission risk. This study defines the level of integration between a hospital and its cardiovascular surgeons as the fraction of surgeons who operate only at that hospital. Our econometric analysis indicates that patient LOS and mortality risk are minimized at integration tipping points of 51% and 45%, respectively.

2 - The Impact Of Healthcare Delivery Complexity On Quality Improvement Practices: A Case Of Improving Healthcare Workers' Hand Hygiene Compliance

Wenlin Chen, University of Electronic Science and Technology of China, Chengdu, China, Chung-Li Tseng

Many practices have been implemented to improve clinical quality, measured as the extent to which healthcare workers (HCWs) comply with standardized procedures to deal with patient issues. However, their effectiveness varied a lot due to the complexity of healthcare delivery, such as different patient conditions, healthcare tasks, and HCWs' reactions to the practices. We conducted a discrete choice experiment (DCE) in the setting of HCWs' hand hygiene compliance to provide ex-ante insights about how to design practices to improve clinical quality with the consideration of the complexity.

3 - An Analysis Of Health Insurers' Strategy For New And Existing Plans In Texas

Hao Jiang, Southern Methodist University, Dallas, TX, United States, Aurelie Thiele

We perform benefit and rate analysis for Marketplace Health Insurance in Texas, whose 254 counties are grouped into 26 rating areas. We focus on the existing and new standard on-Exchange insurance plans that are provided to non-tobacco users over 21 years old from 2016 to 2021. We analyze the interaction between benefit and rate, and existing and new plans in each rating areas in Texas in recent six years, varying levels including Gold, Silver, Bronze, Expanded Bronze, and Catastrophic. We study insurers' strategy regarding new and existing plans, and analyze the effect on consumers.

■ VMC15

Virtual Room 15

Revenue Management with Customer Choice

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Venus Lo, City University of Hong Kong, Kowloon Tong, Hong Kong

Co-Chair: Mika Sumida, Cornell Tech, Cornell Tech, New York, NY, 10128-5805, United States

1 - Omnichannel Assortment Optimization With Two-stage Decisions

Venus Lo, City University of Hong Kong, Kowloon Tong, Hong Kong

Suppose an omnichannel retailer offers a full assortment in his online store and a subset assortment in his physical store. Customers visit the two stores over two stages. In the first stage, customers visit the physical store and request their favourite product. If available, then they purchase the product and leave. Otherwise, they examine the products in the physical store and visit the online store in the second stage. Customers adjust their preferences for the online products based on similarities with the in-store products and make a decision according to MNL. The retailer's problem is to select an assortment for his physical store in order to maximize his total expected revenue. This problem is NP-hard, and I present a FPTAS that uses a novel staircase strategy to achieve better runtime. Via numerical experiments, I show that my FPTAS has good practical performance.

2 - Reinforcement Learning With Max-Min Fairness
Wang Chi Cheung, National University of Singapore, Singapore, Zi Yi Ewe

Markov Decision Processes (MDPs) model important applications such as resource allocations and controlled queueing systems. In those, the decision maker (DM) is often interested in optimizing multiple objectives simultaneously. We consider MDPs with max-min fairness, which involves K > 1 types of rewards. The DM maximizes the minimum of the K cumulative rewards. Our main contribution is a meta algorithm framework that inputs an algorithm for single objective optimization, and outputs another algorithm that achieves max-min fairness. The theoretical analysis of our meta-algorithmic framework involves a careful analysis of a delayed version of the exponentiated gradient algorithm. We empirically evaluate our framework in a multi-server queueing system. Our framework outperforms the longest queue first policy even when the servers and queues are homogenous.

3 - Representing Random Utility Choice Models With Neural Networks
Antoine Desir, INSEAD, Paris, 75011, France, Ali Aouad

Motivated by the recent successes of neural networks, we propose a neural network based class of choice models, called RUM-net, which is inspired by the random utility maximization framework. Our approach approximates both the agents' utility function and the latent heterogeneity due to unobserved factors. We show that RUM-nets tightly express the class of RUM choice models: Any discrete choice model derived from random utility maximization has choice probabilities that can be approximated arbitrarily closely by a RUM-net. Reciprocally, any RUM-net is consistent with the random utility maximization principle. By directly leveraging widely used implementation frameworks for neural networks, we show that RUM-net models outperform other existing state-of-the-art models on various datasets.

4 - Revenue Management For Boutique Hotels: Resources With Unit Capacities And Itineraries Over Intervals Of Resources
Mika Sumida, University of Southern California, Los Angeles, CA, 10128-5805, United States, Paat Rusmevichientong, Huseyin Topaloglu, Yicheng Bai

We consider the revenue management problem for a boutique hotel offering unique rooms. Customers arriving into the system make booking requests for different intervals of stay. The goal is to find a policy that determines an assortment of rooms to offer to each customer to maximize the total expected revenue. Because each room is unique and customers book intervals of days, the problem has two special features. First, each resource has a unit capacity. Second, the resources can be ordered such that each itinerary consumes an interval of resources. We develop two policies and give performance guarantees for both policies. We also develop an approach for computing an upper bound on the optimal total expected revenue. We give computational experiments on both a real-world boutique hotel dataset and synthetic datasets.

■ VMC16

Virtual Room 16

Emerging Topics in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Yiwei Chen, Temple University, Philadelphia, PA, 19122, United States

1 - Dynamic Pricing And Demand Learning For A Large Network Of Products
Prem Talwai, MIT, Cambridge, MA, 02142, United States, N. Bora Keskin, David Simchi-Levi

We consider a seller offering a large network of N products over a time horizon of T periods. The seller does not know the products' demand model and can dynamically adjust product prices to learn the demand model based on sales observations. The seller aims to minimize its regret, i.e., the revenue loss relative to a clairvoyant who knows the underlying demand model. We consider a sparse set of demand relationships between products, and design a dynamic pricing-and-learning policy that achieves near-optimal regret performance in terms of N and T. We also show that under certain sparsity conditions, the seller's regret can be independent of N.

2 - Hotel Demand Forecasting Using A Time Varying Arrival Rate
Alexander Robinson, University of California-Irvine, Long Beach, CA, 90815-4362, United States, John G. Turner

Effective pricing is important in the hotel industry. Especially for budget hotels, price is frequently the primary point of differentiation for a customer. Estimating a function price-dependent demand function presents a number of challenges, including endogeneity and censored data. In this paper, we address these issues by modeling demand as the product of a time-varying arrival probability and purchase probability. We adapt the Expectation Maximization (EM) algorithm to estimate these probabilities separately. We also present a variant of EM that can make convergence time up to 90% faster, with little to no loss of prediction accuracy.

3 - Network Revenue Management with Online Inverse Batch Gradient Descent Method
Yiwei Chen, Temple University, Philadelphia, PA, 19122, United States

We study a family of network revenue management problems that the demand is concave of market shares, such as multinomial logit model. The seller has no prior information about the demand function and must learn it over time. We propose an online learning algorithm that the seller does the stochastic gradient descent operation in the market share space in each iteration. Our algorithm has been proved to perform well both theoretically and numerically.

4 - Persuasion, News Sharing, And Cascades On Social Networks
Chin-Chia Hsu, PhD Candidate, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Amir Ajorlou, Ali Jadbabaie

We study a model of online news dissemination on a Twitter-like social network. Given a news item and its credibility, agents with heterogeneous priors strategically decide whether to share the news with their followers. An agent shares the news, if the news can persuade her followers to take an action (such as voting) in line with the agent's perspectives. We describe the agent's decision making and the conditions that lead to sharing the news with followers, and characterize the size of news spread at the equilibrium of the news-sharing game. We further identify the conditions under which the news with low credibility can spread wider than highly credible news. In particular, we show that when the network is highly-connected or the news is not a "tail event", a sharing cascade can occur even with news that is not credible.

■ VMC17

Virtual Room 17

Algorithms and Markets

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Bar Light, Stanford Graduate School of Business, Stanford, CA, 94305, United States

1 - Presenter
Bar Light, Stanford Graduate School of Business, Stanford, CA, 94305, United States

2 - Optimal Advertising For Information Products
Shuran Zheng, Harvard University, Cambridge, MA, United States, Yiling Chen

When selling information products, sometimes the seller can provide some free partial information to change people's valuations so that the overall revenue can possibly be increased. In this work, we investigate the optimal partial information disclosure strategy of a long-term information seller. We consider buyers who are decision-makers and hold different personal beliefs about the state of the world. The problem is studied in two settings. (1) The seller targets buyers of a certain type. We characterize the optimal advertising strategy as the concave closure of a special function, which can be computed by a finite-size convex program. (2) When the seller faces buyers of different types, we provide an approximation algorithm that finds an -suboptimal mechanism when it is not too hard to predict the possible types of buyers who will make the purchase.

3 - Competing Bandits: The Perils Of Exploration Under Competition
Guy Aridor, Columbia University, New York, NY, United States, Yishay Mansour, Aleksandrs Slivkins, Zhiwei Steven Wu

Most online platforms strive to learn from interactions with users, and engage in exploration: making potentially suboptimal choices in order to acquire new information. We study the interplay between exploration and competition: how such platforms balance the exploration for learning and competition for users. We consider a stylized duopoly model in which two firms face the same multi-armed bandit problem. Users arrive one by one and choose between the two firms, so that each firm makes progress on its bandit problem only if it is chosen. We study whether competition incentivizes the adoption of better algorithms. We find that stark competition induces firms to commit to a "greedy" algorithm that leads to low welfare. However, weakening competition by providing firms with some "free" users incentivizes better exploration strategies and increases welfare.

4 - Price Of Anarchy In Strategic Queuing Systems: Learning And Patience

Jason Gaitonde, Cornell University, Ithaca, NY, United States

An important goal at the interface of economics and computer science is to bound the "price of anarchy," or cost of selfishness, in systems and games governed by the repeated interactions of competitive agents. Previous results commonly assume that the game itself does not change as a result of past actions; in settings like routing or repeated auctions with budgets, this can be unreasonable. Towards understanding this, we present recent work that obtains such bounds in a simple, strategic queuing system: queues receive packets over time and compete to clear them, and uncleared packets remain in the system. We obtain price of anarchy results for when such systems remain stable if queues use no-regret algorithms and also show how these bounds can be improved if queues instead choose stationary policies. This is joint work with Éva Tardos and appeared in EC'20 and EC'21.

■ VMC18

Virtual Room 18

Socio-economic Impacts of Digital Technology

Sponsored: Information Systems

Sponsored Session

Chair: Yash Babar, University of Wisconsin-Madison, Minneapolis, MN, 55455, United States

1 - No Pain, No Gain: Examining the Digital Resilience of the Fitness Sector During the COVID-19 Pandemic

Jiaoping Chen, Michigan State University, Lansing, MI, United States, Uttara Ananthakrishnan, Anjana Susarla

The pandemic shifted patterns of human mobility, whereby the operating model of the fitness sector was suddenly negatively impacted by digital substitution. We consider entrepreneurial alertness and digital agility of these firms in adopting virtualization and social media-enabled customer engagement, and whether such digitization substitutes for co-presence in the relationship between consumers and fitness centers. The mandated lockdowns and re-openings across states provide us with a natural experiment to examine the impact of digital substitution and digital resilience in the fitness sector. We therefore conduct a difference-in-difference analysis to quantify the digital resilience for fitness centers, compared to dental establishments.

2 - Dynamic Pricing to Balance On-demand Vehicle Rental Networks: Empirical Evidence from Carsharing

Karsten Schroer, University of Cologne, Cologne, Germany, Muhammed Demircan, Wolfgang Ketter

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

3 - Does Political Identity Declaration Amplify Or Attenuate Polarization In Online Political Discourse?

Vandith Pamuru, Assistant Professor of Information Systems, Indian School of Business, Hyderabad, 47906-4071, India, Qinglai He, Gordon Burtch, Yili Kevin Hong, Raghu Santanam

Political identity has become a critical social identity in the era of digital platforms. Literature has examined identity disclosure in numerous online platforms. However, little attention has been paid to political identity, which reveals individual political beliefs, and its impact on online political discussion. Our study takes advantage of a policy change on Reddit and utilizes exogenous shock to study how political stance disclosure causally impacts subsequent political discourse. Our preliminary results suggest that, after disclosure, there is a significant drop in participation on posts by new users and an increased polarization in the subsequent discussions. Interestingly, identity declaration also enhances the idea exchange between different political perspectives.

4 - IT-Enabled Collective Prosocial Lending In Crisis Response: A Natural Experiment

Zhiyi Wang, Assistant Professor, University of Colorado Boulder, Boulder, CO, 117418, United States, Lusi Yang, Jungpil Hahn

We examine lenders' responses to crisis as well as the variations of their responses. We propose that lenders respond positively to loans in crisis-affected areas, and that such responses are shaped by contextual factors including loan value orientation and lenders' cultural orientation. With the 2014 Ebola outbreak as a natural experiment design, we find that lenders respond positively to loans in crisis-affected areas. The positive responses are stronger to loans with greater economic value orientation, and lenders in collectivistic cultures respond more positively. We provide important implications for the literature and practice on crisis response and prosocial behaviors.

5 - Algorithmic Outputs as Information Source: The Effects of Zestimates on Home Prices and Racial Bias in the Housing Market

Shuyi Yu, Massachusetts Institute of Technology, Cambridge, MA, United States

This paper investigates market participants' reactions to predictive algorithms and the effects of this public information source on market outcomes. In particular, I study the extent to which buyers and sellers rely on a home's Zestimate when making decisions. Using detailed property transaction data for 120,482 properties sold between May 2017 and May 2019 in the Greater Philadelphia area, I show that the sale price of a property does respond to exogenous shocks to its estimated home value. I develop a theoretical framework and provide empirical evidence to show how people use the Zestimate as a source of publicly available information that plays an important role in coordination and helping people reach an agreement. Moreover, I show that people's reliance on the Zestimate might mitigate racial disparities in the housing market by providing less biased information.

■ VMC19

Virtual Room 19

Stochastic Models In bioscience and engineering

Sponsored: Applied Probability Society

Sponsored Session

Chair: Maria Vlasiou, Eindhoven University of Technology, Eindhoven, 5600 MB, Netherlands

1 - Safe Secured Control In The Presence Of Stochastic Uncertainties

Yorie Nakahira, Assistant professor, Carnegie Mellon University, Pittsburgh, PA, United States

In this talk, I will review our recent work related to safe control in a stochastic system. We consider a stochastic control system where control barrier functions, gradient-based methods, and barrier certificates are used to constrain control actions and validate safety. We derive the probability distributions of the minimum and maximum barrier function values during any time interval and the first entry and exit times to and from any super level sets of the barrier function. These distributions can be used to characterize various quantities associated with invariance and recovery, such as the safety margin, the probability of entering and recovering from safe and unsafe regions, and the mean and tail distributions of failure and recovery times. If time allows, I will also introduce our work in secured safe control and optimal scheduling.

2 - A Markovian Arrival Stream Approach To Stochastic Gene Expression In Cells

Brian Fralix, Clemson University, Clemson, SC, 29642-8005, United States, Mark Holmes, Andreas Lopker

We analyze an abstraction of the stochastic gene expression model studied recently in Fromion et al. (SIAM Journal of Applied Math, 2013) and Robert (Probability Surveys, 2019) using techniques from the theory of point processes, and the theory of matrix-analytic methods. In the model we consider, both the activity of a gene and the creation of mRNA are modeled with an arbitrary Markovian arrival process. This modification is important, as Markovian arrival processes can be used to approximate many types of point processes on the nonnegative real line.

3 - Stability Conditions Of A Distribution Network For EV Charging

Mark Christianen, TU Eindhoven, Eindhoven, Netherlands

We study the process of charging electric vehicles (EVs) in a distribution network. We assume the distribution network is a line with charging stations located on it. We consider the Distflow and the Linearized Distflow model and we assume that EVs have an exponential charging requirement,that voltage drops on the distribution network stay bounded and that the number of charging stations N is going to infinity. For the Linearized Distflow model, we show that, to obtain stability, the maximumfeasible arrival rate of vehicles is decaying as 1/N^2 and, for the Distflow model, the maximum feasible arrival rate for stability is decaying as 1/N^2\ln(N). As the size of the distribution network increases, these rates diverge and the maximal feasible arrival rate, obtained for the Linearized Distflow model, may be too optimistic.

4 - Scalable Load Balancing For Heterogeneous Systems

Kristen Gardner, Amherst College, Amherst, MA, United States, Sherwin Doroudi, Jazeem Abdul Jaleel, Alexander Wickeham

Heterogeneity is becoming increasingly ubiquitous in large-scale computer systems. While load balancing is a classical and well-studied problem in the queueing literature, much of the previous work on large-scale systems assumes that the servers are homogeneous. Unfortunately, policies that perform well in the homogeneous setting can cause unacceptably poor performance in heterogeneous systems. We propose a new framework for characterizing and analyzing new, heterogeneity-aware "power of d choices" dispatching policies. Unlike their heterogeneity-unaware counterparts, policies within our framework use server speed information both when choosing which servers to query and when deciding where (among the queried servers) to dispatch jobs. We derive response time analyses that are exact as the number of servers approaches infinity, under standard assumptions.

5 - Stability And Optimization Of Speculative Queueing Networks

Jonatha Anselmi, INRIA, Grenoble, France

We provide a queueing theoretic framework for job replication schemes based on the principle "replicate a job as soon as the system detects it as a straggler". This is called job "speculation". Recent works have analyzed replication on arrival, referred to as "replication". Replication is motivated by its implementation in Google's BigTable. However, systems such as Apache Spark and Hadoop MapReduce use speculative job execution. The performance and optimization of speculative job execution is not well understood. We propose a queueing network model for load balancing where each server can speculate on the execution time of a job. We provide a necessary and sufficient condition for the stability of speculative queueing networks and find that speculation can increase the stability region of the network when compared with standard load balancing and replication schemes.

■ VMC20

Virtual Room 20

Random Graphs and Learning in Applied Probability

Sponsored: Applied Probability Society

Sponsored Session

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

1 - Shotgun Assembly Of Erd s-Rényi Random Graphs

Julia Gaudio, Northwestern University, Evanston, IL, 02139-4204, United States, Elchanan Mossel

Graph shotgun assembly refers to the problem of reconstructing a graph from a collection of local neighborhoods. We consider shotgun assembly of Erdos-Renyi random graphs G(n, p_n), where p_n = n^{-\alpha} for 0 < \alpha < 1. We consider both reconstruction up to isomorphism as well as exact reconstruction (recovering the vertex labels as well as the structure). We show that given the collection of distance-1 neighborhoods, G is exactly reconstructable for 0 < \alpha < 1/3, but not reconstructable for 1/2 < \alpha < 1. Given the collection of distance-2 neighborhoods, G is exactly reconstructable for 0 < \alpha < 3/5, but not reconstructable for 3/4 < \alpha < 1.

2 - Partial Recovery In The Graph Alignment Problem

Georgina Hall, INSEAD, Fontainebleau, 77300, France

We consider two graphs generated via a correlated Erdos-Renyi model with parameters (n,q,s) and permute the labels of one of these graphs with a permutation π^*. Our goal is to establish conditions on (n,q,s) under which one can recover an alignment, or permutation, π which overlaps with π^* on a constant fraction of nodes with high probability. This can be viewed as a formulation of the graph alignment problem, a fundamental problem with connections to graph isomorphism and applications in social network deanonymization and biology. We show that it is possible to achieve partial recovery in the nqs= (1) regime under certain additional assumptions, which complements existing results relating to exact and almost exact recovery.

Joint work with Laurent Massoulie.

3 - The Planted Matching Problem: Sharp Threshold And Infinite-order Phase Transition

Dana Yang, Duke University, Durham, NC, United States, Jian Ding, Yihong Wu, Jiaming Xu

Motivated by the application of tracking moving particles from snapshots, we study the problem of reconstructing a perfect matching hidden in a randomly weighted Erd s-Rényi bipartite graph with average degree d. The edges are associated with weights independently drawn from distributions P or Q, depending on whether the edge is in the hidden matching. We establish that the information-theoretic threshold for recovering almost all the edges of the hidden matching occurs at $\sqrt{dB(P,Q)}=1$, where B(P,Q) stands for the Bhattacharyya coefficient. Furthermore, in the special case of complete exponentially weighted graphs, we characterize the optimal reconstruction error near the sharp threshold, confirming the conjectured infinite-order phase transition in [Semerjian et al. 2020].

4 - Inferring Latent Network Growth Processes Via The PAPER Model.

Min Xu, Rutgers University, New Brunswick, NJ, United States

We introduce the PAPER (Preferential Attachment Plus Erdos--Renyi) model for random networks, in which we let a network be the union of a preferential attachment (PA) tree and additional Erdos--Renyi (ER) random edges. The PA tree captures the fact that a real network often has an underlying growth process where vertices are added sequentially and the ER edges can be regarded as noise. Given only a snapshot of the final network, we study the problem of constructing confidence sets for the root node of the latent growth process. We propose inference algorithms that scale to networks with millions of nodes and provide theoretical analysis showing that the expected size of the confidence set is small so long as the noise level is small. We also propose variations in which multiple growth processes occur simultaneously and use these to derive a new approach to community detection.

5 - Detection And Recovery Thresholds For Graph Matching

Sophie H. Yu, Duke University, Durham, NC, United States, Yihong Wu, Jiaming Xu

This talk focuses on detection and recovery problems of matching two Erdos-Renyi random graphs. Specifically, for detection, we aim to decide whether the two observed graphs are independent, or edge-correlated under some latent node correspondence. For recovery, our goal is to recover the latent node correspondence given the two graphs are edge-correlated. In the dense graph regime, we prove that both detection and recovery exhibit an "all-or-nothing" phase transition at a sharp threshold. For sparse graphs, we identify the information-theoretic threshold within some constant factor.

■ VMC21

Virtual Room 21

APS Student Best Student Paper Prize Finalists

Sponsored: Applied Probability Society

Sponsored Session

Chair: Itai Gurvich, Northwestern University, Evanston, IL, 60208, United States

1 - Applied Probability Society 2021 Student Paper Competition

Itai Gurvich, Northwestern University, Evanston, IL, 60208, United States

The Applied Probability Society seeks to identify and honor outstanding papers in the field of applied probability that are written primarily by a student. We define applied probability broadly, as any paper related to the modeling, analysis, and control of stochastic systems. The paper's contribution may lie in the formulation of new mathematical models, in the development of new mathematical or computational methods, in the innovative application of existing methods, or in the opening of new application domains.

2 - Queueing Network Controls via Deep Reinforcement Learning

Mark Gluzman, Cornell University, Ithaca, NY, 14850-6311, United States

One of the most difficult problems in applied probability and operations research is to find a scalable algorithm for approximately solving the optimal control of stochastic processing networks (SPNs), particularly when they are heavily loaded. We develop theory and demonstrate that a class of deep reinforcement learning algorithms known as Proximal Policy Optimization can generate control policies for SPNs that consistently beat the performance of all state-of-arts control policies known in the literature.

3 - Towards Optimal Problem Dependent Generalization Error Bounds In Statistical Learning Theory

Yunbei Xu, Columbia University, New York, NY, 10027, United States

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 across the areas of non-convex learning, stochastic optimization and learning with missing data.

4 - Restless Bandits with Many Arms: Beating the Central Limit Theorem

Xiangyu Zhang, Cornell University, Ithaca, NY, 14850, United States

We consider finite-horizon restless bandits with many arms and multiple pulls per period, which are important in recommender systems, active learning, revenue management, and other areas. An optimal policy can be found by solving a Markov decision process, but the computation required scales exponentially in the number of arms N. Thus, scalable approximate policies are important for problems with large N. We study the optimality gap, i.e., the loss in expected performance vs. optimal, of such scalable policies in a classical asymptotic regime proposed by Whittle in which N grows while holding constant the fraction of arms pulled per period. Intuition from the Central Limit Theorem and the tightest previous theoretical bounds suggest that this optimality gap should grow like O(\sqrt{N}). Surprisingly, we show a stronger bound: we characterize a non-degeneracy condition and a wide class of novel practically-computable policies, called fluid-priority policies, for which the optimality gap is O(1). When this non-degeneracy condition does not hold, we show that fluid-priority policies nevertheless have an O(\sqrt{N})optimality gap, matching the best previous rates and significantly generalizing the class of policies for which convergence rates are known. We then demonstrate that fluid-priority policies offer state-of-the-art empirical performance in numerical experiments.

5 - How Big Should Your Data Really Be? Data-Driven Newsvendor and the Transient of Learning

Omar Mouchtaki, Columbia University, New York, NY, 10027, United States

We study the newsvendor problem in which the decision-maker does not know the underlying demand distribution but has only access to historical data. We evaluate the performance of any algorithm through its worst-case expected relative regret, compared to an oracle knowing the distribution. We provide the first finite sample exact analysis of the classical Sample Average Approximation algorithm for this class of problem. We then focus on the general class of mappings from data to decisions and derive an optimal algorithm and characterize its associated performance across all data sizes.

■ VMC22

Virtual Room 22

Deep Learning Models for Prognostic Analysis and Condition Monitoring

Sponsored: Quality, Statistics and Reliability

Sponsored Session

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

1 - USAL-Uncorrelated Sparse Autoencoder With Long Short-term Memory For State-of-charge Estimations

Mayuresh Savargaonkar, University of Michigan-Dearborn, Dearborn, MI, United States, Isaiah Oyewole, Abdallah A. Chehade

For the safe, reliable, and prolonged operation of battery-driven machines, fast and accurate estimation of State-of-Charge (SOC) is necessary. Existing methods for SOC estimations often fail to reliably identify aging patterns due to the complex cell characteristics. This work proposes a neural network to address the challenging task of accurate SOC estimation near End-of-Life (EOL) given a limited initial history. The proposed neural network denoted as USAL, is a unique combination of sparsely trained autoencoder with reduced cross-correlations and a Long Short-Term Memory (LSTM) network. USAL transforms inputs into uncorrelated latent encodings which are then used as inputs for an LSTM network. In our experiments for SOC estimations, USAL is shown to outperform benchmarked models on diverse public datasets with an MAE of 2.44%.

2 - Controllable Deep Transfer Learning Network With Multiple Domain Adaptation For Battery Soc Estimation

Isaiah Oyewole, University of Michigan-Dearborn, Dearborn, MI, 48128, United States, Abdallah Chehade, Youngki Kim

Deep learning models are receiving significant attention in the literature of SOC estimation because of their capabilities to capture non-trivial temporal patterns. Most of such models ignore cell-to-cell variations. While there are some attempts to utilize transfer learning concepts to identify shared temporal patterns between cells, those attempts are often uncontrollable and learned by trial-and-error making it susceptible to negative transfer learning. To address those limitations, we propose a deep LSTM with multiple domain adaptation that allows for improved model generalizability, and reduced potential in negative transfer learning. The proposed model offers controllable deep transfer learning with theoretical guarantees that enable long-term SOC estimation near the battery cell's end-of-life.

3 - A Collaborative Gaussian Process Regression Model For Transfer Learning Of Capacity Trends Between Li-ion Battery Cells

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

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

4 - A Deep Neural Network-based Control Chart For Monitoring And Interpreting Autocorrelated Multivariate Processes Using Layer-wise Relevance Propagation

Jinwen Sun, University of Wisconsin-Madison, Madison, WI, United States, Shiyu Zhou, Dharmaraj Veeramani

Recent advances in information technology are enabling multivariate sensory data to be collected at a high sampling frequency. The resulting data streams often exhibit strong autocorrelation. In this study, we propose a deep neural network-based residual control chart to monitor the autocorrelated multivariate processes for real-time detection of abnormal equipment performance. Furthermore, we propose an interpretation method, based on layer-wise relevance propagation (LRP), to identify the responsible variable when an out-of-control condition is detected by the control chart. Numerical studies and real data application demonstrate that the proposed method has good monitoring performance and is capable of providing effective interpretation results.

■ VMC23

Virtual Room 23

Incorporating Human Intelligence in Statistical Modeling and Data Analytics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Changyue Song, Stevens Institute of Technology, Madison, WI, 53705-2819, United States

Co-Chair: Chenang Liu, Oklahoma State University, Oklahoma State University, Stillwater, OK, 74075-1290, United States

1 - Knowledge-constrained Bayesian Neural Networks

Jiayu Huang, Arizona State University, Tempe, AZ, United States, Hao Yan, Yongming Liu

Neural Networks (NNs) have been widely used in various fields due to their ability to model complex nonlinear patterns, often presented in high dimensional data. However, traditional NNs lack the ability to quantify uncertainty. Bayesian Neural Networks (BNNs) could measure the confidence level by using distributions in modeling. Besides, domain knowledge is commonly available and could improve the performance of BNNs if it can be incorporated properly. In this work, we propose a knowledge-constrained BNN by incorporating such constraint function as a posterior regularization term. Furthermore, we propose the importance sampling-based approach and stochastic optimization algorithm for efficient updating. The simulation and case study in aviation landing point and speed prediction shows the improvement of the model performance over BNNs without the constraint.

2 - Failure Analysis of Adhesive Joints by Utilizing Fracture Surface Information

Xingyu Chen, Wayne State University, Detroit, MI, United States, Qingyu Yang

The adhesive joints play a critical role in joint a wide variety of constructional materials. In this study, we propose a new adhesive joint degradation model by integrating fracture surface information. Based on the degradation model, the reliability analysis and failure prediction methods are developed. Simulation studies and a real-world case study are conducted to verify the developed methods.

3 - Estimating Size And Number Density Of Three-dimensional Particles Using Truncated Cross-sectional Data
Yuanyuan Gao

The need for estimating three-dimensional (3D) information based on two-dimensional (2D) images has been increasing in numerous fields. It is essential in quality assessment, quality control, and process optimization. However, all the existing methods have not considered the data truncation issue, which is commonly faced in metrology. This paper proposes a new statistical approach to infer size distribution, volume number density of 3D particles based on 2D cross-sectional images with data truncation considered. The effectiveness of the proposed method is demonstrated through both simulation study and real case studies in metal additive manufacturing (AM) and metal-matrix nanocomposites (MMNCs) manufacturing.

4 - Semi-Supervised Clustered Multi-task Learning (SSC-MTL) for Modeling Connected Systems
Sajjad Seyedsalehi, University of Michigan, Ann Arbor, MI, United States, Wenbo Sun, Judy Jin

In multitask learning (MTL), multiple learning problems (e.g. regressions) will be solved together to improve performance. A way to enforce MTL is by imposing a cluster structure among tasks. Here we are proposing a new approach named Semi-Supervised Clustered Multi-Task Learning (SSC-MTL) that benefits the tasks with known cluster assignment. One application is for modeling connected systems (with unknown cluster assignment) in the presence of experimental systems (with known cluster assignment). Our proposed approach uses the k-means algorithm concept and a specific regularization to share information between tasks with known cluster assignment and those with unknown cluster assignment.

■ VMC24

Virtual Room 24

Technometrics Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Matthew Plumlee, Northwestern University, Evanston, IL, 60201-3203, United States

1 - Moderator
Matthew Plumlee, Northwestern University, Evanston, IL, 60201-3203, United States

This session will contain three talks based on some recent articles published in Technometrics. The first talk will be on a new SPC method for discrete part manufacturing process using surface and manifold data. The second talk will be on an approach to model processes with heterogeneous data using multiple tensor-on-tensor regression technique. The third talk will be on an exponentially weighted moving average control chart that incorporates covariate information.

2 - An Intrinsic Geometrical Approach For Statistical Process Control Of Surface And Manifold Data
Xueqi Zhao, Penn State University, University Park, PA, 16801-4554, United States

3 - Multiple Tensor-on-tensor Regression: An Approach For Modeling Processes With Heterogeneous Sources Of Data
Kamran Paynabar, ISyE Georgia Tech, Atlanta, GA, 30332-0205, United States

4 - Adaptive Process Monitoring Using Covariate Information
Peihua Qiu, University of Florida, Gainesville, FL, 32610-3010, United States

■ VMC25

Virtual Room 25

Behavioral Operations Management

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Andrew M. Davis, Cornell University, Ithaca, NY, 14853, United States

1 - Behavioral Responses To Nonprofit Metrics: Efficiency Vs. Impact
Leon Valdes, University of Pittsburgh, Pittsburgh, PA, 15260-7501, United States, Hasti Rahemi, Gloria Urrea

When making donation decisions, donors often pay attention to nonprofit organizations' (NPOs) efficiency measures - most notably, the program spending ratio. This measure captures an NPO's expenditure on programs as a fraction of its total expenses, where the latter includes administration and fundraising costs. However, NPOs and third-party organizations are also increasingly communicating measures of impact, such as the value of a service delivered over its cost, or the number and type of service that can be provided given a certain donation amount. In this study, we conduct a behavioral experiment to investigate how people respond to the availability and type of information about the impact of their donations.

2 - Transparency In Collaborative Projects
Ruth Beer, Baruch College, CUNY, New York, NY, 10019-4545, United States, Anyan Qi

Projects such as new product development often involve tight collaboration among several firms. We consider a setting with two firms engaging in a collaborative project and study a firm's decision to voluntarily improve the transparency of her quality outputs to the collaborating firm. We first solve game-theoretic models and then test the predictions of the model with a series of experiments. We observe that a firm's decision to voluntarily report her progress induces a higher belief about her quality in the collaborator, and it is positively correlated with the firm's own belief about the collaborator's future quality provision, resulting in significantly higher quality by both firms. We also find that the effectiveness of this practice heavily relies on the truthfulness of the report and it is fostered when the reporting firm can be monitored.

3 - Correlation Neglect In Supply Chains
Anugna Reddy Gondi, Cornell University, Ithaca, NY, United States

We study the effect of correlation in two operations contexts: supply risk and demand uncertainty, and hypothesize that individuals do not adequately account for correlation in such contexts. Through controlled lab experiments, we investigate how human subjects make ordering decisions under non-zero correlation (positive or negative) and zero correlation scenarios. Despite it being optimal to set different orders across these two scenarios, we find that participants set orders that are virtually the same across both settings. We also find that the effect of correlation on order bias is robust to controlling for other known biases.

■ VMC26

Virtual Room 26

Empirical Operations

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States

Co-Chair: Shumpei Goke, United States

1 - Disclosure-driven Social Engagement In Supply Chains
Caleb Kwon, Harvard Business School, Cambridge, MA, United States, Jun Li, Andrew Wu

We empirically examine the real effects of corporate social responsibility (CSR) disclosures on actual societal outcomes of disclosing firms and their supply chain connections. To do so, we exploit the passage of the California Transparency in Supply Chains Act (CTSCA) as a regime shift in mandated disclosures and examine the law's impact on an objective measure of CSR impact, which we measure using actual, media-covered incidents in human trafficking, forced labor, child labor, and human rights abuses. Firm-level responses to the CTSCA are measured by scraping the Web for firm disclosures and by analyzing the disclosure's contents using NLP machine learning algorithms. Our principal finding is that CSR activity has significant spillover effects which suggests that supply relations could serve as an important link for the propagation of socially impactful actions.

2 - Non-Binding Secret Reserve Prices: The Case of Wholesale Used-Car Auctions
Shumpei Goke, United States

I study secret reserve prices in auctions that are non-binding in the sense that the sellers can accept bids below them. Such a reserve price has a bite only when the winning bid exceeds it, in which case the winning bid is accepted without seller's action. This work investigates the motivation for this puzzling practice that many real-world auctions take, such as wholesale used car auctions. I estimate a structural model of ascending auctions using the auction data in the wholesale used-car market first used by Larsen (2021). To microfound seller's decision of the secret reserve price, I follow Andreyanov and Caoui (2020) and posit that the seller has uncertainty as to the value of the item when she sets the reserve price and that this uncertainty is resolved after she observes the auction price. I compare the status quo with two counterfactual auction formats: (i) no reserve prices and the seller gets to accept or reject every winning bid, and (ii) the seller commits to the secret reserve price. I observe very little difference among them in terms of probability of trade, seller's payoff and revenue. This suggests that the current format may be rationalized as reducing transaction costs for asking sellers' confirmation of all winning bids and avoiding sellers' cognitive cost of committing to a reserve price.

3 - Machine Learning For Demand Estimation In Long Tail Markets

Hammaad Adam, MIT, Cambridge, MA, United States, Pu He, Fanyin Zheng

Random coefficient multinomial logit models are widely used to estimate customer preferences from sales data. However, these estimation models can only allow for products with positive sales; this selection leads to highly biased estimates in long tail markets--i.e., markets where many products have zero or low sales. Such markets are increasingly common in areas such as online retail and other online marketplaces. In this paper, we propose a two-stage estimator that uses machine learning to correct for this bias. Our method performs well on simulated and actual long tail data, producing accurate estimates of customer behavior. These improved estimates can subsequently be used to provide prescriptive policy recommendations on important managerial decisions like pricing, assortment, or the introduction of new products.

4 - The Social Divide Of Social Distancing: Lockdowns In Santiago During The Covid-19 Pandemic

Marcel Goic, University of Chile, Santiago, 8370439, Chile

In this paper we study the impact voluntary shelter-in-place directives and lockdowns in Santiago, Chile. A distinctive feature of our study is that we use granular geolocated mobile phone data to construct mobility measures that capture (1) shelter-in-place behavior, and (2) trips within the city to destinations with potentially different risk profiles. Using panel regression models, we first show that the impact of social distancing and lockdowns on mobility is highly heterogeneous and dependent on socioeconomic levels. Second, we show that our mobility measures are important predictors of infections: a 10% increase in mobility correlates with approximately a 5% increase in the rate of infection. Our results suggest that mobility is an important factor explaining differences in infections rates between high and low incomes areas within the city.

■ VMC27

Virtual Room 27

Agriculture Applications

Contributed Session

Chair: Erick Jones, University of Texas, Arlington, TX, United States

1 - Climate-aware Forecasting Of Agricultural Produce Across Large Regions

Kamal Das, IBM Research, Bangalore, India, Navin Twarakavi, Fred Otieno, Mohamed Akram Zaytar, Jitendra Singh

As the climate is changing, an increasing occurrence of extreme events combined with random shift in seasonal weather patterns is leading to a high uncertainty in food supply. In this research, we present a methodology that combines seasonal forecasts of weather and extreme events, along with agronomic data using AI methods to predict risk to food production at scale. In our case study, we forecast supply of corn across a large state in India, with lead times of up to 4 months. Our method can predict other important considerations such as harvest window prediction and water footprint. Our analysis shows the potential of AI and geo-spatial data analytics to better quantify future food production.

2 - Choosing Planting Locations To Estimate Genotype Main Effects

Hanisha Vemireddy, Iowa State University, Ames, IA, United States, Sigurdur Olafsson

Multi-environment trials (METs) are a critical but expensive and time-consuming element of any plant breeding program, which makes the selection of test locations in such trial an important issue for plant breeders. There are numerous considerations for the choice of test location for METs, including eliminating redundancy and ensuring that a representative genotype-by-environment (GxE) interaction effects are present, but just as importantly the set of planted locations should have the ability to discriminate between the main effects of genotypes. We present a new method that can be applied to past MET data to identify which test locations best discriminate the genotype main effects.

3 - Stochastic Optimization Modeling Of An Agriculture, Water And Energy System Under Future Water Uncertainty

Erick Jones, University of Texas at Arlington, Arlington, TX, United States

Climate change has caused prolonged droughts which strains water resource availability. However, there are unconventional sources of water that could become profitable for agricultural uses when water or crop prices increase. Therefore, we develop a stochastic multi-systems optimization scheme based on decomposition that takes creates a distribution for likely water and energy resource futures and optimize all the systems under uncertainty simultaneously so that the farm can make the best decisions today.

■ VMC28

Virtual Room 28

Work Design And Scheduling In Health Care

Sponsored: MSOM/Healthcare

Sponsored Session

Chair: Hummy Song, University of Pennsylvania, Philadelphia, PA, 19104, United States

1 - The Role Of Schedule Volatility In Employee Turnover: The Case Of Home Health Care

Alon Bergman, Postdoctoral Scholar, University of Pennsylvania, Philadelphia, PA, United States, Guy David, Hummy Song

High rates of employee turnover increase employee search costs and training costs, and can contribute to the loss of organizational knowledge and productivity. In the case of licensed nurses, high job turnover is likely to raise healthcare costs and reduce its quality. This paper identifies schedule volatility, an operationally measurable element, to be a key determinant of nursing turnover in home health care. Using administrative data from a large home health agency, we define and document different measures of worker schedule volatility, and recover causal estimates for the effect of schedule volatility on nurses' voluntary separation (quitting) using an IV approach. We then consider several counterfactual scheduling policies. Through simulations, we calculate the counterfactual schedule volatility resulting from each policy and its effect on nursing turnover.

2 - Can Peer Effects Benefit Traditionally Personalized Services? A Study Of Shared Medical Appointments

Nazli Sonmez, London Business School, London, NW1 4SA, United Kingdom, Kamalini Ramdas, Ryan Buell

In shared service delivery, a group of clients is served at once, potentially enabling peer effects. While common in some services, shared delivery is rare in many. We examine the impact of peer effects in the context of shared medical appointments (SMAs), in which patients with similar chronic conditions meet with a doctor simultaneously, and each receives one-on-one care in turn. Using data from a 1,000 patient, multistage RCT on glaucoma patients at the Aravind Eye Hospital in India, we investigate how patient satisfaction and follow-up rates in SMAs vary with peer familiarity. We find that having familiar peers in the group significantly increases patient satisfaction, and reduces lateness to follow-up appointments. Our results shed light on how SMA groups should be formed and highlight the benefits of peer effects in a non-traditional shared service delivery setting.

3 - On Scheduling Appointments In Tandem Service Systems

Guohua Wan, Shanghai Jiao Tong University, Shanghai, 200030, China, Nan Liu, Shan Wang

In many healthcare settings, patients receive a series of services during a single visit. Examples include infusion, orthopedic visit, and mammography testing. A key commonality is the tandem structure, where each stage involves a non-trivial random service time. We study how to manage such tandem service systems via appointment scheduling.

4 - Does Tort Liability Affect Input Choice and Quality in the Nursing Home Industry?

Gerard Wedig, University of Rochester, Rochester, NY, United States, Susan F. Lu

We provide time series evidence of tort reform's impact on inputs and quality in the nursing home industry. Between 2003 and 2006, 11 state reforms capped noneconomic damages for health care services. Small chain and unaffiliated nursing homes enjoyed "judgment proof standing" and were less apt to be sued, prior to reform. We find that the managers of such homes were relatively unresponsive to the implementation of state caps on noneconomic dam- ages. Large chain-affiliated homes lacked judgment proof standing and implemented greater reductions in their nursing inputs in the aftermath of tort relief. However, we find little evidence of service quality erosion across four measured dimensions of care outcomes. Our findings are consistent with a "defensive care" model in which large chain homes employ unproductive in- puts in an effort to meet a negligence standard of care. Managers of large chains must account for the costs of added nursing inputs when considering entry into high-litigation markets.

■ VMC29

Virtual Room 29

Commodity Finance, Operations, and Risk Management

Sponsored: MSOM/iForm

Sponsored Session

Chair: Andrea Roncoroni, ESSEC Business School, Cergy-Pontoise, 95021, France

1 - Meeting Corporate Renewable Power Targets

Selvaprabu Nadarajah, Information and Decision Sciences, University of Illinois at Chicago, Woodridge, IL, 60517, United States

Corporate power purchase agreements (CPPAs) are popular long-term contracts to meet a renewable power purchase target (RPPT), which entails buying a percentage of power demand from renewable sources by a future date. We show that the generation capacity contracted via a CPPA is more nuanced to structure optimally than with a traditional power contract due to the co-movement of price/supply uncertainties and the RPPT. We develop forecast-based reoptimization heuristics and a novel information-relaxation based reoptimization method for meeting an RPPT. A computational study on realistic instances supports the continued effectiveness of CPPAs for meeting an RPPT, while highlighting risks. Rolling power purchases from our information-relaxation based procurement heuristic are near optimal and help tie the knot between reducing energy costs and meeting RPPTs.

2 - The Term Structure of Optimal Integrated Hedges

Danko Turcic, University of California, Riverside, UCR Graduate School of Business, Riverside, CA, 92521-9800, United States

We show how a commodity processor facing stochastic demand and stochastic selling price has a capacity and lead-time preference and how that preference can be advantageously manipulated with hedging. The results apply in industries in which firms' revenues are significantly affected by movements in commodity prices.

3 - Production Planning with Risk Hedging under a CVaR Objective

Liao Wang, University of Hong Kong, Hong Kong, Hong Kong

We develop a model that integrates capacity planning and risk hedging decisions under a popular risk measure, conditional value at risk (CVaR). The starting point of our model is to incorporate the impact on demand from a financial asset via a demand rate function. Then, in addition to the capacity decision at the beginning of the planning horizon, there is also a dynamic hedging strategy throughout the horizon. The hedging strategy is restricted to partial information along with a cap on loss (pathwise). We find the optimal hedging policy by duality approach and show that the production optimization is a convex problem. With both production and hedging (jointly) optimized, we provide a complete characterization of the efficient frontier, and quantify the improvement over the production-only approach. In particular, we show that hedging induces larger production quantity.

4 - Optimal Commodity Portfolio in the Long Run

Andrea Roncoroni, ESSEC Business School, Cergy-Pontoise, 95021, France

We define and theoretically investigate the term structure of optimal expected utility that an agent obtains by dynamically investing in a commodity asset and a risk-free bond or, equivalently, by positioning in a financial derivative written on the commodity. Under a binomial setup with CRRA utility function, we establish lower bounds for one-period utility variations and a universal interval for the risk-free rate/cost-of-carry entailing a decreasing term structure.

■ VMC31

Virtual Room 31

Service Workforces

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Vincent Slaugh, Cornell University, Genoa, NY, 13071, United States

1 - Staffing For Housekeeping Operations

Buyun Li, Indiana University, Bloomington, IN, United States, Vincent Slaugh

We develop an analytical model of hotel housekeeping to minimize staffing costs and guest wait times for room readiness. We show structural properties, including discrete convexity, of the single-day rostering problem for room attendant shift start times. Using data from a hotel, heuristics enabled by these save up to 17% of total costs compared to a common industry staffing heuristic. We also describe strategies for hotels facing a staffing shortage, including the use of part-time workers.

2 - The Relationship Between Expected Service Times And Service Rates For State-dependent Queues

Likang Ding, University of Alberta, Edmonton, AB, T5A 5G9, Canada, Bora Kolfal, Armann Ingolfsson

Queueing models are typically formulated in terms of service rates but recent empirical queueing research focuses on expected service times. We analyze service times in queueing models with state-dependent service rates. We provide closed-form solutions to convert service rates into expected service times and vice versa. Contrary to what is sometimes assumed, in general, expected service times are not the inverse of service rates. We find conditions under which monotonicity in service rates implies monotonicity in expected service times and vice versa.

3 - Optimal Alliance Strategies for Car Manufacturer and Car-Sharing Platform

Lifei Sheng, University of Houston-Clear Lake, Edinburgh, TX, United States, Hao Zhang

One-way car sharing has proliferated globally in recent years, enabled by rapid technological advancements in mobile communications and stimulated by concerns over road congestion and environmental pollution. This research presents a comprehensive model for a car manufacturer and a car-sharing platform company to choose an appropriate alliance strategy (revenue sharing, RS, or profit sharing, PS) to provide a local car-sharing service. The model also includes strategic consumers who choose from private cars, public transportation, and the car-sharing service. We identify two opposing effects of car sharing from the manufacturer's perspective: it cannibalizes the sales in the retail market and it encroaches into the demand for public transportation. To provide insights into practical issues, we conduct a numerical study based on data crawled from a popular car-sharing platform and on information obtained from interviews with the platform managers. In studying the entry decisions for the manufacturer and the platform, we compare the profitability of the two parties under RS and PS. We then examine the choice between new energy vehicles (NEVs) and traditional fuel vehicles (TFVs), and suggest the proper way to give subsidies to promote the use of NEVs for car sharing. Finally, we explore how car sharing affects traffic. We find that the answers to the above research questions vary according to the size and infrastructure of the city, as driven by the interplay between the cannibalization and encroachment effects.

4 - Optimal Return Time Window With Consumer Learning

Punya Chatterjee, Pennsylvania State University, State College, PA, United States, Aydin Alptekinoglu, Nicholas C. Petruzzi

In this paper, we analytically study a retailer's decision of the length of return time window when consumers update their product valuation over time as they consume a product. We develop a model consisting of a profit-maximizing retailer who sets the length of its return time window, a product which has a finite life-time, and a forward looking consumer who needs to consume the product to understand how much they value the product (e.g., electronics). Our results can guide retailers to select return time windows for various product categories and different consumer types in the case that the consumers learn over time.

■ VMC32

Virtual Room 32

Emerging Topics in Responsible Operations Management

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Anyan Qi, The University of Texas at Dallas, Richardson, TX, 75080-3021, United States

1 - Impact Of Tariffs And Price Premiums Of Locally Manufactured Products On Global Manufacturers' Sourcing Strategies

Kanglin Chen, The Hong Kong University of Science and Technology, Kowloon, Hong Kong, Xin Wang, Ying-Ju Chen, Baozhuang Niu

The past decade has witnessed significant movements to push manufacturing back to developed countries. Such movements call for raising import tariffs, which is believed to motivate local sourcing. We build a game-theoretical model to analyze the sourcing decision of a global manufacturer that maintains production sites and sells products in both domestic and foreign markets in a competitive environment. The firm can choose to source components from suppliers located in the same markets of the manufacturing sites to gain tariff savings, or choose to source all components from a single foreign supplier to obtain a lower sourcing cost. We find that raising tariffs might backfire and discourage local sourcing because of the firm's global supply chain structure and the foreign supplier's strategic response to the higher tariffs.

2 - Recover To Discover The New Normal: A Case Study Of Automotive Supply Chain Restoration After The Covid-19 Disruption

Li Chen, Cornell University, Ithaca, NY, 14853, United States, Xueyuan Liu, Lingli Luo, Thomas Choi

We investigate the process of restarting a supply chain that had gone cold due to COVID-19. An inductive case study is conducted involving a three-tier supply chain—the auto manufacturer in the middle, with four suppliers to the upstream and four dealers to the downstream. Our analysis identifies four main contributing factors and their relative importance and complementarity, as well as their spillover effects to the new normal post recovery.

3 - Collaborating With The Enemy? Sourcing Decisions In The Presence Of The Potential Entry Of Counterfeiters

Xin Fang, Singapore Management University, Singapore, 178899, Singapore, Liling Lu, Yini Gao, Burak Kazaz

We investigate sourcing strategies of a brand-name firm facing two types of suppliers: a licit home supplier and an overseas supplier who potentially becomes a counterfeiter when not used as a supplier. Our study identifies the conditions under which a brand-name firm can convert a potential counterfeit supplier to a licit source. We show that, when the perceived quality of the counterfeit is low, the brand-name firm sources from the overseas supplier through either dual sourcing or single sourcing. When the perceived quality of the counterfeit is high, however, the brand-name firm may fail to engage the overseas supplier. We also show that sourcing from the counterfeiter as an authorized overseas supplier can benefit both the brand-name firm and the overseas supplier; however, this action hurts consumer surplus and does not always improve social surplus.

4 - Entry Of Not-for-profit Food Cooperatives And Its Implications On For-profit Retailers

Jiayi Joey Yu, Fudan University, Shanghai, 200433, China, Gizem Korpeoglu, Ersin Korpeoglu, Christopher S. Tang

Propelled by the recent social activism that calls for not-for-profit food cooperatives (coops) to address the food desert and job desert issues, more food coops are establishing their presence in less-populated areas or poor communities. This trend has motivated us to examine the entry conditions for food coops with the following two related social missions: (A) maximize reserve to support the local community needs; and (B) maximize sales to support the local economy. We present a game-theoretic model to analyze the compe- tition between an entrant not-for-profit coop and an incumbent for-profit retailer in a market comprising heterogeneous consumers with different annual consumption rates and social benefit levels.

5 - Combating Excessive Overtime In Global Supply Chains

Chuanya Jiao, University of Science and Technology of China, Hefei, China, Anyan Qi

Workers in developing economies may be forced to work excessive overtime, which not only causes severe mental and physical issues to the workers, but also results in significant brand damages to the buyers if exposed in public. In this paper, we develop a game-theoretic model of a dyadic supply chain and analyze the buyer's strategies to combat such excessive overtime issues of the supplier, including auditing the supplier's practice and conducting supplier development activities such as cross training the workers and sharing capacity investment costs of the supplier.

■ VMC33

Virtual Room 33

Empirical Research in Supply Chains

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Jing Wu, Chinese University of Hong Kong, Hong Kong

1 - Credit Rating Prediction Through Supply Chains

Zhaocheng Zhang, University of Cambridge, Cambridge, United Kingdom, Sean Zhou, Jing Wu

As supply chain channels physical, financial, and information flows as well as associated risks, a firm's supply chain information should be helpful in understanding and predicting its credit risks. This paper studies the role of supply chain information in firm credit risk prediction. Using firm-level supplier-customer linkages and corporate credit rating data, we develop a machine learning framework of gradient boosted decision tree to examine whether and what supply chain features can significantly improve the prediction accuracy of credit ratings, and what types of supply chain links have higher information content that positively affects the predictability of the supply chain features.

2 - The Impact Of Covid-19 On Supply Chain Credit Risk

Ziang Wang, The Chinese University of Hong Kong, Hong Kong, Senay Agca, John R. Birge, Jing Wu

COVID-19 and its differential impact on different parts of the world provide an opportunity for insight into supply chain credit risk, and how operational and structural characteristics of global supply chains affect this risk. We examine supply chain credit risk during different phases of the COVID-19 pandemic by focusing on CDS and China supply chain links. We find that CDS spreads for firms with China partners increase with the economic shutdown in China during the pandemic, and go down when the economic activity resumes with the reopening in China. The impact of pandemic-related disruptions to even flow of goods and firms with better operating performance, lower inventory turnover, better ability with longer lead times, higher spatial, horizontal complexity, and network centrality, mitigate the impact of supply chain vulnerabilities on supply chain credit risk.

3 - Estimation Of Heterogeneous And Nonstationary Retail Demand With Aggregate Data

Yihui Huang, Tsinghua University, Beijing, 100084, China, Chen (Mavis) Wang, Lei Zhao, Jan C Fransoo

Expected demand (e.g., number of customer visits) is an important measure for a retailer to decide whether to open a new store at a candidate location. In research collaboration with a supermarket chain retailer, we observe that customers from different segments exhibit different store visit patterns. However, the retailer can only collect store-level aggregate data on daily customer visits. Given the composition of customer segments and competitors within the trading areas of existing stores, we propose a parametric model that learns both temporal and store choice behaviors of different segments from the historical aggregate data. We study the theoretical properties of the proposed model, develop an expectation-maximization algorithm to estimate the model parameters, and test its efficacy using the geographic and demographic data in Beijing.

■ VMC34

Virtual Room 34

Public Sector and Social Impact: An OM Perspective

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Priyank Arora, University of Massachusetts-Amherst, Amherst, MA, 01003-9310, United States

Co-Chair: Wei Wei, Hadley, MA, 01035-3544, United States

1 - Donations For The Refugee Crisis: In-kind Versus Cash Assistance

Telesilla Kotsi

Motivated by our field observations during the humanitarian responses to the 2017 refugee crisis in north-western Greece, we analyze trade-offs between cash and in-kind assistance that a humanitarian organization offers to refugees. Our goal is to help humanitarian organizations and governments balance the mix of assistance to maximize the overall benefits to refugees and local communities (i.e. businesses and residents). Cash assistance allows refugees' spending flexibility, according to their individual preferences, and supports local economy, but is complicated by the presence of market power of the local retailer. We examine various pricing regulations that a social-welfare maximizing humanitarian organization could implement in partnership with the government.

2 - How Does Physical Access Affect Emergency Department Utilization? Evidence From Insurance Coverage Expansion

Eric Xu, University of Minnesota, Minneapolis, MN, 55455-0438, United States, Anant Mishra, Kevin Linderman

The Patient Protection and Affordable Care Act was an attempt to provide widespread insurance coverage. While the law's Medicaid Expansion provided individuals with a financial means, we find that the impact of physical accessibility, e.g. spatiotemporal characteristics, has a non-trivial impact on emergency department use. We also find that congestion at the nearest primary care clinic due to a post-enforcement increase in Medicaid managed care encounters represents an underlying mechanism affecting annual emergency department use.

3 - Allocation Of Funds In Bilevel Subsidy Welfare Programs

Wei Wei, University of Massachusetts-Amherst, Amherst, MA, 01002, United States, Priyank Arora, Senay Solak

We analyze inequity outcomes of different funding methods used to distribute limited funds within bi-level subsidy welfare programs (e.g., child care and housing voucher programs). Specifically, we develop a two-stage optimization model that captures divergent objectives of the various entities (a funding agency and multiple service agencies), and geographic and demographic differences.

4 - Managing Stock-outs Through Provider-focused Interventions: Empirical Evidence From Indonesia

Amir Karimi, The University of Texas at San Antonio, San Antonio, TX, 78210, United States, Anant Mishra, Karthik Natarajan, Kingshuk K Sinha

Applying difference-in-differences estimation on novel data from Indonesia, we investigate whether improving the inventory management skills of healthcare providers leads to a meaningful reduction in the likelihood of stock-outs.

■ VMC35

Virtual Room 35

Recent Development in Unit Commitment Models

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Feng Pan, Pacific Northwest National Laboratory, Richland, WA, 99354-1793, United States

1 - Battery Storage Formulation And Impact On Day Ahead Security Constrained Unit Commitment

Yonghong Chen, Midcontinent ISO, Carmel, IN, 46032-3826, United States

This presentation discusses battery storage formulations and analyzes the impact of the constraints on the computational performance of security constrained unit commitment (SCUC). Binary variables are in general required due to mutual exclusiveness of charging and discharging modes. We develop valid inequalities to improve the SOC constraints. Studies with adding batteries to the MISO day ahead market clearing cases reveal the impact of binary variables and the valid inequalities on SCUC solving time. Warm start and lazy constraint techniques are applied to further improve the performance and make the valid inequalities more effective, reducing computation time to acceptable levels for implementation.

2 - Day-ahead SCUC For Integrating Large-scale DERs Into Wholesale Energy Market

Lei Wu, Stevens Institute of Technology, Hoboken, NJ, 7030, United States, Yonghong Chen, Yikui Liu, Yafei Yang

The increasing needs on clean and reliable electric energy supply have necessitated the rapid deployment of heterogeneous distributed energy resources (DER). However, as the key decision tool to support power system and electricity market operations, SCUC has long been designed for today's grid with centralized generators and one-way flow of real power from transmission to distribution. Although having been constantly revitalized, existing SCUC tools still cannot accommodate new and more complex challenges induced by proliferated heterogeneous DERs with complicated operation schemes and unprecedented variabilities, varied sizes and dispersed locations, and intensified transmission-distribution interaction. This talk discusses advanced models and solution approaches to resolve size and scalability issues of proliferated DERs in ISO market operation.

3 - Presenter

Yongpei Guan, University of Florida, Gainesville, FL, 32611-6595, United States

■ VMC36

Virtual Room 36

Computational Advancement in Power Systems

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

1 - A High-Efficiency And Numerically Robust Computing Tool For Power Flows And Dynamic Simulation

Rui Yao, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

As the power systems are facing potential disturbances with a wider spectrum of timescales and increasing interdependencies, traditional computational approaches for steady state or dynamic analysis have shown apparent limitations in many aspects, such as numerical stability, scalability, multi time scale simulation efficiency, etc. In this presentation, we will introduce the semi analytical solutions (SAS) an emerging computational methodology for the modeling and computation of power system and other engineering systems. The SAS has desirable features such as numerical robustness, high efficiency, cross time scale capability, modeling flexibility, as well as support for parallel computing. This presentation will first introduce the concept of SAS, and then we will discuss the key SAS based methods for steady state analysis, dynamic analysis and multi timescale hybrid analysis in the power system planning and operational scenarios. Computational experiments, including benchmarking against commercial software PSS/E, will also be presented to highlight the features of the SAS methodology.

2 - Pumped Storage Optimization In Day-ahead And Real-time Market Under Uncertainty

Bing Huang, Mid-continent Independent System Operator, Carmel, IN, United States, Ghesmati Arezou, Yonghong Chen, Ross Baldick

In this presentation, we focus on the work of developing models for the day-ahead (DA) market & real-time (RT) market to enhance the use of Pumped Storage Hydro (PSH) resources for flexibility. A compact, configuration-based PSH model is proposed for the DA market. The proposed model has been prototyped in a benchmarked clearing engine proxy of the Mid-continent Independent System Operator DA market (HIPPO) & it is tested with numerical studies using Midcontinent Independent System Operator (MISO) system data. The DA PSH model has been extended to a look-ahead commitment (LAC) problem. A probabilistic RT locational marginal price (LMP) forecast methodology is developed to estimate the cost of dispatching a PSH in a LAC. The participants' risk preference about the real-time volatile prices is considered. A HIPPO LAC platform is developed with the MISO system data.

3 - Data-driven Power System Optimization Under Uncertainty

Qifeng Li, University of Central Florida, Orlando, FL, 32816-8035, United States

Though the convex optimization has been widely used in power systems, it still cannot guarantee to yield a tight (accurate) solution to some problems. To mitigate this issue, this paper proposes an ensemble learning based convex approximation for alternating current (AC) power flow equations that differs from the existing convex relaxations. The proposed approach is based on three-phase quadratic power flow equations in rectangular coordinates. To develop this data-driven convex ap-proximation of power flows, the polynomial regression (PR) is first deployed as a basic learner to fit convex relationships between the independent and dependent variables. Then, ensemble learning algorithms such as gradient boosting (GB) and bagging are introduced to combine learners to boost model performance. Based on the learned convex approximation of power flows, optimal power flow (OPF) is formulated as a con-vex quadratic programming problem. The simulation results on IEEE standard cases of both balanced and unbalanced systems show that, in the context of solving OPF, the proposed da-ta-driven convex approximation outperforms the conventional semi-definite programming (SDP) relaxation in both accuracy and computational efficiency, especially in the cases that the conventional SDP relaxation fails.

■ VMC37

Virtual Room 37

Energy Equity Part II

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Erin Baker, University of Massachusetts-Amherst, Amherst, MA, 1003, United States

Co-Chair: Ines Azevedo, Stanford University, Palo Alto, CA, 94304-1157, United States

1 - Chance-constrained Multi-stage Stochastic Energy Infrastructure Expansion Planning

Yuang Chen, Georgia Institute of Technology, Atlanta, GA, 30363, United States

We develop an energy infrastructure expansion planning model for application in developing countries with massive energy infrastructure development. A novel multi-stage stochastic planning model is developed considering the future demand uncertainty. In addition, to provide flexibility in meeting demand, chance constraints are proposed by unsatisfying a portion of demand in certain years to reduce the overall cost. Chance constraints allow time for the construction of more cost-effective infrastructure. A case study of the country of Rwanda shows that implementation of the chance constraints, by allowing time-flexibility in meeting demand, affects the structure of the resulting electricity system, with up to 5% greater use of slower-to-build yet lower-cost electricity generation technology.

2 - Air pollution, climate change and economic distributional effects by race and income in the current US energy systems

Ines Azevedo, Stanford University, Stanford, CA, United States

Abstract not available at this time

3 - Evaluating climate change impacts on electricity systems in the Western US with an integrated modeling approach.

Julia Szinai, UC Berkeley, Berkeley, CA, United States

In the Western US (WUS), climate change is projected to impact the electricity system directly, as well as indirectly, through the linked water sector. Changes in temperature and precipitation affect hydropower and energy demand related to water. However, electricity planning typically ignores climate and water interactions when optimizing future investment. We link a climatically-driven water resources model with a grid linear optimization model to simulate water system operations and grid investment in the WUS under an ensemble of climate projections out to 2050. We quantify hydropower and energy demand changes, and the sensitivity of future generation and transmission capacity and costs.

■ VMC38

Virtual Room 38

Macro Energy Systems: Energy and Climate

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Tyler Ruggles, Carnegie Science, Stanford, CA, United States

1 - Idealized Least-cost Analysis Of Nuclear Power With Heat Storage In Decarbonized Electricity Systems Worldwide

Lei Duan, Carnegie Institution for Science, Stanford, CA, United States, Robert Petroski, Lowell Wood, Ken Caldeira

Advanced nuclear power plants have been proposed that may be less expensive and more flexible compared to current designs. Here we modeled the potential role of nuclear with heat storage system in an idealized linear-optimization electricity system. Our model takes into account technoeconomic factors only, and we consider electricity demand and renewable potential in 42 regions worldwide. At near current cost levels, solar and wind can provide less costly electricity primarily in moderate decarbonization scenarios, whereas deeply-decarbonized systems employ more nuclear with heat storage. Adding heat storage would either increase or decrease nuclear capacity, and lowing nuclear costs substantially increase nuclear use. Our study indicates great potential of lower-cost nuclear with heat storage to reduce system costs of deeply decarbonized electricity systems.

2 - Evaluating the Role of Hydrogen and Policy Choices for Japan's Long-term Clean Energy Vision

Kenji Shiraishi, University of California, Berkeley, CA, United States, Daniel Kammen

Hydrogen has a huge potential as a secondary energy carrier/storage of intermittent renewable energy for decarbonizing the power sector. We explore the case of Japan because of its aggressive investments in the use and import of hydrogen and its relatively limited renewable energy potential. We use a linear programming model, SWITCH-Japan, to analyze the least-cost electricity path and the hydrogen's role in achieving carbon neutrality by 2050. Our result shows both imported and domestic hydrogen is critical due to the seasonal pattern of renewable generation and electricity demand.

3 - How Many Years Of Data Is Enough?: Using Multiple Years Of Data To Increase Performance Of Electricity System Models

Tyler H. Ruggles, Research Scientist, Carnegie Science, Stanford, CA, United States, David J. Farnham, Nathan S. Lewis, Ken Caldeira

Wind and solar generation are both subject to geophysical variability in their power output from hour to hour and on longer time scales. Recent studies looked at the frequency and duration of resource droughts that could have detrimental impacts of wind- and solar-powered energy systems. In this study, we use multi-decadal historical electricity demand and wind and solar data to study reliable least-cost electricity systems optimized over multiple years of input data. We show how asset capacities and system cost increase as a function of the number of years of input data (Nyrs). The performance of systems improves as a function of Nyrs when tested on out-of-sample years of data, which may help guide long-term system planning decisions.

4 - North American Natural Gas Market Developments Under Different Mechanisms Of Renewable Policy Coordination

Charalampos Avraam, Johns Hopkins University, Baltimore, MD, 21218-2625, United States, John Bistline, Maxwell Brown, Kathleen Vaillancourt, Sauleh Siddiqui

Renewable Portfolio Standards (RPS) aim to accelerate the decarbonization of power generation, but also affect natural gas markets, through their interdependencies. We study the resilience of North American natural gas infrastructure to more stringent RPS under different levels of renewable policy coordination by soft-linking four energy-economy models and a bottom-up natural gas market model. We study the impact of international RPS coordination on regional natural gas infrastructure investment and prices and discuss policy-design implications towards low-carbon North American power generation.

5 - Balancing Public Acceptance Against Costs In The Energy Transition: The Role Of Energy Transmission And Onshore Wind In Future Scenarios

Tom Brown, Technische Universität-Berlin, Berlin, Germany, Fabian Neumann, Marta Victoria, Elisabeth Zeyen

There are many different combinations of technologies that would allow Europe to reach net-zero greenhouse gas emissions by 2050. We examine the trade-off between costs and public acceptance for onshore wind and overhead transmission lines in highly renewable scenarios for Europe that meet this target. We use a capacity expansion model of the European energy system, PyPSA-Eur-Sec, which, in contrast to previous studies combines a fully sector-coupled approach (electricity, heat, transport and industry) with a high-resolution grid model (181 nodes) so that it can capture the grid bottlenecks that constrain the integration of renewable energy. We successively constrain the allowed onshore wind and new overhead grid projects down to zero to examine the effects on total system cost and the composition of technologies in the system.

■ VMC39

Virtual Room 39

Social-Ecological-Technological Systems (SETS) Resilience for Urban Sustainability in the Anthropocene

Committee Choice: ENRE/Environment and Sustainability

Committee Choice Session

Chair: Yeowon Kim, Carleton University

1 - Centralization and Decentralization for Resilient Infrastructure and Complexity

Alysha Helmrich, Arizona State University, Tempe, AZ, United States, Samuel Markolf, Rui Li, Thomaz Carvalhaes, Yeowon Kim, Emily Bondank, Mukunth Natarajan, Nasir Ahmad, Mikhail Chester

Pervasive across infrastructure literature and discourse are the concepts of centralized, decentralized, and distributed systems. There does not appear to be a concerted effort to align how these concepts are used, and what different configurations mean for resilient infrastructure systems. We review framings of these concepts across infrastructure sectors, revealing polysemous framings; describe how the concepts are applied to resilient infrastructure theory, identifying conditions supporting resilience principles; and recommend a multi-dimensional framing through a network-governance perspective, where capabilities to shift between stability and instability are emphasized.

2 - Climate Adaptation Strategies in Cities: The Case of Air Conditioning Adoption in N.Y.C.

Luis E. Ortiz, The New School, New York, NY, United States

As climate change warms our summers, adapting to extreme heat will be increasingly important. At city-scales, however, adaptive strategies can impact many a wide range of social, environmental, and infrastructure. Here, we leverage advances in urban climate models and public data to study the socio-techno-ecological implications of full air conditioning adoption as a function of climate change, using the case of NYC. Our work highlights some of the tradeoffs involved in climate adaptation in terms of human health, peak electric demand, energy use costs, and urban heat. Finally, we show how building-scale strategies can help mitigate some of these impacts using the example of household energy burden.

3 - Leveraging Smart-meter Data To Understand How Residential Electricity Consumers Respond To Increases In Urban Warming

Kelly T. Sanders, Associate Professor of Civil & Environmental Eng., University of Southern California, Los Angeles, CA, United States

By 2050, approximately two-thirds of the global population is expected to live in urban regions. Urban warming, influenced by factors including climate change, urban heat islands, and population densification, is already driving large increases in the global demand for air-conditioning, but despite its importance to a city's future electricity consumption, there are still large unknowns in terms of how energy consumers respond to increases in temperature. Here we use the hourly smart meter records of nearly 200,000 electricity consuming households in the Southern California region, as well as other publicly available datasets, to characterize how households respond to extreme heat and analyze how these responses vary according to building characteristics, socio-economic status, and other climatic/regional factors.

4 - Leveraging Social-Ecological-Technological Systems Resilience Capabilities For Safe-to-fail Infrastructure And Climate Change

Yeowon Kim, Carleton University, Ottawa, ON, Canada, Mikhail Chester, Samuel Markolf, Thomaz Carvalhaes, Alysha Hemrich, Rui Li, Nasir Ahmad

As the rehabilitation of infrastructure is outpaced by changes in the environment, failures become increasingly likely. Infrastructure have been designed around models of rigidity, and the deep uncertainty around climate change represents a decoupling between what our critical systems are designed to handle and how the environment is changing. If failures of infrastructure are increasingly likely then new approaches are needed to manage the consequences. Safe-to-fail approaches that call for the planning of failure responses in design to minimize damages when failures occur appear well-positioned to support resilience efforts by identifying social, ecological, and technological/infrastructural (SETS) capabilities.

5 - Towards Improved Estimates In Regional Flood Damage Through Probability Bounds Analysis
Hiva Viseh, PhD Student, University of Victoria, Victoria, BC, Canada, David N. Bristow

Increasing risk of floods in a changing climate is driving a greater need to assess the potential effects associated with these events. Flood risk analysis is often hampered by data quality issues, methodological challenges, ambiguous dependency among variables, and unspecified uncertainties. We illustrate a novel approach to address these difficulties through interval-type bounds on cumulative distribution functions (probability-boxes). This approach enables us to deal with the major issues that analysts face with conventional methods while differentiating between aleatoric and epistemic uncertainty and while addressing the problem of neglecting interdependencies between variates.

■ VMC40

Virtual Room 40

Managing Uncertainty and Scarcity in Energy Systems: Part I

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Sam Chevalier, Technical University of Denmark, Denmark

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

1 - New Reserve Products To Improve Primary Frequency Response
Manuel Joseph Garcia, Sandia National Laboratories, Albuquerque, NM, 78703, United States, Ross Baldick, Felipe Wilches-Bernal

Primary frequency control is being challenged because Inverter-Based Resources (IBRs) are replacing traditional generators causing inertia levels to drop and less governor response to be available. This presentation proposes introducing novel primary frequency response reserve products into the electricity market to provide incentive for IBRs to contribute to primary frequency control. I will explain three different types of primary frequency response reserve and propose a reserve requirement that captures their interdependencies. Finally, I will analyze pricing incentives to determine which reserve type IBRs prefer to provide. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525

2 - Market Design Options for Scarcity Pricing in European Balancing Markets
Gilles Bertrand, CREG, Brusssels, Belgium, Anthony Papavasiliou

The high penetration of renewable units with intermittent generation and zero marginal operating costs creates challenges in electricity markets. To overcome these challenges, Belgium is considering the implementation of scarcity pricing. This implementation poses a number of interesting market design dilemmas. These market design choices can affect the valuation of reserve capacity, and the back-propagation of price signals to forward reserve markets. In this work, we analyse the ability of various European balancing market design options to (i) back-propagate the value of reserve to forward reserve markets; and (ii) give the right incentives to market participants in the balancing market.

3 - Optimization And Control Of Power Grid Under Line Parameter Uncertainty
Dongchan Lee, MIT, Cambridge, MA, United States, Yury Maximov, Line Roald, Audun Botterud

Operation and control of the electric power grid rely on the assumption that the system model is accurately known and stays constant throughout the dispatch periods. However, this assumption may not hold when there is model uncertainty in the transmission and distribution line parameters, such as resistance and reactance. These parameters could be inaccurate due to outdated models of the physical systems or unknown variations. In this talk, we consider computing the emergency control dispatch problem in the presence of uncertainty and propose a two-step algorithm based on robustness verification and optimization steps. We first compute the required margin in operational limits for the given uncertainty set. These margins are then used to optimize the control cost, which can be solved in similar complexity to the nominal problem without robustness constraint.

4 - Distributionally Robust Chance Constrained Power Grid Topology Optimization Under Resource Uncertainty
Yuqi Zhou, The University of Texas at Austin, Austin, TX, United States, Hao Zhu, Grani Adiwena Hanasusanto

Increasing penetration of renewable generation poses significant challenges to ensure robust guarantees in real-time power system decision making. This work will present a robust and efficient algorithm for the optimal grid topology optimization problem that aims to relieve network congestion via judiciously changing the grid topology. To deal with resource uncertainty, this problem is first formulated as a distributionally robust chance constrained (DRCC) problem by enforcing limited security constraint violations. By considering the mean-mean absolute deviation of uncertainty or the Wasserstein ambiguity set, we have attained mixed-integer linear programming (MILP) reformulations for the resultant DRCC problems that can be efficiently solvable and used for real-time grid operations.

■ VMC41

Virtual Room 41

Solution Approaches for Problems with Knapsack-Type Constraints

Sponsored: Computing Society

Sponsored Session

Chair: Kartik Kulkarni, Virginia Institute of Technology, Blacksburg, VA, 24060-5807, United States"

1 - Recent Advancements For Solving Generalizations Of The Capacitated Lot-sizing Problem
Kartik Kulkarni, Virginia Institute of Technology, Blacksburg, VA, 24060-5807, United States

In this talk, we present solution approaches for generalizations of the classical single-item economic lot-sizing problem where the total production capacity in each period can be the summation of binary multiples of capacity modules of different sizes.

2 - Multi-cover Inequalities For Multiple Knapsack Set
Haoran Zhu, University of Wisconsin–Madison, Madison, WI, 53706-1539, United States

we propose a method to generate cutting-planes from multiple covers of knapsack constraints. The covers may come from different knapsack inequalities if the weights in the inequalities from a totally-ordered set. Thus, we introduce and study the structure of a totally-ordered multiple knapsack set. The valid multi-cover inequalities we derive for its convex hull have a number of interesting properties. First, they generalize the well-known (1,k)-configuration inequalities. Second, they are not aggregation cuts. Third, they cannot be generated as a rank-1 Chvatal-Gomory cut from the inequality system consisting of the knapsack constraints and all their minimal cover inequalities. Finally, the separation problem can be exactly solved, and numerical experiments showcase the strength of our inequalities.

■ VMC42

Virtual Room 42

Special Session on Combinatorial Optimization on Quantum Computers

Sponsored: Computing Society

Sponsored Session

Chair: Ruslan Shaydulin, Argonne National Laboratory, Clemson, SC, 29634, United States

Co-Chair: Ilya Safro, Clemson University, Clemson, SC, 29634, United States

Co-Chair: Yuri Alexeev, Argonne National Lab, Chicago, IL, United States

1 - Combinatorial Optimization On Quantum Computers
Ruslan Shaydulin, Argonne National Laboratory, Lemont, IL, 29634, United States

Combinatorial optimization is considered one of the most promising applications of near-term quantum computers, with Quantum Approximate Optimization Algorithm (QAOA) being the most promising candidate algorithm. In this tutorial, I will provide a ground-up introduction to constructing Hamiltonians for optimization problems and solving them using QAOA, assuming no prior background beyond linear algebra and some familiarity with the circuit model of quantum computing. Then I will delve deeper into the nuts and bolts of getting QAOA to produce high-quality solutions, with the focus on understanding the mechanics of QAOA and the near-term challenges. This tutorial will provide a sufficiently deep and mathematically rigorous introduction to enable attendees to jump-start their efforts to develop quantum optimization solutions for their problems.

2 - Presenter
Yuri Alexeev, Argonne National Lab, Chicago, IL, United States

3 - Presenter
Ruslan Shaydulin, Argonne National Lab, Argonne, IL, United States, Ilya Safro, Yuri Alexeev

Quantum computing has potential to efficiently solve combinatorial optimization problems. Recent advances in both hardware and algorithm development have made it possible to solve small problems on modern quantum computers. Combinatorial optimization problems (especially NP-hard problems) are of particular interest, since for many of these problems efficient classical algorithms are not known. One such problem is MaxCut on graphs. In this minitutorial, we will introduce the MaxCut problem and explain how it can be solved on IBM quantum computers available on the cloud today using the Qiskit framework. Our presentation will assume little to no prior knowledge of quantum computation.

■ VMC43

Virtual Room 43

Fairness in Operations

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Vahideh Manshadi, Yale University, New Haven, CT, United States

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

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

1 - Bias And Discrimination In Machine Learning: Automated Employment Screening As A Case Study
Manish Raghavan, Cornell University

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

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

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

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

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

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

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

■ VMC44

Virtual Room 44

Economics and Computation V

Sponsored: Auctions and Market Design

Sponsored Session

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

1 - The Landscape Of Autobidding Auctions: Value Versus Utility Maximization
Jieming Mao, Google, New York, NY, United States

Internet advertisers are increasingly adopting automated bidders to buy advertising opportunities. One popular goal adopted by advertisers is to maximize their clicks (or conversions) subject to a return on spend (RoS) constraint, which imposes that the ratio of total value to total spend is greater than a target ratio. The emergence of automated bidders brings into question whether the standard mechanisms used to sell ads are still effective in this new landscape. Thus motivated, in this paper we study the problem of characterizing optimal mechanisms for selling an item to one of multiple agents with return on spend constraints when either the values or target ratios are private.

2 - Online Learning Via Offline Greedy Algorithms: Applications In Market Design And Optimization
Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, United States, Negin Golrezaei, Fransisca Susan, Joshua Wang, Ashwinkumar Badanidiyuru

Motivated by online decision-making in time-varying combinatorial environments, we study the problem of transforming offline algorithms to their online counterparts. We focus on offline combinatorial problems that are amenable to a constant factor approximation using a greedy algorithm that is robust to local errors. For such problems, we provide a general framework that efficiently transforms offline robust greedy algorithms to online ones using Blackwell approachability. Demonstrating the flexibility of our framework, we apply our offline-to-online transformation to several problems at the intersection of revenue management, market design, and online optimization.

■ VMC45

Virtual Room 45

Behavioral OM in Sustainability, CSR, and Public Policy

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Javad Nasiry, McGill University, Montreal, QC, H3A 1G5, Canada

1 - Accountability and the Starvation Cycle in the Nonprofit Sector
Iman Parsa, Arizona State University, Tempe, AZ, 85287, United States, Mahyar Eftekhar, Charles J Corbett

Donors to nonprofit organizations are sensitive to overhead expenses and support charities with lower administration and fundraising costs. This can lead to under-investments in essential organizational and operational infrastructure, or misleading financial reports, and an increasing expectation of donors for low overhead costs. In this paper, we empirically investigate whether the IRS policy change in 2008 has helped in breaking this cycle by providing additional information about nonprofits' accountability. This empirical study is based on a large dataset containing information of nonprofits in different sectors in the time period 2009-2017.

■ VMC46

Virtual Room 46

Analytics in Supply Chain Networks

Sponsored: Artificial Intelligence

Sponsored Session

Chair: John Rios, University of Iowa, Iowa City, IA, 52242-1994, United States

1 - Vulnerability Of Global Supply Chains:impact Of Industrial And Geopolitical Concentration Of Upstream Industries

Jafar Namdar, University of Iowa, Iowa City, IA, 52246, United States, Gautam Pant, Jennifer Blackhurst

In addition to the well-known notion of concentration due to the dominance of a few firms within an industry (i.e., industrial concentration), our study highlights the role of a relatively under-recognized dimension of geopolitical concentration. Using a large data set of firms, we find that the sales growth of firms whose suppliers are operating in high concentrated industries saw a relative drop of 5 percentage points during the pandemic. Our robust findings provide insights for both policy makers and managers for mitigating the supply chain risks stemming from industrial concentrations.

2 - Enhancing A Multi-commodity Supply Chain Network Resilience Through Fairness-based Distribution During Disruptions

Andres David Gonzalez, University of Oklahoma, Norman, OK, 73019, United States, Osamah Y Moshebah

The flow of multi-commodities in supply chain networks SCNs can be significantly impacted by any sort of disruption in the network, in particularly the road transportation network. Enhancing the SCN performance can be ensured by implementing a fair-based distribution of commodities while restoring the SCN resilience and maintaining higher satisfaction rate at most of the demand nodes.

3 - Predicting Firm Performance With Supply Chain Networks

John Rios, University of Iowa, Iowa City, IA, 52242-1994, United States, Kang Zhao, Nick Street, Hu Tian, Xiaolong Zheng

Based on the fact that firms are rarely operating in isolation, this research aims to predict a firm's performance based on the performance of other companies operating in the same supply chain network. We propose a novel Hybrid and Temporal Graph Neural Network (HT-GNN) that learns time-dependent node embeddings by aggregating neighbors' information and provides node classifications over time. Results based on over 2,600 public firms demonstrate that our model can provide higher predictive performance and better interpretability than traditional features included in finance literature.

4 - An Integrated Multitiered Supply Chain Network Model Of Competing Agricultural Firms And Processing Firms

Deniz Besik, University of Richmond, Richmond, VA, 23220, United States, Anna B. Nagurney, Pritha Dutta

The COVID-19 pandemic has created many disruptions in the agricultural supply chain networks, encompassing production, processing, packaging, storage, and distribution, affecting many stakeholders in the agriculture industry. This presentation shows an integrated multitiered competitive agricultural supply chain network model in which agricultural firms and processing firms compete to sell their differentiated products at the demand markets. The competition among agricultural firms and processing firms at the demand markets is formulated and studied via game theory, where the governing Cournot-Nash equilibrium conditions correspond to a variational inequality problem. We use an algorithm to test our modeling framework through a numerical study consisting of several supply chain disruption scenarios, including ones relevant to the Covid-19 pandemic.

■ VMC47

Virtual Room 47

Accounting

Contributed Session

Chair: Bin Fang

1 - A Conceptual Framework For Financial DEA

Claire Cui, University of Auckland, Auckland, New Zealand, Julie Anne Harrison, Frederick Ng, Paul Rouse

DEA originates from economics and flourishes in operational research and has emerged in accounting. In recent years, a stream of DEA only incorporates financial accounting variables (Financial DEA) for firm performance measurement. However, Financial DEA research is fragmented with little conceptual foundation. This thesis provides a comprehensive conceptual foundation for Financial DEA with quantified illustrations. A two-phase mixed method analytical approach is conducted. Phase one provides a taxonomy of Financial DEA empirical studies and a conceptual framework for Financial DEA models. Phase two further provides quantitative illustrations, with Monte Carlo empirical tests.

2 - Time Series Forecasting For Equity Valuation Using Accounting Data

Lukas Benjamin Heidbrink, Bielefeld University, Bielefeld, Germany

Companies and investors need to forecast accounting data in a variety of cases, such as equity valuation and cash flow forecasting, or due to regulators requirements. I evaluate modeling alternatives in equity valuation and profitability forecasting given the nonstationary nature of many variables, focusing on the value relevance of accrual and cash basis accounting measures. Thus, I utilize classic multivariate time series models, error correction models and different artificial neural networks to test their predictive performance empirically and improve valuations.

3 - Blockchain Technology Adoption And Audit Quality: Evidence From Chinese Listing Firms

Yusang Zhuo, School of Management, Xiamen University, Xiamen, China, Bin Fang, Xinming Liu

This study investigates the implications of adoption blockchain technology in companies on audit quality. As a decentralized technology, all information recorded in blockchain systems is immutable, which improves the reliability and efficiency of financial information that auditors required in financial statement audit. Based on a sample of 33242 firm-year observations from China stock exchanges during 2007-2019, we find evidence consistent with the adoption of blockchain technology and associated higher audit quality. The findings are robust to controlling for endogeneity and alternative measures of audit quality. Our results bear important implications for regulators and investors.

■ VMC48

Virtual Room 48

Analytics in ebusiness

Sponsored: eBusiness

Sponsored Session

Chair: Mingwen Yang, University of Washington, Seattle, WA, 98195, United States

1 - Service Quality And Wage Differentiation In Two-sided Ridesharing Platforms

Haozhao Zhang, University of Texas at Dallas, Richardson, TX, 75080-3021, United States, Chenglong Zhang, Srinivasan Raghunathan

We examine the quality differentiation strategy for a two-sided platform that matches drivers with riders. The riders have different valuations for waiting time, which is one measure of service quality. Unlike product markets, the ridesharing platform faces a self-scheduled supply and they may also be strategic in accepting a ride request. In the presence of strategic drivers, offering differential wages to control driver supply leads to adverse effects from driver-side cannibalization. An increase in the driver-side cannibalization diminishes the platform's incentive to practice wage differentiation as well as quality-differentiated services.

2 - Economic Analysis Of Pre-Service Tipping Policies In Online Marketplaces

Kai Sun, University of Texas at Dallas, Richardson, TX, 75080, United States, Mingwen Yang, Vijay S. Mookerjee

Pre-service tipping becomes more prevalent for sharing economy platforms that provide services from ride-sharing to grocery/food deliveries. One key feature of these platforms is the uncertainty in service quality provided by heterogeneous service providers (drivers). Among different platforms, there are policy variations in terms of adjustability (that is, whether consumers can adjust their tipping after receiving the service) and visibility (that is, whether drivers can observe the pre-service tipping before providing the service). In this study, we develop a game-theoretical model to analyze how consumers and drivers strategically behave under different tipping policies and how their best responses impact the mean market service quality. Our findings provide implications for the platform policymakers.

3 - When Struggle is a Good Thing: Service Innovation Through Gig-economy in Service Delivery Platforms

Geng Sun, University of Texas Rio Grande Valley, Edinburg, TX, United States, Yeongin Kim

Online food delivery platforms like UberEats and DoorDash leverage the uprising trend of sharing economy to facilitate transactions between consumers and restaurants. However, the best practices, accounting for the market's unique characteristics, are yet to be well understood. In this paper, we study these platforms in the context of multi-sided markets with the presence of gig labor. We find that a platform's service quality dramatically affects its subsidization strategy. The platforms' optimal practices depend on the market tendency. The competition of the gig market allows consumers (restaurants) to enjoy a lower (higher) access fee, which interestingly improves the platform profits.

4 - Analytics Services On A Marketplace Platform: A Game-theoretic Model

Zhe Wang, Tsinghua University, Beijing, 100084, China, Hong Guo, Dengpan Liu

In this paper, we characterize the role of analytics services as improving sellers' knowledge about the preference variation of the consumer market on a platform, which in turn helps sellers make better marketing decisions. Using a game-theoretic model, we analyze the platform's pricing and the sellers' adoption strategies for analytics services in two different market scenarios - the market with low taste dispersion and the market with high taste dispersion. We find that, with the analytics service, the sellers move toward each other and command a lower price in the low-taste-dispersion market, whereas they move away from each other and command a higher price in the high-taste-dispersion market. In addition, we find that the service does not necessarily benefit the sellers and is not necessarily welfare-enhancing.

5 - To Brush or Not to Brush: Product Rankings, Consumer Search, and Fake Orders

Chen Jin, National University of Singapore, Singapore, 117417, Singapore

"Brushing"---online merchants placing fake orders of their own products---has been a widespread phenomenon on major e-commerce platforms. One key reason why merchants brush is that it boosts their rankings in search results. On the one hand, products with higher sales volume are more likely to rank higher. On the other hand, rankings matter because consumers face search frictions and narrow their attention to only a few products that show up at the top. Thus, fake orders can affect real consumer choice. We focus on this search-ranking aspect of brushing and build a stylized model to understand merchants' strategic brushing behavior as well as how it affects consumers. We consider a high-type merchant (who sells a more popular product) and a low-type merchant (who sells a less popular product) competing on an e-commerce platform where product rankings evolve over time. We find that if brushing gets more costly for merchants (e.g., due to tougher regulations), it may sometimes surprisingly harm consumers as it may only blunt brushing by the high-type merchant but intensify brushing by the low-type merchant. If search is less costly for consumers (e.g., due to improved search technologies), it may not always benefit consumers, either. Moreover, the design of the ranking algorithm is critical: placing more weight on sales-volume-related factors may trigger a non-monotone change in consumer welfare; tracking recent sales only as opposed to cumulative sales does not always dial down brushing and, in fact, may sometimes cause the low-type merchant to brush more.

■ VMC49

Virtual Room 49

Methodological Improvements and Innovative Applications of MCDM

Sponsored: Multi Criteria Decision Making

Sponsored Session

Chair: Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Recife PE, 50740533, Brazil

Co-Chair: Eduarda Asfora Frej, Universidade Federal de Pernambuco, Brazil

1 - Preference Modeling With Fitradeoff Method: Combining Elicitation By Decomposition And Holistic Evaluation

Manoel L Ribeiro, Universidade Federal de Pernambuco, Recife, Brazil, Eduarda Asfora Frej, Adiel Teixeira De Almeida

According to the literature the elicitation process may be conducted by considering either the action or consequence space. Although these approaches have already been used to solve problems in MCDM/A context, FITradeoff (Flexible and Interactive Tradeoff) is the first method which combines holistic evaluation and decomposition elicitation. This work aims to highlight the benefits of combining these two paradigms to facilitate the decision-making process, giving special attention to FITradeoff flexibility and its DSS new features. Considering the variety of decision support methods, FITradeoff stands out for its continuous improvement, providing the decision maker with new tools and seeking for the reduction of his/her cognitive effort.

2 - Metaheuristics Approach With Partial Information For Multicriteria Portfolio Selection Problem

Adriana Cavalcante Marques, Universidade Federal de Pernambuco, Recife, Brazil, Eduarda Asfora Frej, Adiel Teixeira De Almeida

The portfolio selection problem is one of the most relevant optimization problems within the engineering domain. However, the task of determining the solution is not trivial since the underlying NP-complete problem becomes increasingly demanding as the number of projects grows. This work proposes metaheuristics to reduce the solution space, maintaining their quality once the decision-maker's preferences are considered and keeping computational effort within reasonable limits. Then, applying the FITradeoff method to the feasible and efficient portfolios generated by the metaheuristics, to result in the optimal portfolio using partial information through linear programming models.

3 - Ergonomic Performance Index: A Multi Criteria Decision Model For Application In A Federal Justice Organization 81 In Brazil

Aleson Belo da Silva, Postgraduate Student, UFRN, Natal, Brazil, Thiago Allan Macedo, Wilkson Ricardo Castro, Marco Antonio Cabral, Ricardo Pires de Souza, Ricardo Pires de Souza

Ergonomics, in general, is an area that studies the relationship between the worker and their work environment. As technology progressed, people began to log working hours exclusively on computers and quite so often with inadequate postures. With the advancement of the COVID-19 pandemic, telework has grown, and it is often carried out in inappropriate workstations. Thus, the research has developed a multicriteria decision model to compose an ergonomic index. The model was developed with the support of the FITradeoff method and was inserted into previously developed software for work posture monitoring. The criteria established were: upper limbs, spine, head, neck, distance from the monitor, height of the monitor, ergonomic breaks, as well as participation in health activities. The model was validated with the occupational physician of a federal justice unit in Brazil

4 - Applying The Fitradeoff Method To Support The Compliance Program In A Brazilian Organization

Maria Elvira Borges Tunú Pessoa, Universidade Federal de Pernambuco, Recife, Brazil, Lucia Reis Peixoto Roselli, Adiel Teixeira de Almeida

This paper proposes an application of the FITradeoff method in a decision problem involving the compliance program. The demand for this program has grown over the last few years in Brazil, due to the approval of the anti-corruption law. In this problem, conflicting objectives were identified, measured by four criteria. In addition, 21 alternatives were evaluated. These alternatives represent actions that a company could take to improve its performance in relation to the compliance program. The multicriteria problem was solved using the FITradeoff method for ranking problems by combining decomposition elicitation and holistic evaluation. The method is operated through a decision support system, which allows the graphical visualization of the ranking at each interaction. Finally, a ranking with 14 levels was obtained.

■ VMC50

Virtual Room 50

Robust Statistics and Simulation Optimization

Sponsored: Simulation Society

Sponsored Session

Chair: Soumyadip Ghosh, IBM TJ Watson Research Center, Yorktown Heights, NY, 10598, United States

1 - Bounds For Multistage Mixed-integer Distributionally Robust Optimization

Guzin Bayraksan, The Ohio State University, Columbus, OH, 43210-1271, United States, Francesca Maggioni, Ming Yang, Daniel Faccini

Multistage mixed-integer distributionally robust optimization (MMIDRO) forms a class of extremely challenging problems. In this talk, new lower bounding criteria for MMIDRO are provided through scenario grouping and convolution of risk measures for commonly used phi-divergences and the Wasserstein distance. Our approach does not require any special problem structure such as convexity and linearity. Therefore, the bounds can be applied to a wide range of distributionally robust problems. Numerical results on a multistage mixed-integer production problem show the efficiency of the proposed approach through different choices of partition strategies and levels of robustness.

2 - Solving Distributionally Robust Optimization Formulations Efficiently

Soumyadip Ghosh, IBM TJ Watson Research Center, Yorktown Heights, NY, 10598, United States, Mark S. Squillante

We investigate new stochastic gradient descent (SGD) algorithms to efficiently solve distributionally robust optimization (DRO) formulations that arise a wide range of applications. Our approach for the min-max formulations of DRO applies SGD to the outer minimization problem. Towards this end, the gradient of the inner maximization in each iteration is estimated from a sample average approximation. This gradient estimate suffers a bias, and we propose two techniques to mitigate or eliminate the impact of this bias. We rigorously establish convergence of our methods for a broad class of models, and show under restricted conditions how parameters of the techniques can be tuned for computational effort optimal convergence. Empirical results demonstrate the significant benefits of our approach over previous work in solving these DRO formulations efficiently.

3 - Self Structuring Importance Samplers For Achieving Efficiency In Black Box Simulation Of Distribution Tails
Anand Deo, Singapore University of Technology and Design, Singapore, Singapore

This talk presents a novel Importance Sampling (IS) scheme for estimating distribution tails of a rich class of performance functionals modelled with tools such as linear programs, neural networks, etc. Conventional efficient IS approaches suffer from feasibility and scalability concerns in such settings as they require the sampler to be intricately tailored to the underlying probability distribution and the performance functional considered. This challenge is overcome in the proposed black-box scheme by automating the selection of an effective IS distribution with a transformation that implicitly learns and replicates the concentration properties observed in less rare samples. The proposed sampler attains asymptotically optimal variance reduction across a spectrum of multivariate distributions despite being oblivious to the underlying structure.

■ VMC51

Virtual Room 51

Stochastic Models in Transportation and Inventory

Sponsored: Service Science

Sponsored Session

Chair: Bo Wei, Bilkent University

1 - Newsvendor Model With Environmental Regulations Under Partial Demand Information
Dincer Konur, Texas State University, San Marcos, TX, 78666, United States, Gonca Yildirim

In this study, we first revisit the newsvendor model with full demand information under four common environmental regulations, namely, carbon taxing, carbon cap, carbon trading, and carbon offsetting. Several results are presented on the effects of carbon regulation parameters on the order quantity and maximum profits. Later, we relax the assumption of full demand information and analyze the newsvendor model under these regulations considering different scenarios of partial demand information. Maximum entropy principle is utilized to make order quantity decisions under each partial demand information scenario. Numerical studies are conducted to evaluate the value of various pieces of demand information on the newsvendor's profit and environmental impact.

2 - Inbound Replenishment And Outbound Dispatch Decisions Under Hybrid Shipment Consolidation
Sila Cetinkaya, Southern Methodist University, Dallas, TX, 75205, United States, Bo Wei, Daren Cline

We consider a distribution warehouse where both the inbound inventory replenishment and outbound dispatch decisions are subject to fixed (as well as per-unit) transportation charges and demand is stochastic. We examine the impact of hybrid consolidation policies for outbound transportation on the joint replenishment-dispatch decisions.

3 - A Pessimistic Bi-level Framework For Risk Mitigation In Hazmat Transportation
Ginger Yi Ke, Memorial University of Newfoundland, St. John's, NL, A1B 3X5, Canada, Jeremy Dominique Alexandre Briere, James H. Bookbinder

This paper proposes a pessimistic bi-level model to mitigate the risk associated with the transportation of hazardous materials (hazmat). More specifically, the upper level represents the network design decision of the authority (government), aiming to minimize the risk through the availability of network segments and location of hazmat response teams, while the lower level reflects the hazmat carriers' routing decisions to minimize the transportation costs. The optimal solution can be obtained through a reformulation of the original model into a single-level format for smaller problems, whereas for large instances, a heuristic is outlined and shown to yield good approximate solutions in a computationally efficient manner.

4 - A Stochastic Location-routing Problem For Infectious Waste Management With Time Windows
Saeed Tasouji Hassanpour, Memorial University of Newfoundland, St. John's, NL, Canada, Ginger Y. Ke, Jiahong Zhao

One major challenge that the authorities have been experiencing during COVID-19 is the management of infectious waste generated by healthcare activities. Focusing on the massive increment of infectious waste in a pandemic, a stochastic model is developed to determine the facility locations and collection routes considering the uncertain demands in different pandemic phases. A set of chance constraints are used to formulate the deviations in travel time, which may lead to violations of time windows. The proposed model is then applied to a real-world case of the COVID-19 outbreak in Wuhan, China, from which managerial insights are derived to enhance the preparedness of the waste logistics system.

5 - On The Service Performance Of Stochastic Clearing Systems
Bo Wei, Bilkent University, Ankara, Turkey, Sila Cetinkaya, Daren B. H. Cline

Although stochastic clearing theory has a long history, measurement of average order/delivery delay (AODD) under general clearing policies remain an area of interest. We propose a new method for the derivation of AODD which in turn leads to a complete comparative analysis of alternative renewal-type clearing policies in terms of AODD. The results are of particular interest in context of stochastic clearing applications in transportation where AODD is a primary service measure.

■ VMC52

Virtual Room 52

MSOM Distinguished Speaker Session Featuring Professor David Simchi-Levi

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: So Yeon Chun, INSEAD, Fontainebleau, 77300, France

Co-Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States

1 - Statistical Learning in Operations Management
David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

Traditionally, statistical learning is focused on either (i) online learning where data is generated online according to some unknown model; or (ii) offline learning where the entire data is available at the beginning of the process. In this talk we show that combining both approaches can accelerate learning. Specifically, we show that difficult online learning problems can be reduced to well-understood offline regression problems. We demonstrate the impact of our work in the context of product recommendation, multiclass classification problems, personalized medicine and dynamic pricing.

■ VMC53

Virtual Room 53

Forecasting with Social Media Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Alex Rudniy, University of Scranton, Scranton, PA, United States

1 - The Effect of Sentiment on Forecasting Efficiency in Fashion Market
Olena Rudna, Rutgers, Newark, NJ, 18426, United States

In order to improve demand planning for the fashion industry we turn attention to social media. We found that forecasting models using the embedded Twitter trend factor showed superior outcomes as indicated by the smaller values of forecasting error when compared to models based purely on historical sales data.

2 - Can AI Beat Vegas: Forecasting National Basketball Association Game and Gambling Outcomes
Michael J Wynn, University of Scranton, Scranton, PA, United States, Alexander Rudniy

Originally, this project intended to use standard team statistics paired with gambling point spreads, due to their constantly updating nature and recent digital abundance, to improve predictive models for NBA game outcomes. When this failed, the objective shifted to optimizing predictive models for game and gambling outcomes. A variety of data from the 2005-18 NBA regular seasons was tested in combination with different machine learning models to maximize accuracy. The best gambling prediction model scored an accuracy of 57.6%. The best win prediction model achieved an accuracy of 73.9%, which qualifies as the best NBA regular season game outcome prediction model available in the public domain.

3 - Correlations Between Stock Performance and Google Trends
Justin Thomas, Masters, University of Scranton, Scranton, PA, United States

The Financial Portfolio Prediction Tool (FPPT) utilizes Data Science practices along with; The Python coding environment- Anaconda, Internet search trend analyzer-Google Trends, and financial asset records from Yahoo! Finance to predict how financial assets (stocks, bonds, T-bills, etc.) should react to current trends in internet search traffic. Collecting financial data and comparing it to internet trends then presenting it in meaningful ways (graphs and correlation predictions) is a significant task that typically requires several programs and many hours. Recognizing this I have decided to develop a single program to perform these tasks and represent the findings in an organized and clear style. With fewer programs to manage users would take on less stress and have a clearer mindset to

make accurate decisions that in theory should align with what the FPPT indicates.

4 - Amazon Review to Forecast Product Match
Alexa Baldon, University of Scranton, Scranton, PA, United States, Alex Rudniy, Ahmed Gomaa

This work presents the Product Matchup system automating product comparison based on features extracted from customers' reviews, which are considered as an output of an online social network of customers sharing their experiences and answering each other's questions. We apply natural language processing methods, such as n-gram analysis and sentiment analysis to extract product features, calculate sentiment polarity of product reviews, and produce summarizing reports. In summary, reviews are split into n-grams, which are used to build a list of features. The system matches products based on their features. It allows to identify products containing a feature of interest and distinguish products where the feature is mentioned mostly negatively or positively. Finally, the user is enabled with browsing reviews per product, per feature, and per sentiment polarity.

5 - Predicting the Outcomes of Baseball Games Using Machine Learning Approaches
Michael Delevan, Student, University of Scranton, Scranton, PA, United States, Alexander Rudniy

This work studies forecasting of the Major League Baseball scores by utilizing openly available data and machine learning algorithms. The data was gathered through openly available baseball archives and social media sources. Machine learning algorithms were used to predict the winner and the final score. The produced models achieved up to 92% accuracy when applied to past games. When applied to future games, accuracy dropped to 53% while RMSE score changed from 1 to 3.5. The study demonstrated that exploratory data analysis and feature engineering improve the overall predictive ability of machine learning models. Rolling 10-game average for imputing data for future games proved to be a successful approach. As well, several simpler machine learning models outperformed the more sophisticated artificial intelligence models showing that sometimes simpler is better.

6 - Social Media for Product Demand Forecasting
Alexander Rudniy, University of Scranton, Scranton, PA, United States

This work demonstrated promising results for forecasting product demand based on insights retrieved with the help of social media analytics Google and Twitter Trends are used to forecast demand for products possessing certain features. Natural Language Processing techniques are employed for initial data processing. Deep learning artificial intelligence methods, such as Convolutional Neural Network and Long Short-Term Memory Neural Network, along with time series analysis are utilized for forecasting. Several models are evaluated on the historical Amazon sales data. The study identifies improvement in forecasting results due to the application of social media variables.

■ VMC55

Virtual Room 55

New Frontiers in Behavioral OM

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Evgeny Kagan, Johns Hopkins Carey Business School, Baltimore, MD, 21202-4673, United States

1 - How Humans can Benefit from Personalized AI Support
Andreas Fuegener, University of Cologne, Köln, 50923, Germany

While humans typically benefit from advice, we demonstrate that advice from a common source, such as an AI, has a detrimental effect on unique human knowledge. This harms group decision settings, where diversity is crucial. A potential way out is personalizing AI advice with the goal to maintain positive effects on individual performance without harming unique human knowledge and the potential to perform in group settings.

2 - Decision Bias In Project Selection: Experimental Evidence From The Knapsack Problem
Tom Pape, University of Cambridge, Cambridge, United Kingdom, Stylianos Kavadias, Svenja C. Sommer

Governments and businesses face the same fundamental challenge in resource allocation: to select the most valuable projects while respecting the budget constraint. Operations Research offers algorithms to solve these knapsack problems, but the higher complexity of real-world selection problems makes their adoption impractical. Instead, decision makers perform mental searches. Through a lab experiment, we show that mental search is biased towards selecting too many small-cost projects, leading to inefficient resource allocation. This fundamental bias stems from decision makers predominantly building up feasible solutions. We recommend elimination search to counterbalance this bias.

3 - Seeing The Bigger Picture? Ramping Up Production With The Use Of Augmented Reality
Enno Siemsen, University of Wisconsin-Madison, Madison, WI, 53706-1324, United States, David Wuttke, Ankit Upadhyay, Alexandra Wuttke-Linnemann

Firms increasingly use augmented reality (AR) devices to improve their production ramp-up processes. Our field experiment provides empirical evidence related to the strengths and weaknesses of AR in the ramp-up of production. When faced with a new task, workers instructed by AR smart glasses achieve a 74% higher flow rate compared with a control group. However, workers that use AR glasses consistently perform 21% slower than the control group when both groups repeat the task, without either AR or paper-based instructions. After the devices have been removed, workers instructed based on paper improve their productivity faster through learning than those instructed by AR. In addition, the former group suggests better process improvements than the latter.

4 - Does Redeeming Loyalty Rewards Increase Customer Loyalty
Yang Chen, Queen's University, Smith School of Business, Kingston, ON, K7L 4A9, Canada, Anton Ovchinnikov, Nicole Robitaille

Loyalty points are, in essence, artificial switching costs introduced by loyalty programs. For consumers, redeeming rewards from loyalty programs is often associated with a positive experience that in turn should increase their loyalty. However, the redemption processes actually "frees" them from these switching costs and as a result could make strategic consumers less loyal. With a large longitudinal proprietary data set, our study investigates the direct and mediated effects of reward redemption behavior on long term consumer loyalty. We find differential effects of redemption on loyalty depending on the relative size of redemptions.

■ VMC56

Virtual Room 56

Countless Possibilities: A Panel Discussion with Minority Women in OR/MS

Sponsored: Women in O.R./MS (WORMS)

Sponsored Session

Chair: Banafsheh Behzad, California State University, Long Beach, CA, 90808-0506, United States

1 - Moderator
Banafsheh Behzad, California State University, Long Beach, CA, 90808-0506, United States

This panel consists of a few minority female professionals from both academia and industry. They will share their stories, talk about their careers, their successes and their struggles. We will discuss ways to increase the presence of minority women in our profession.

2 - Panelist
Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States

3 - Panelist
Estelle Kone, PhD, Goldman Sacha, New York, NY, United States

4 - Panelist
Jessye Talley, Morgan State University, Baltimore, MD, 21251, United States

5 - Panelist
Trilce Encarnacion, University of Missouri- St. Louis, Saint Louis, MO, 63121, United States

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

■ VMC57

Virtual Room 57

Innovation, Technology, and Development Contests

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

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

Co-Chair: Zhi Chen, National University of Singapore, Singapore, 138676, Singapore

1 - Optimal Feedback In Contests

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

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

2 - Dueling Contests On Crowdsourcing Platforms

Konstantinos Stouras, UCD Smurfit Business School, Dublin, 17676, Ireland, Sanjiv Erat, Casey Lichtendahl

We study the design and social efficiency in the equilibrium of dueling crowdsourcing contests and competing solvers.

3 - Data Sharing In Innovations

Zhi Chen, National University of Singapore, Singapore, 119245, Singapore, Jussi Keppo

Many innovations today are data-driven such as self-driving cars. To improve the algorithms of these products, firms make substantial investments in data collection. However, the data is limited for an individual firm. This paper studies whether data collected by individual firms should be shared in order to promote innovation.

4 - Dynamic Development Contests

Ersin Korpeoglu, University College London, London, E14 5AA, United Kingdom, Sina Khorasani, Vish Krishnan

We study dynamic development contests that can help organizations outsource their development projects at the minimum lead time by stimulating competition among suppliers. We show that dynamically adjusted flexible rewards can achieve the absolute minimum expected lead time by paying the absolute minimum expected reward (i.e., the first best). We further study the case where the organization does not have sufficient budget to offer a reward that attains the absolute minimum expected lead time. We propose that the organization can dynamically increase the contest reward until its budget constraint binds and then use an easy-to-implement random-update policy where the organization periodically monitors the status of suppliers at random times and immediately discloses any partial progress. Our policy outperforms other canonical information disclosure strategies.

■ VMC58

Virtual Room 58

On demand Mobility: Operation and Competition

Sponsored: Transportation Science and Logistics

Sponsored Session

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

1 - Competition And Congestion In The Ride-for-hire Market

Daniel Vignon, University of Michigan, Ann Arbor, MI, United States

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

2 - A Joint Parking Allocation and Ride Matching Problem

Fernando A. Acosta Perez, University of Puerto Rico-Mayaguez, Aguadilla, PR, United States, Hector J. Carlo, vDaniel Rodriguez-Roman

The standard policy prescription to address parking scarcity problems is to implement pricing schemes. Pricing, however, generates equity concerns and considerable political opposition. Therefore, this study proposes an alternative parking demand management strategy that circumvents income-based equity concerns and attempts to address the transportation needs of all drivers. Rather than using pricing mechanisms, in the proposed scheme parking slots are assigned, free of cost, to drivers based on the available parking supply and the information in the reservation requests of users. Concurrent to the parking allocations, carpools are coordinated to serve users whose parking requests are denied. An optimization model is proposed to jointly determine the parking allocations and carpools, and a heuristic is developed to find solutions to the proposed problem.

3 - Fleet Sizing for Automated Mobility-on-Demand Services

Michael Hyland, University of California-Irvine, Irvine, CA, 92697-3600, United States

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

4 - Should Ubers Be Used As Flexible Shuttles?

Partha S. Mishra, PhD Student, Northwestern University, Evanston, IL, United States, Sunil Chopra, Sebastien Martin, Karen Smilowitz

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

5 - The Integrated On-demand Bus Routing Problem: Combining On-demand Buses With A Fixed Route Network

Lissa Melis, PhD, University of Antwerp, Antwerp, Belgium, Kenneth Sörensen

The on-demand bus routing problem (ODBRP) combines the dial-a-ride problem with bus stop assignment. The aim of this problem is to assign each passenger to an origin and arrival bus stop within walking distance, and develop a set of bus routes, serving all passengers in time. An on-demand bus system would expand the accessibility of public transport, but it would not be able to replace e.g., high-frequency metro lines. Therefore, we introduce the integrated ODBRP or I-ODBRP. In the I-ODBRP part of each journey may be carried out by a fixed route service. We will present a heuristic for this problem and determine ways to shorten the computation time by smartly assigning fixed lines and buses to passengers.

■ VMC59

Virtual Room 59

Transportation-Freight I

Contributed Session

Chair: Vishal Badyal, Clemson University, Central, SC, 29630-4412, United States

1 - Modeling And Solving The Container-Loading Problem With Regular And Irregular-Shaped Cargo

Juan Carlos Pachón, Universidad de los Andes, Bogota, Colombia, German Pantoja, Daniel Cuellar, Camilo Quiroga, Luis Escobar, Laura Escobar, César Marín, David Álvarez

The container-loading problem (CLP) has not been extensively studied with irregular-shaped cargo. Irregularity increases the complexity and extends the CLP scope (e.g., packing of furniture and mechanical parts). We propose a mathematical model (MILP) and a heuristic approach (based on simulated movements and forces) for the CLP considering regular and irregular-shaped cargo. These two approaches verify three constraints: containment, non-overlapping, and non-intertwining. We compared the performance of these approaches with methodologies that solve regular and irregular 3D packing problems.

2 - The Behavior Prediction Of Senders And Couriers In A Real-world Crowd-shipping System
Hui Shen, University of Illinois-Chicago, Chicago, IL, United States, Jane Lin

This research aims to study the behavior of senders in producing delivery requests and the behavior of couriers in bidding requests in a real-world crowd-shipping (CS) service. Several deep learning (DL) methods are developed to predict the short-term delivery requests by considering both spatial and temporal attributes. Some popular machine learning (ML) methods are estimated to analyze the factors that affect whether couriers bids or not. Besides, the SHAP value is used to explain impacts of features on the target in the ML methods. The findings would give insights on developing strategies to control senders and couriers, and mitigating the imbalance between supply and demand in the CS system.

3 - Loading Kitchens Into Trailers: A Package Bundling Heuristic For A Container Loading Problem With Multi-Drop Constraints
Jakob Schulte, Bielefeld University, Bielefeld, Germany, Michael Roemer, Kevin Tierney

We address a real world logistics problem arising at a large kitchen manufacturer involving packing sets of boxes containing partially assembled kitchen parts into a trailer. The boxes are considered as given, and thus, the task considered here is to check if they fit into the trailer or not. We consider approximately 500 heterogeneous packages with multi-drop constraints, where all packages of a customer must always be loaded together. To solve this problem, we present a novel multi-start heuristic relying on aggregating packages to bundles.

4 - The End Of "Set It And Forget It'' Pricing? Opportunities For Market-based Freight Contracts
Angela Acocella, Massachusetts Institute of Technology, Cambridge, MA, United States, Chris Caplice, Yossi Sheffi

In the for-hire truckload market, firms experience unexpected costs from contracted transportation service providers due to load rejections. Moreover, the dominant procurement strategy results in long-term fixed-price contracts that become stale as providers' networks change and freight markets fluctuate between over and under supply. We build behavioral models of carriers' load acceptance decisions under two distinct market conditions. We quantify carriers' contract price stickiness as their best-known alternative priced load options become more attractive for different lane, freight, and carrier segments to identify best opportunities for market-based contracts.

5 - A Holistic Approach For Intermodal Facility Location And Freight Distribution Under Hurricane Disruptions
Vishal Badyal, Clemson University, Clemson, SC, United States, William G. Ferrell, Nathan Huynh, Bhavya Padmanabhan

We study the intermodal facility location problem under hurricane disruptions. Hurricanes can cause disruption in supply at shippers and throughput capacity at intermodal facilities. Realistic hurricane scenarios are generated using k-means clustering. A level method-based decomposition solution approach is applied. The model is tested and validated by developing a case study for the state of South Carolina. Real-world data sets (FAF4 and HURDAT2) are used. The results show that as direct shipping costs increase, the long-term savings using this model increase non-linearly. The increase in direct shipping cost leads to more intermodal locations selected despite being partially disrupted.

■ VMC60

Virtual Room 60

Game Theory for Security Panel

Sponsored: Military and Security

Sponsored Session

Chair: Quanyan Zhu, New York University, New York University, New York, NY, 11201, United States

1 - Panelist
Quanyan Zhu, New York University, New York, NY, 11201, United States

2 - Panelist
Stefan Rass, Universitaet Klagenfurt, Klagenfurt, Austria

3 - Moderator
Quanyan Zhu, New York University, New York, NY, 11201, United States

■ VMC61

Virtual Room 61

Coordination And Planning For Advanced Air Mobility Applications

Sponsored: Aviation Applications

Sponsored Session

Chair: Karthik Gopalakrishnan, Massachusetts Institute of Technology, Cambridge, MA, 02139-4933, United States

1 - Presenter
Christopher Chin, United States

Advanced air mobility operations are expected to significantly increase the demand for limited airspace resources. Two key characteristics of these operations are that flights will have short lead times and operators may be unable or reluctant to share flight intent information. We design a protocol that determines the "rules-of-the-road" for airspace access in dynamic, reduced-information settings. We leverage the concepts of backpressure and cycle detection to avoid gridlock and promote efficiency, and present several flight- and operator-level prioritization schemes to promote fairness. We evaluate the impacts of the prioritization schemes with simulation and find that backpressure prioritization yields the most efficient solution and accrued delay or dominant resource prioritization is the fairest depending on the user's choice of fairness metric.

2 - Trust But Verify: Cryptographic Data Privacy For Mobility Management
Kaidi Yang, Stanford University, Stanford, CA, United States, Matthew Tsao, Stephen Zoepf, Marco Pavone

The era of Big Data brings opportunities for a richer understanding of user behavior through massive data sets. In transportation research, data provides Municipal Authorities (MA) with insights on how to operate, regulate or improve the transportation network. Mobility data, however, contains sensitive information on users and trade secrets of Mobility Providers (MP). Data privacy also introduces a question of verifiability; how does one check the correctness of numerical studies when the data cannot be shared due to privacy concerns? Using ideas from cryptography, we propose a protocol between a MA and a MP that enables MA to obtain insights from data in a verifiable and privacy-preserving manner.

3 - Decentralized Traffic Management for Urban Air Mobility
Suda Bharadwaj, The University of Texas at Austin, Austin, TX, United States

Urban air mobility (UAM) refers to air transportation services within an urban area, often in an on-demand fashion. No established infrastructure exists for providing air traffic management (ATM) at scale for UAM. We propose a decentralized, hierarchical architecture for UAM ATM that allows for scalability to high traffic densities as well as providing theoretical guarantees of correctness with respect to user provided safety specifications. The architecture employs a contract-based correct-by-construction reactive synthesis approach to generate controllers for ATM that provably guarantee safety across the entire system. We also show how the framework can be extended to incorporate minimum-violation planning in cases where safety violations cannot be avoided.

■ VMC62

Virtual Room 62

Latest Developments in Scheduling and Supply Chain

Informs Special Session: Scheduling and Project Management

Informs Special Session Session

Chair: Zhi-Long Chen, University of Maryland, College Park, MD, 20742-1815, United States

1 - Adding Capacity To Parallel Batch Machine
Zhixin Liu, University of Michigan-Dearborn, Dearborn, MI, 48126-2638, United States, Jun Xu, Jun-Qiang Wang

Scheduling performance naturally improves with machine capacity, but the per-unit improvement typically decreases with extra capacity. We consider parallel batch scheduling on identical machines to minimize the makespan. We analyze the impact of machine capacity on the objective function and determine optimal machine capacity that minimizes the weighted sum of scheduling objective and capacity cost.

2 - Tasking Scheduling Problems With Progress Control On Parallel Machines

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

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

3 - Online Integrated Production And Distribution Scheduling: Review And Extensions

Zhi-Long Chen, University of Maryland, Robert H. Smith School of Business, College Park, MD, 20742-1815, United States

We survey existing results on online integrated production and distribution scheduling problems, and present some new results.

■ VMC64

Virtual Room 64

Global Optimization and Computing Applications

Sponsored: OPT/Global Optimization

Sponsored Session

Chair: Daphne Skipper, United States Naval Academy, Annapolis, MD, 21402-1363, United States

1 - Hungry For Equality: Fighting Food Deserts With Optimization

Drew Horton, University of Colorado Denver, Denver, CO, United States

Food deserts are a form of food insecurity that have been exacerbated by the ongoing COVID-19 pandemic, and disproportionately affects marginalized communities. To address food deserts, and the existing inequities, we demonstrate how the Kolm-Pollak equally-distributed equivalent function (EDE) can be minimized over a facility location integer program to minimize not only expected distance but also the inequality of the distribution. The EDE is a nonlinear function making the problem computationally significantly harder than the traditional model, therefore we discuss various ways to approach the optimization including a piecewise linear relaxation of the model, and present results demonstrating how our model works on real-world data to produce an optimal distribution of grocery store locations.

2 - Approximating A Linear Multiplicative Objective In Watershed Management Optimization

Nelson A. Uhan, United States Naval Academy, Annapolis, MD, 21402-5026, United States, Daphne Skipper, Daniel E. Kaufman

We investigate the problem of applying pollution controls (best management practices or BMPs) to the Chesapeake Bay in order to minimize the resulting pollutant load, as computed by a widely used regulatory watershed model, subject to budgetary and environmental constraints. Due to how the pollutant load is computed, this problem is naturally formulated as a nonlinear program with a linear multiplicative objective function. To handle this nonlinearity, we approximate the nonlinear program as a linear program with exponentially more variables. We examine the theoretical and computational behavior of these models, and investigate substantially smaller and carefully crafted restrictions of the linear program. We show that the linear program and its restrictions approximate the problem well in practice, despite their poor approximation properties in the worst case.

3 - Minimization Of A Particular Singular Value

Michael C Rotkowitz, Amazon, Palo Alto, CA, United States

We consider the problem of minimizing a particular singular value of a matrix variable, neither the largest nor the smallest, with the matrix subject to various constraints. This simply stated but unstudied problem arises in control theory, where it serves as the main obstacle to computing metrics for stabilizability, controllability, and robustness. Prior work found fast methods for obtaining upper bounds, but scalable lower bounds remained elusive. We show how to achieve convex upper and lower bounds for this problem, beginning with using a Difference of Convex (DC) formulation.

4 - Risk Based Allocation Of COVID-19 PPEs Under Supply Shortages

Gohram Baloch, University of Waterloo, Waterloo, ON, Canada, Fatma Gzara, Samir Elhedhli

We consider a resource allocation problem for personal protective equipment (PPEs) by integrating government supply and procurement decisions with healthcare facilities' PPE usage policy. We present a modelling framework to make these decisions simultaneously to minimize both infection risk and monetary cost to the government. We derive closed-form expressions under different objective criteria to present easy-to-use policies to decision-makers. A mixed-integer quadratically constrained program (MIQCP) is also proposed to handle real-life PPE distribution planning problems. An Ontario-based case is built to derive managerial insights.

5 - Two-stage Distributionally Robust Optimization In Natural Disaster Management

Mohamed El Tonbari, ISyE Georgia Tech, Atlanta, GA, United States, Alejandro Toriello, George L Nemhauser

We are motivated by natural disaster applications where data is limited. We solve a two-stage distributionally robust optimization model with a Wasserstein ambiguity set, where the first stage is a facility location problem and the second stage is a fixed-charge transportation problem. We develop a column and constraint generation algorithm and handle the presence of binary variables in the second stage by leveraging the structure of our support set and of the second stage value function.

6 - Creating Equitable Communities Through Natural Disaster Recovery

Anna C Svirsko, Assistant Professor, United States Naval Academy, Annapolis, MD, United States, Daphne Skipper, Tom Logan, Tommy Reeder, Christina Domanowski

When a natural disaster strikes, a resident's ability to access services such as food and gas, are crucial to rebuilding the community. Instead of simply rebuilding, a natural disaster can be used as a catalyst to create equitable communities where residents have increased access to these services. We develop an integer programming model that determines a recovery plan after a natural disaster which looks to provide access as quickly as possible while also considering equitable access in the long-term. We solve both the deterministic and robust model with data from Hurricane Florence to demonstrate the advantages of including uncertainty in the recovery process.

■ VMC65

Virtual Room 65

Dynamic Decision Making in Transportation

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Kianoush Mousavi, University of Toronto, Toronto, ON, M5S 3A6, Canada

1 - Same-Day Delivery With Fairness

Xinwei Chen, University of Iowa, Iowa City, IA, 52242-1419, United States, Tong Wang, Marlin Wolf Ulmer, Barrett Thomas

The demand for same-day delivery (SDD) has increased rapidly in the last decade and has particularly boomed during the COVID-19 pandemic. Existing literature focuses on maximizing the expected number of customers served. However, such solutions result in unequal opportunities for customers to receive the service, raising concerns about unfairness. In this talk, we present SDD with fairness and develop a deep Q-learning approach to learn policies that focus on both overall and regional service rates. Computational results demonstrate the effectiveness of our approach in mitigating the unfairness caused by bias in the distance to depot and the density of customer requests. We also illustrate the long-term benefits of fairer service.

2 - A Deep Reinforcement Learning Approach For The Meal Delivery Problem

Mucahit Cevik, Ryerson University, Toronto, ON, M5B 2K3, Canada, Hadi Jahanshahi, Aysun Bozanta, Ayse Tosun, Eray Kavuk, Ayse Bener

We consider a meal delivery service fulfilling dynamic customer requests given a set of couriers over the course of a day. A courier's duty is to pick-up an order from a restaurant and deliver it to a customer. We model this service as a Markov decision process and use deep reinforcement learning as the solution approach. Our numerical experiments show that, by incorporating the geographical locations of the restaurants, customers, and the depot, our model significantly improves the overall service quality as characterized by the expected total reward and the delivery times. Our results present valuable insights on both the courier assignment process and the optimal number of couriers for different order frequencies on a given day. The proposed model also shows a robust performance under a variety of scenarios for real-world implementation.

3 - Multi-Period Workload Balancing With Delivery Familiarity In Last-mile Urban Delivery

Yang Wang, Tsinghua University, Beijing, 100084, China, Lei Zhao, Barrett Thomas

In the daily dispatching of urban deliveries, a last-mile delivery station manager has to consider workload balance among the couriers to maintain workforce morale. We consider two types of workload: incentive workload, which relates to the delivery quantity, and effort workload, which relates to the delivery time. Further, a courier can deliver packages faster if he/she is more familiar with the delivery locations (e.g., traffic conditions, entrances, etc.). We explicitly incorporate delivery familiarity with learning and forgetting curves in our workload balancing model. We formulate the problem as a Markov Decision Process, develop a solution algorithm using approximate dynamic programming, and perform a numerical study on the performance of the proposed algorithm against benchmark policies and the derived managerial insights.

4 - Dynamic Same-day Delivery With Crowd-shipping: Approximate Dynamic Programming Approach

Kianoush Mousavi, University of Toronto, Toronto, ON, M5S 3A6, Canada, Merve Bodur, Mucahit Cevik, Matthew Roorda

We present a dynamic crowd-shipping model which employs in-store customers as crowd-shippers for delivering online orders within few hours to their delivery locations. Furthermore, we present an approximate dynamic programming solution algorithm to obtain a high-quality matching policy by incorporating spatial and temporal uncertainty of crowd-shippers and online orders.

■ VMC66

Virtual Room 66

Optimization Over Sparse And Low-rank Structures

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Ryan Cory-Wright, MIT, Cambridge, MA, 02141-1534, United States

1 - A New Perspective On Low Rank Optimization

Ryan Cory-Wright, MIT, Cambridge, MA, 02141-1534, United States, Dimitris Bertsimas, Jean Pauphilet

A key question in many low-rank problems is to characterize the convex hulls of simple low-rank sets and judiciously apply these convex hulls to obtain strong yet affordable convex relaxations. We apply the matrix perspective function —the matrix analog of the perspective function — to characterize explicitly the convex hull of epigraphs of convex quadratic, matrix exponential, and matrix power functions under rank constraints. Further, we exploit these characterizations to develop strong relaxations for a variety of low-rank problems including reduced rank regression and factor analysis. We establish that these relaxations can be modeled via semidefinite, relative entropy, and matrix power cone constraints and thus optimized over tractably. The proposed approach parallels and generalizes the perspective reformulation technique in mixed-integer optimization.

2 - Sparse And Low Rank Matrix Decomposition: A Discrete Optimization Approach

Nicholas Andre G. Johnson, United States

The Sparse Plus Low-Rank decomposition problem (SLR), or the problem of approximately decomposing a data matrix into a sparse matrix plus a low-rank matrix, arises throughout many fundamental applications in Operations Research, Machine Learning and Statistics. The difficulty of this problem stems from the natural rank and sparsity constraints which are non convex and non smooth. Existing approaches are heuristic in nature, many relying on nuclear norm and L1 norm based convex relaxations, and do not possess optimality guarantees. We introduce a novel formulation for SLR that directly models the underlying discreteness of the problem. For this formulation, we develop an algorithmic approach to solving SLR to certifiable optimality by deriving a strong heuristic, a strong convex relaxation and embedding these within a custom branch and bound routine.

3 - Sparse Quadratic Optimization With Sparse Matrices

Peijing Liu, University of Southern California, Los Angeles, CA, United States, Andres Gomez, Simge Kucukyavuz

We study problems arising in sparse regression, where additionally the model matrix is sparse. We first show that a class of problems with tridiagonal matrices can be solved efficiently in polynomial time. For problems involving sparse but not tridiagonal matrices, we discuss decomposition approaches using Fenchel duality that leverage sparsity and produce high quality solutions in a fraction of the time required to solve the problems using standard techniques.

4 - Kfw: A Frank-wolfe Style Algorithm With Stronger Subproblem Oracles

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

This talk proposes a new variant of Frank-Wolfe (FW),called kFW. Standard FW suffers from slow convergence:iterates often zig-zag as update directions oscillate around extreme points of the constraint set. The new variant, kFW, overcomes this problem by using two stronger subproblem oracles. The first is a k linear optimization oracle (kLOO) that computes the k best update directions. The second is a k direction search (kDS) that minimizes the objective over a constraint set represented by the k best update directions and the previous iterate. When the problem solution admits a sparse representation, both oracles are easy to compute, and kFW converges quickly for smooth convex objectives and several interesting constraint sets: kFW achieves finite convergence on polytopes and group norm balls, and linear convergence on spectrahedra and nuclear norm balls.

■ VMC67

Virtual Room 67

Towards the Future of Air Traffic Flow Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Lu Dai, University of California, Berkeley, CA, United States

1 - Evaluation Of Wind And Convective Weather Impacts On Trajectory-based Operations (TBO)

Gabriele Enea, Technical Staff, MIT Lincoln Laboratory, Lexington, MA, 02421, United States, Michael McPartland

The FAA is evolving the air traffic control system from a tactical, position-based approach, to a more strategic, trajectory-based operations (TBO) approach. Currently, TBO systems do not have appropriate information about convective weather and extreme wind conditions to continue to operate effectively under these demanding conditions. This presentation will discuss MIT Lincoln Laboratory work in building the TBO Weather Testbed to develop a roadmap of studies and enhancements necessary to support TBO under all wind and weather conditions and the vision to create weather-aware TBO automation.

2 - Requirements Consideration For Commercial Aircraft Formation Flight

Safa Saber, King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia, Eric Feron

Aircraft have been flying in formation for mutual benefit for about a century. The possibility of commercial aircraft formations are only now becoming a viable option due to modern flight control systems and more capable computation. At the same time, commercial aircraft formations are also becoming a valuable construct due to congested airspace and the desire for greater fuel efficiency. The realization of commercial formations requires serious consideration of aircraft deconfliction and safety during closer-in maneuvering of large aircraft. This paper introduces formation deconfliction of transport category aircraft and presents possible solutions and questions for further research.

3 - Predicting Future Delay In The National Airspace System

Mark M. Hansen, University of California-Berkeley, Berkeley, CA, 94720, United States

Air traffic flow management (ATFM) is the regulation of air traffic in order to minimize overall delays in the NAS, while ensuring capacity is not exceeded. To shed some light on the future TFM concepts and strategies, we employ machine learning techniques to model the system-wide delay for the 2010s, with a wide range of location-specific, time-varying features. In this presentation, we will discuss to what degree the NAS delay is changing over time, and how different factors affect the NAS performance spatially and temporally. Moreover, the model estimates are transferable to a counterfactual context for enhancing our understanding of how the system and its environment have changed and affected the system delay over time.

4 - Applying Artificial Intelligence To Air Traffic Flow Management

Craig Wanke, MITRE Corporation, McLean, VA, 22102, United States

Recent successes in applying machine learning (ML) to decision making suggest that such techniques could help solve the complex task of air traffic flow management (ATFM), a discipline marked by large design spaces and high uncertainty. We have been exploring the use of ML to generate new ATFM strategies and to study the performance of traditional ATFM approaches. This talk will cover some successes and some newfound challenges in using ML for ATFM.

■ VMC68

Virtual Room 68

Recent Advances in Nonconvex Optimization I

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

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

Co-Chair: Madeleine Udell, Cornell University, Ithaca, NY, 14850, United States

1 - Polynomial Time Guarantees for the Burer-Monteiro Method

Diego Cifuentes, Georgia Institute of Technology, Atlanta, GA, 02139-4301, United States

The Burer-Monteiro method is one of the most widely used techniques for solving large-scale semidefinite programs (SDP). The basic idea is to solve a nonconvex program in Y, where Y is an n×p matrix such that X = YY'. In this paper, we show that this method can solve SDPs in polynomial time in an smoothed analysis setting. More precisely, we consider an SDP whose domain satisfies some compactness and smoothness assumptions, and slightly perturb the cost matrix and the constraints. We show that if p √(2+2)m, where m is the number of constraints and >0 is any fixed constant, then the Burer-Monteiro method can solve SDPs to any desired accuracy in polynomial time, in the setting of smooth analysis. Our bound on p approaches the celebrated Barvinok-Pataki bound in the limit as goes to zero, beneath which it is known that the nonconvex program can be suboptimal.

2 - Low-rank Projections for Low-rank Non-Smooth Matrix Optimization

Atara Kaplan, Technion, Haifa, Israel

Low-rank and nonsmooth matrix optimization problems capture many fundamental tasks in statistics and machine learning. While significant progress has been made in recent years in developing efficient methods for smooth low-rank optimization problems that avoid maintaining high-rank matrices and computing expensive high-rank SVDs, advances for nonsmooth problems have been slow-paced. We consider standard convex relaxations for such problems. Mainly, we prove that under a natural generalized strict complementarity condition and under the relatively mild assumption that the nonsmooth objective can be written as a maximum of smooth functions, the projected extragradient method, when initialized with a “warm-start" point, converges with rate O(1/t) while requiring only two low-rank SVDs per iteration.

3 - Why Are Neural Networks Better Than Convex Learners?

Yuanzhi Li

Multi-layer neural networks, trained based on non-convex objectives, has demonstrated superior power in practice over traditional convex learners such as kernel methods/linear function over prescribed feature mappings. In this talk, we formally study why are deep learners better than traditional convex learners. We first show that under certain mild regularization conditions, any convex learners must be shallow -- They can only take form of linear functions over prescribed feature mappings. We then show that deep learning can perform hierarchical learning efficiently, where those convex (shallow) learners can not. As a result, we conclude that deep learning can provably learn many natural concept classes much more efficiently than convex learners.

4 - Beyond Gradient Dominance Of Linear Quadratic Regulator: A Generalized Framework

Yue Sun, University of Washington, Seattle, Seattle, WA, United States

Policy iteration, or policy gradient method, as named in Bradtke et al, is first used to solve linear quadratic regulator (LQR) problem, and recently becomes prevailing for reinforcement learning. For optimal control, policy iteration seeks optimal controllers for unknown dynamical systems by searching in the policy space directly, which is a model free method. Recent research shows the “gradient dominance” property for a few problems such as LQR, mixed H_2/H_infty control, etc., but the property has so far been verified on a case-by-case basis. In our work, we make a connection between these works and classical convexification techniques with linear matrix inequalities, and propose a unified framework showing gradient dominance indeed holds for a broad class of problems including LQR, optimal control using system-level parameterization and minimizing the L_2 gain.

■ VMC69

Virtual Room 69

Exact and Approximation Algorithms for Distributionally Robust Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Nan Jiang, Virginia Tech, Virginia Tech, Blacksburg, VA, 24061, United States

Co-Chair: Weijun Xie, Virginia Tech, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Wasserstein-based Distributionally Robust Multistage Stochastic Programming In Transmission Expansion Problem

Hideaki Nakao, Argonne National Laboratory, Lemont, IL, 48105, United States, Kibaek Kim, Siqian Shen

The transmission Expansion Planning problem aims to improve and update the electricity transmission infrastructure to adapt to the changes of load and generation in power systems by minimizing the cost of expanding existing transmission circuits for future operation. We formulate the problem by a multistage mixed-integer stochastic programming model and consider a distributionally robust variant to take into account the shortages of data on the uncertainty of future loads and generation capabilities. We employ a dual decomposition algorithm and analyze the numerical performance through randomly generated instances.

2 - Optimistic Distributionally Robust Policy Optimization

Chaoyue Zhao, University of Washington, Seattle, WA, 74075, United States, Jun Song

Trust Region Policy Optimization (TRPO) and Proximal Policy Optimization (PPO), as the widely employed policy based reinforcement learning methods, are prone to converge to a sub-optimal solution as they limit the policy representation to a particular parametric distribution class. To address this issue, we develop an innovative Optimistic Distributionally Robust Policy Optimization algorithm, which effectively utilizes Optimistic Distributionally Robust Optimization approach to solve the trust region constrained optimization problem without parameterizing the policies. Our algorithm improves TRPO and PPO with a higher sample efficiency and a better performance of the final policy while attaining the learning stability. Experiments across tabular domains and robotic locomotion tasks demonstrate the effectiveness of our approach.

3 - New Algorithms And Complexity Analysis For Distributionally Robust Multistage Convex Optimization

Shixuan Zhang, Georgia Institute of Technology, Atlanta, GA, United States, Andy Sun

We present a novel algorithmic study and complexity analysis of stagewise independent distributionally robust multistage convex optimization (DR-MCO). A new class of dual dynamic programming (DDP) algorithms for solving DR-MCO is proposed. The new algorithms generalize existing DDP-type algorithms by introducing the technique of regularization that enables the algorithms to handle fast growth of Lipschitz constants, and problems without relatively complete recourse. We then provide a thorough complexity analysis of the new algorithms, proving both upper complexity bounds and a matching lower bound. Numerical examples are given to show the effectiveness of the proposed algorithms.

4 - Distributionally Favorable Optimization: A Generic Framework For Data-driven Decision-making With Outliers

Nan Jiang, Virginia Tech, Blacksburg, VA, United States, Weijun Xie

This work studies Distributionally Favorable Optimization (DFO), which seeks an optimal decision under the most favorable distribution. When the data contain outliers, the commonly-used Distributionally Robust Optimization (DRO) model may over-emphasize the unrealistic outliers or scenarios and cause misleading decisions. On the contrary, DFO can significantly mitigate the effects of outliers and has been not yet well studied. Thus, this paper fills the gap and shows that DFO recovers many robust statistics and can be more robust with the existence of outliers; and while being NP-hard in general, DFO can be tractable in many cases. We further propose a generic DFO framework for the data-driven optimization with outliers and extend it to solve two-stage stochastic programs without relatively complete recourse.

■ VMC70

Virtual Room 70

Recent Advances In Nonlinear Optimization Under Uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Anirudh Subramanyam, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

1 - Adaptive Robust Parallel Machine Scheduling

Krzysztof Postek, Assistant Professor, Delft University of Technology, Delft, Netherlands

Real-life machine scheduling problems involve (i) limited information about the task duration at scheduling time, and (ii) an opportunity to reschedule the remaining tasks each time a machine becomes idle. Robust optimization can cope with the first characteristic, yet the existing literature does not consider the second characteristic. We develop an approach that takes into account, at the beginning of the planning horizon, the possibility that scheduling decisions can be adjusted, showing that it can lead to better here-and-now decisions. To that end, we develop the first MILP model for adjustable robust scheduling, where we minimize the worst-case makespan. We show via a numerical study that adjustable scheduling leads to solutions with better and more stable makespan realizations compared to static approaches.

2 - CVaR Optimization: Extreme Value Theory Perspective

Joseph Kennedy, Auburn University, Auburn, AL, United States, Alexander Vinel

Conditional-Value-at-Risk (CVaR) is a well-known and well-studied measure of risk that is widely used in stochastic optimization applications. In the presence of low sample size and heavy-tailed distributions, though, its empirical estimation can be highly inaccurate. However, extreme value theory (EVT) methods can leverage more sample points, and are known to produce more reliable estimates of tail behavior. We demonstrate that despite significant computational challenges, linear portfolio optimization can be accomplished with EVT-based estimators and illustrate some advantages and disadvantages of this approach, particularly compared to the standard linear programming formulation.

3 - Risk-averse Regret Minimization In Multi-stage Stochastic Programs

Mehran Poursoltani, HEC Montreal, Montreal, QC, H3S1W4, Canada, Erick Delage, Angelos Georghiou

Within the context of optimization under uncertainty, a well-known alternative to minimizing expected value or the worst-case scenario consists in minimizing regret. In a multi-stage stochastic programming setting with a discrete probability distribution, we explore the idea of risk-averse regret minimization, where the hindsight decisions benefit from getting access to the realizations of a certain number of stages ahead. We provide theoretical and numerical insights about this paradigm under popular risk measures and shed light on the effect of the length of the period used by the decision-maker when evaluating regret.

4 - An Active-set Method For Two Stage Stochastic Quadratic Programming

Niloofar Fadavi, Southern Methodist University, Dallas, TX, United States, Harsha Gangammanavar

In this talk, we examine two-stage stochastic quadratic programming problems, where the objective function of the first and second stages are quadratic functions and the constraints are linear. The uncertainty is associated with the second-stage right-hand sides. One of the main challenges we face is solving the second-stage problem, when the random variable associated with the right-hand side has a continuous support or a large number of scenarios in the discrete case. To deal with this issue, we develop the dual active-set strategy to obtain an approximate solution for the second-stage problem. This approximation is used to design a computationally efficient solution algorithm to solve stochastic quadratic programs. We will present the convergence and numerical analysis of the algorithm.

5 - Gradient Formulae For Nonlinear Probabilistic Constraints With Non-convex Quadratic Forms

Wim van Ackooij, EDF R&D, Palaiseau, France, Pedro Pérez-Aros

Probability functions appearing in chance constraints are an ingredient of many practical applications. Understanding differentiability, and providing explicit formulae for gradients, allow us to build nonlinear programming methods for solving these optimization problems from practice. Unfortunately, differentiability of probability functions cannot be taken for granted. Motivated by gas network applications, we investigate differentiability of probability functions acting on non-convex quadratic forms. It turns out that these inequality systems make the analysis of the probability functions significantly harder. In this talk we will discuss these issues. We will also establish continuous differentiability for the broad class of elliptical random vectors under mild conditions.

■ VMC71

Virtual Room 71

Passenger Rail I

Committee Choice: Railway Applications

Committee Choice Session

Chair: Jiateng Yin

Co-Chair: D'Ariano Andrea, Italy

1 - Automatic Train Dispatching: A Real-life Application in the Greater Oslo Region

Carlo Mannino, SINTEF Digital, Oslo, Norway, Giorgio Sartor, Andreas Nakkerud, Oddvar Kloster, Christian Schulz, Bjørnutar Leberget, Giorgio Grani

Serving more than a million residents, the railway network of the Greater Oslo Region is composed of several lines incident to the large Oslo central station (Oslo S). An ongoing project with Bane NOR, the Norwegian infrastructure manager aims at developing a system to dispatch trains for the entire region. A prototype of such system is currently being tested by Bane NOR dispatchers. It uses mathematical optimization and decomposition to find optimal schedules (every few seconds) based on the real-time train positions and the network status. To our knowledge, this is the largest real-life application of automatic train dispatching in Europe.

2 - Effective Pruning Strategies for the Alternative Graph Model

Marcella Sama, Roma Tre University, Rome, Italy, Andrea D'Ariano, Dario Pacciarelli

We present static and dynamic speed-up procedures and pruning strategies to efficiently handle hard deadline constraint in the alternative graph model. The idea is to prove that no improvement to the current best-known solution is possible if a specific sequencing/timing decision is taken for a given partial or empty solution. Static speed-ups allow to effectively reduce the initial number of variables in a pre-processing phase. Dynamic ones take place during the solution process and can extend a partial scheduling by avoiding infeasibility areas in the search space. Computational experiments on train scheduling instances show the potential gain that can be obtained.

3 - Train Scheduling Optimization For Commuter-metro Networks: An Improved Job-shop Formulation With Procedence Constraints

Jiateng Yin, Beijing Jiaotong University, Kowloon, China

In this study, we address the train scheduling problem for commuter rail-metro systems, where the trains from commuter rail lines can go directly into metro systems to provide seamless services for passengers. In order to optimize the schedule of trains for both commuter rail lines and metro lines, we propose an improved job-shop scheduling model by taking a series of practical constraints arising from commuter-metro networks into account and develop a mixed-integer programming (MIP) model with quadratic constraints. Since these constraints involve several sets of IF-THEN logic rules, we prove that these logic constraints can be equivalently reformulated as linear inequalities, without adding new variables. Two sets of numerical experiments are implemented to verify the effectiveness (be more precise) of the proposed approaches.

4 - Including Stochasticity In Railway Traffic Management Models

Francesco Corman, ETH Zurich, Zurich, Switzerland, Alessio Trivella, Oskar Eikenbroek

Railway traffic management determines control actions, like changing times of events or rerouting vehicles, to improve quality of operations and updating an offline timetable to delays. Those actions are taken in real-time and under uncertainty regarding the future evolution of the disturbances. How transport operators and travelers react to the decision is also subject to uncertainty. We discuss how to extend job shop models for railway traffic control to incorporate uncertainty. We present approaches going beyond the commonly accepted assumption of determinism and full certainty regarding the future operations. Uncertainty can be described by distributions or stochastic processes; stochastic optimization can solve the resulting high-dimensional stochastic control problem.

■ VMC72

Virtual Room 72

IBM and DecisionBrain Demonstrate: Inbound Logistics Optimization for Toyota and Mobile Workforce Optimization for JLL

Sponsored: Data Mining

Sponsored Session

Chair: Shouyi Wang, University of Texas at Arlington, Arlington, TX, 76019-1000, United States

1 - Panelist
Jigna Jhamnani, Decision Brain, Paris, France

2 - IBM and DecisionBrain demonstrate: Inbound Logistics Optimization for Toyota and Mobile Workforce Optimization for JLL
Filippo Focacci, Decision Brain, Paris, 75010, France

3 - Panelist
Vanessa Henry, Decision Brain, Paris, France

■ VMC73

Virtual Room 73

Decision Analysis Applications II

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Victor Tang, Massachusetts Institute of Technolog, Cambridge, MA, United States

1 - Countering Misinformation: Techniques To Mitigate The Belief Perseverance Bias
Jana Siebert, Palacky University Olomouc, Olomouc, Czech Republic, Johannes Ulrich Siebert

The spread and influence of misinformation have become a matter of concern in society. Research has shown that simple retraction of misinformation is not sufficient to eliminate its influence on individuals. A reason for the failure of simple retractions is the belief perseverance bias. However, the research on mitigating the belief perseverance bias has been scarce. We develop two debiasing techniques with a higher potential for practical applicability than existing techniques and show in an experiment that they are effective in mitigating the belief perseverance bias after the retraction of misinformation.

2 - Nearest Neighbors One-sample Estimation of Information Value
Mariusz Budzinski, Bocconi University, Milano, Italy

Quantitative models are widely used to aid decision-makers in the solution of complex decision analysis problems. Under uncertainty, sensitivity analysis, and uncertainty quantification play an important role. In Decision Analysis, a special role is played by the value of information and the key aspect is the ability for approximating it numerically. This work presents an algorithm based on the nearest neighbors' approach for approximating information value and estimating information density. The proposed solution seems to outperform existing methods in lower dimensions and is easy to implement.

3 - Representing And Modeling Group Option-generation Process
Jiahui Zhang, Tsinghua University, Beijing, China, Chen Wang, Lefei Li

We propose a novel empirical method that characterizes the group option-generation process in two stages: one is to use natural language processing to represent the cognitive space of a group based on their conversation transcripts; second is to assess the inclinations of exploration versus exploitation by a multivariate Hawkes process. With a unique dataset of a high-school product design contest, we identify three types of brainstormer groups - thinker, propeller and mechanic, and analyze how the ways of navigating the cognitive space affect popularity and novelty of the generated options.

4 - Robust Decisions: Definition, Necessary And Sufficient Conditions, Mathematical Methodology, And A Complex Example
Victor Tang, Massachusetts Institute of Technology, Cambridge, MA, United States

This paper is about Robust Decisions. First, a definition: Robust Decisions have highly insensitive outcomes to uncontrollable conditions even when uncontrollable factors are not removed. Second, robust decisions seek outcomes that satisfice. Third, the decision process must be statistically reproducible and repeatable. Fourth, any hypothetical "what-if" question, from the decision space and outcome space, must be rigorously answerable. Fifth, we present our rigorous mathematical methodology for robust decisions. Sixth, we solve a complex real-world problem to reveal its robust solution, whose outcome space has 1,374,389,534,720 decision alternatives.

■ VMC74

Virtual Room 74

Judgment in Predictive Analytics

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Matthias Seifer, Operations & Technology Area, IE Business School -, Madrid, 28006, Spain

■ VMC75

Virtual Room 75

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 - Stable Online Set Cover With A Cycle Time Consideration
Daniel Chen, Amazon.com, Seattle, WA, United States, Tolga Cezik

We consider fulfilling customer requests comprising multiple tasks, and servers fulfill tasks by accessing a node. In order to maintain a high service rate with a fixed number of servers, it is crucial to select nodes for assigning to servers such that each node access fulfills a consistently high number of tasks. This can be modeled as a stable online set cover problem, with an added cycle time consideration since partially completed customer requests take up space in a buffer until fully completed. We discuss applications in robotic picking and content delivery protocols.

2 - Optimal Trailer Management Using a Multi-Period Multi-Location Variant on the Newsvendor Model
Dmitriy Belyi, Amazon.com, Austin, TX, 78750-4024, United States

We consider the trailer management problem in Amazon's transportation network, where we must allocate available trailers to accommodate all transportation needs at the lowest cost. This problem is fraught with uncertainty and high dimensionality, and is difficult to model and solve using standard approaches. In this talk, we consider a novel modeling approach for this problem, reminiscent of the classic newsvendor. We also present an efficient parallelized solution methodology based on marginal costs.

3 - Solving Large-scaled Constrained Network Flow Problems With A Modern MIP Solver
Cid Carvalho de Souza, Amazon, Seattle, WA, 13083-852, United States

In this talk, we report on our experience in solving large-scaled models for constrained network flow problems with a modern MIP solver. The sizes of the instances we deal with are challenging, as they often have tens of millions of variables and constraints. We discuss the actions taken to increase efficiency, including the development of a MIP-based warm start heuristic and the reformulation of the problem. We analyze the impact of these initiatives both in terms of run time and solution quality. Results show that the proposed approaches were effective for the instances to remain tractable.

■ VMC76

Virtual Room 76

Artificial Intelligence III

Contributed Session

Chair: Pedro Cesar Lopes Gerum, Cleveland State University, Lakewood, OH, 44107, United States

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

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

2 - Creating A Self-sufficient Virtual Platform For Medical Visits For Expectant Mothers Using High-reliability Organizations And The Human-organization-technology Model

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

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

3 - What Went Wrong? Signals And Mechanisms For Unintended Consequences In AI

Madhav Sharma, Oklahoma State University, Stillwater, OK, United States, David P. Biros, Corey Baham

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

4 - Dynamic Probabilistic Deep Learning Forecasting Models for Traffic Congestion

Pedro Cesar Lopes Gerum, Cleveland State University, Cleveland, OH, United States

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

■ VMC77

Virtual Room 77

Idea to Product to Business

Informs Special Session: New Product Development

Informs Special Session Session

Chair: Hallie Sue Cho, PhD, Vanderbilt University, Nashville, TN, 37203, United States

1 - Quality, Time And Designer Satisfaction With Collaborative Computer-aided Design Tools: A Series Of Experiments

Alison Olechowski, Assistant Professor, University of Toronto, Toronto, ON, Canada

Computer-Aided Design (CAD) software is a key tool for new product development. Recently CAD has moved from a single-user tool to a collaborative one; real-time synchronous CAD platforms are now commercially available. This capability enables new ways of designing products, analogous to those seen in software development, such as pair programming. Yet little is known about the effect of this enhanced collaboration affordance on the outcomes of new product design. I will present the results of a series of experiments that compare the performance of pairs of designers to individual designers. Experimental evidence suggests that collaborative design enhances CAD model quality at the cost of lower time efficiency. Further, designers working in pairs exhibit higher levels of emotion, indicating a more engaging and, therefore, satisfying experience.

2 - Going Beyond Conversational Partners: Entrepreneurs' Framing And Audiences' Support For Their Innovations In Online Platforms

Jamie Seoyeon Song, Assistant Professor, ESMT Berlin, Berlin, Germany

This study examines how entrepreneurs' framing of their innovation influences the audience evaluation in a widely public domain. In such a domain, I argue that showing alignment with entrepreneurs' immediate conversational partners may limit the understanding of the wider audience who are observing the conversations To test this idea, I use rich conversational data from Product Hunt, an online product discovery platform. I build on the neural-network word embedding model, which is a machine learning algorithm for natural language processing, to capture the similarity between the frames used by conversational partners in their comments and the frames used by entrepreneurs in their responses. Overall, this study contributes to how entrepreneurs can use the conversations with their immediate interactional partners to influence the wider audience.

3 - Discovering "Design Gaps" In The Market Using Machine Learning

Alex Burnap, Yale University, New Haven, CT, United States, John R. Hauser

Successful firms develop products that meet consumer demand, are feasible to produce, and sell at a premium over costs. Marketing has a long history of identifying design gaps that lead to the greatest revenue (and sometimes profit). More recent models consider design feasibility, but the challenges have been the scale of the practical problem. We combine optimization methods with deep learning to search a high-dimensional space to generate new product concepts that balance demand, engineering feasibility, and costs. We test our approach with both synthetic and empirical data from the US automotive market on over one million revealed purchases. Preliminary results suggest that it is possible to identify "design gaps" enabling firms to search more efficiently for profitable new products.

4 - The Role Of Learning Mechanisms On Pivoting Success In Start-ups

Stylianos Kavadias, Margaret Thatcher Professor of Innovation & Growth, University of Cambridge, Cambridge, CB2 1AG, United Kingdom, Konstantinos Ladas

Entrepreneurial pivots have become almost necessities for start-up companies to survive and succeed. However, it remains unclear how should entrepreneurs learn which options to pursue during these pivots. We build an evolutionary model based on the cultural evolution tradition and we identify circumstances where imitation (social learning) benefits more than the often advocated learning based on experiments (so called "scientific entrepreneurialism"). We identify how different learning mechanisms aid or hinder entrepreneurs during their pivoting efforts.

5 - Best In Class: The Effect Of Relative Perceived Quality On Demand In The U. S. Automobile Industry

Hallie Cho, Vanderbilt University, Nashville, TN, United States

This paper explores which factors drive consumers to consider certain products together and which factors set apart the ultimate choice from the rest. Based on co-occurring product mentions in online customer reviews, we find which products are often considered together. Using aggregated customer review measures as a proxy for product quality, we investigate how relative quality amongst similar products influences market shares in a competitive market. Our findings help to understand what drives optimal distinctiveness from the consumer's perspective and have important implications for an automobile manufacturer's product strategy.

■ VMC78

Virtual Room 78

Quantum Optimization: Theory and Applications

Committee Choice: Computing Society

Committee Choice Session

Chair: Ilya Safro, University of Delaware, Newark, DE, United States

Co-Chair: Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY, 10598, United States

1 - Simpler (classical) And Faster (quantum) Algorithms For Gibbs Partition Functions

Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY, 10598, United States, Srinivasan Arunachalam, Vojtech Havlicek, Kristan Temme, Pawel Wocjan

We consider the problem of approximating the partition function of a classical Hamiltonian using simulated annealing. This requires the computation of a cooling schedule, and the ability to estimate the mean of the Gibbs distributions at the corresponding inverse temperatures. We propose classical and quantum algorithms for these two tasks, achieving two goals: (i) we simplify the seminal work of Štefankovi , Vempala and Vigoda (J. ACM, 56(3), 2009), improving their running time and almost matching that of the current classical state of the art; (ii) we quantize our new simple algorithm, improving upon the best known algorithm for computing partition functions of many problems, due to Harrow and Wei (SODA 2020). A key ingredient of our method is the paired-product estimator of Huber (Ann. Appl. Probab., 25(2),2015).

2 - Mathematical Programming Methods For Swap Mapping

Claudio Gambella, IBM Quantum, Dublin, Ireland, Andrea Simonetto, Anton Dekusar, Giacomo Nannicini

In quantum compiling, efficiently placing logical circuits onto the physical architectures amounts to determining a mapping from logical qubits to physical qubits which satisfies two-qubit gate location constraints. Additional gates, e.g. realizing SWAP operations, are typically inserted in order to "move" the logical qubits to other physical ones. In order to keep the circuit as reliable as possible, and limit the execution time, we investigate Mathematical Programming formulations and decomposition algorithms to limit the number of added gates in quantum compiling.

■ VMC79

Virtual Room 79

Decision Making in Agriculture Industry

Informs Special Session: Agriculture

Informs Special Session Session

Chair: Erkut Sonmez, University of Nebraska-Lincoln, Lincoln, NE, 68588-1201, United States

Co-Chair: Heng Chen, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States

1 - Random Yield, Forward Market and Price Formation

Derui Wang, Fudan University, Shanghai, China, Lusheng Shao, Xiaole Wu

This paper studies the interplay of random yield and forward market in a hybrid market with spot and forward transactions. We examine two main questions: How does yield uncertainty affect the equilibrium outcome in this hybrid market? How does the existence of a forward market influence the firms' strategic behaviors and spot price volatility? It is found that as yield risk increases, firms may sell less in the forward market, and higher yield risk may benefit firms and make the spot price less volatile. The existence of a forward market leads to greater spot price volatility. We identify a mitigating effect of yield variability but an enhancing effect of yield correlation, on the role of the forward market.

2 - Improving Proactive Decision Making In Agriculture

Jay Parsons, University of Nebraska-Lincoln, Lincoln, NE, 68583-0922, United States, Johannes Ulrich Siebert

Since 2017, we have conducted a pre and post-evaluation of proactive decision making at the Nebraska Ranch Practicum, an 8-month experience consisting of eight days of instruction on ranching principles in a systems context. The results show participants assess their proactive cognitive skills significantly higher after the course. They have the tendency to be more aware of their objectives and to use these objectives for a purposeful search for relevant information and for a systematical creation of more and better alternatives. Further, they have a tendency to plan their decisions more purposefully. A decision making process is introduced at the beginning but a majority of the course materials cover general ranch production issues. These results provide evidence of the impact even limited exposure to decision making concepts can have on decision makers in agriculture.

3 - Crop Planting Decisions Under Climate Change

Hongqiao Chen, Nanjing University, Nanjing, China, Wenbin Wang, Ming Hu

Climate change imposes a great supply risk on crop yields. We use a theoretical model to study the dynamic Impact of the climate change on firms' crop planting decision and consumers' welfare.

4 - Economic And Environmental Implications Of Biomass Commercialization In Agricultural Processing

Buket Avci, Singapore Management University, Singapore, 178899, Singapore, Bin Li, Onur Boyabatli

We examine the economic and environmental implications of commercializing organic waste (biomass) from the perspective of an agri-processor. We characterize the economic value and find that commercializing biomass makes profits more robust to changes in spot price uncertainty. To examine the environmental implications, we characterize the expected carbon emissions considering the profit-maximizing operational decisions. In comparison with the static model which ignores the changes in operational decisions after commercialization, we identify two types of misconceptions. In particular, we would mistakenly think that biomass commercialization is environmentally beneficial when it is not, and vice versa. Based on our results, we put forward important practical implications that are of relevance to both agri-processors and policy makers.

5 - Farmers' Adoption Of Precision Agriculture - Learning By Doing

Heng Chen, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States, Ying Zhang

Under the prevailing pressure of food shortage, precision agriculture has been adopted to grow more food in a sustainable manner. In this paper, we explore the pricing strategy of the service provider of precision agriculture, considering that farmers may need to learn by observing the trials before adoption.

■ VMC81

Virtual Room 81

Emerging Transportaion and Transportation-Enabled Services

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Hai Wang, Carnegie Mellon University, Pittsburgh, PA, 15213-3725, United States

1 - Routing Optimization With Floating Targets

Alexandre Jacquillat, MIT Sloan School of Management, Cambridge, MA, 2142, United States, Kai Wang, Shuaian Wang, Wei Zhang

In several modern transportation systems, vehicles can choose where to visit customers. Such "floating targets" introduce an additional degree of freedom but complicate operations. The resulting vehicle routing problems with floating targets can be formulated as mixed-integer linear or conic programs, but are too complex to be solved directly in large-scale instances. This paper develops an exact decomposition algorithm, by leveraging the geometric structure of operations to optimize each pickup location, and developing iterative procedures to decompose multi-stop problems into a series of one-stop problems. Computational results show that our solution approach results in superior solutions and shorter computational times than state-of-the-art benchmarks, and enables online implementation in huge-scale instances like New York City.

2 - Multimodal Transportation Alliance Design With Endogenous Demand: Large-scale Optimization For Rapid Welfare Gains

Kayla Spring Cummings, Massachusetts Institute of Technology, Cambridge, MA, 02134-1506, United States, Vikrant Vaze, Ozlem Ergun, Cynthia Barnhart

We present an incentive-aligned collaborative pricing structure for competing urban transportation operators to jointly maximize system welfare. The alliance requires no change in infrastructure and captures behavior of all strategic agents in the system. We demonstrate the alliance's utility on a full-scale case study of the Greater Boston Area which integrates 10 different datasets.

3 - Can Autonomous Vehicles Solve The Commuter Parking Problem?

Neda Mirzaeian, Carnegie Mellon University, Pittsburgh, PA, 15217-1249, United States, Soo-Haeng Cho, Sean Z. Qian

We investigate the effect of autonomous vehicles (AVs) on the morning commute. We characterize a user equilibrium for commuters by developing a continuous-time traffic model that takes into account parking fees and traffic congestion as two key economic deterrents to driving. In addition, we consider the case of a social planner who aims to minimize the total system cost by controlling the commuters' decisions. We illustrate our results using data from Pittsburgh, and show that AVs reduce the need for downtown parking. We also show that, in the short run, adjusting downtown parking fees and imposing tolls on downtown congestion can reduce the total system cost significantly (e.g., a 51% reduction for Pittsburgh), and that adjusting the road and parking capacities as a long-term plan may reduce the total cost even further (e.g., an additional 70% reduction for Pittsburgh).

4 - Optimization Of Ride-sharing From Public Transportation Hub

Hai Wang, Singapore Management University, Singapore, 15213-3725, Singapore, Jiangang Jin

Inter-modal transfer efficiency is the key to success for the Inter-modal passengers transportation systems. Long waiting time often occurs for passengers when they get off trains and transfer to taxis, who also suffer from long waiting times for picking up customers. It becomes urgent for transport hub operators to design systematic approaches to maximize the transfer efficiency between rail trains and last-mile transport. We propose a ride-sharing approach and develop an arc-based mixed-integer linear programming model and a set partitioning model with the objective of minimizing total vehicle operating cost and passenger transfer cost. Two solution approaches are developed: a branch-&-price exact algorithm and a column generation heuristic method.

5 - Choice-driven Service Network Design For An Integrated Fixed Line And Demand Responsive Mobility System

Mette Wagenvoort, Erasmus University Rotterdam, Rotterdam, Netherlands, Shadi Sharif Azadeh, Shadi Sharif Azadeh

Fixed Line and Schedule, FLS, public transport is not always justifiable in sparsely populated areas. Customer satisfaction can increase by partially replacing FLS services with Demand Responsive Transport, DRT. We propose a mixed integer linear problem, MILP, to design an integrated FLS and DRT network and a tailored Adaptive Large Neighbourhood Search, ALNS, with tabu search and simulated annealing. We test our algorithm on real instances from a public transport system in The Netherlands. The algorithm can solve the problem up to 170 times faster than the MILP with a four to ten percent gap. We find that integrating DRT and FLS can increase the service level, especially on non working days.

■ VMC82

Virtual Room 82

E-commerce logistics

Sponsored: TSL/Facility Logistics

Sponsored Session

Chair: Reem Khir, Georgia Institute of Technology, Atlanta, GA, United States

1 - Dynamic Containerized Consolidation In Urban Parcel Logistics

Sara Kaboudvand, ISyE Georgia Tech, Atlanta, GA, 30318, United States, Benoit Montreuil

Hub-based network structures are common in urban parcel logistics for better freight consolidation and economies of scale. However, sorting every parcel at (intermediate) hubs requires significant investment in real-estate, human, and machine resources and imposes extra waiting and processing times. Such re-sorting can be bypassed by smartly encapsulating parcels that share common service features and a subsequent destination. In this study, we formally describe the problem of dynamically consolidating parcels into containers of potentially different sizes, then present and compare four highly scalable heuristic policies. We provide empirical results and a set of sensitivity analyses using an agent-oriented discrete-event megacity logistics simulator developed by Georgia Tech's Physical Internet Center.

2 - Learning-based Online Decision-making in Multi-order Picking Environments

Jana Boerger, Georgia Tech, Atlanta, GA, United States, Marlin Wolf Ulmer, Benoit Montreuil

Promising their customers fast deliveries, retail companies and logistics providers need efficient warehouse processes, especially for the resource consuming order picking. Orders are unknown and are streaming in in real-time. Pickers perform repeated picking trips throughout the day. With a picking trolley or cobot, they move through the warehouse to pick items according to a pick list of ordered items. As multiple orders can be picked concurrently, controls need to carefully balance the trade-off between consolidation and timely fulfillment. Aiming for smart balancing, we present a reinforcement learning based decision-support algorithm and evaluate it through simulations based on real world data.

3 - The Value of Limited Adaptability for Workload Balance in Logistics Operations

Reem Khir, Georgia Institute of Technology, Atlanta, GA, United States, Alan Erera, Alejandro Toriello

This talk presents a flexible assignment balancing problem with a focus on parcel sort systems critical for modern e-commerce operations. The idea is to use simple and practical recourse strategy that allows sort systems to be reconfigured once information about the actual demand is revealed. We introduce the stochastic k-adaptable assignment balancing problem that generates k assignment options apriori with the objective of minimizing the maximum expected workload assigned to any sorter. The goal is to enable decision makers to adapt their operations to a plan that works best under the realized demand while maintaining a good level of consistency and stability in operations desired in practice. We compare exact and heuristic solution approaches and test them on real data obtained from a large parcel carrier.

4 - Dynamic Parcel Consolidation And Containerization In Hyperconnected Logistic Hubs

Nidhima Grover, Graduate Research Assistant, Georgia Institute of Technology, Atlanta, GA, United States, Benoit Montreuil

In Physical Internet-based hyperconnected logistics, parcels are consolidated into modular containers and routed through a network of logistic hubs so that they remain together for a long portion of their multi-hub journey. At hubs where the parcels' joint travel is completed, the containers are opened, and parcels are sorted for final delivery or re-consolidated for the next part of their inter-hub journey. This research focuses on the optimization of parcel consolidation at a hub, considering each parcel's sequence of hubs in the path, arrival time, target time of departure, and dimensions. We develop an optimization model that minimizes handling cost such that delivery time, consolidation target, and other operational constraints are met. We present preliminary computational results that demonstrate the increase in performance due to effective consolidation.

5 - An Optimization Model of U-Shape Kitting Cell Configuration Design

Wencang Bao, Georgia Institute of Technology, Atlanta, GA, United States

Kitting is an effective part-feeding mode to supply varied parts to highly customized assembly lines, however, there are less optimization models of kitting cell design have been investigated yet. Considering material handling and space cost, we focus on U-shape configuration, build an optimization model to determine: 1. the size of the kitting cell, 2. the storage type of each part and 3. the location of each part. To deal with the computational inefficiency, we propose an Upper-Lower-Bounds (ULB) strategy to accelerate the solving process via deciding the max and min number of parts in each storage type. Experiments show that our model can get a significantly lower cost than current benchmarks. Finally, some heuristic algorithms are discussed.

■ VMC83

Virtual Room 83

Optimizing Ride-Sourcing Vehicle Routing, Tolling and Information Provision

Sponsored: TSL/Intelligent Transportation Systems

Sponsored Session

Chair: Song Gao, University of Massachusetts, Amherst, MA, 01002, United States

1 - A Co-optimization Approach for Compensating Toll Facility Concessionaires for Reduced Tolls during Roadway Maintenance

Sohrab Mamdoohi, George Mason University, Fairfax, VA, 22030-7108, United States, Elise Miller-Hooks, Jonathan Gifford

Execution of improvement activities, such as maintenance and repair, along roadways reduces roadway capacity and, thus, increases traffic congestion. This study investigates the potential to reduce such resulting congestion through an option to reimburse a toll facility concessionaire for decreasing or suspending tolls during improvement activity execution. The problem of determining optimal toll prices, concessionaire remuneration and improvement action schedules is formulated through concepts of bilevel mixed integer programming and equilibrium modeling.

2 - A Game Theorectic Approach for Ride-hail Vehicle Routing

Kenan Zhang, Northwestern University, Evanston, IL, 60208-0001, United States, Nie Yu

This study proposes a game-theoretic approach to modeling the routing behaviors of drivers in a spatiotemporal ride-hail market. Driven by profit, idle drivers move across local markets for passenger search and their search strategies are modeled as Markov decision process (MDP). Since the probability of meeting a passenger in a local market is determined by the number of idle drivers, each driver has to optimize his own search strategy given others' strategies. The collective vehicle routing behaviors lead to an MDP congestion game. We characterize the congestion game for two common ride-hail modes, namely, street-hail and e-hail, and develop a solution algorithm to solve the equilibrium.

3 - Optimal Routing of Multiple Vacant Taxis: A Policy Gradient Method with Endogenous State Transition Probabilities

Guocheng Jiang, University of Massachusetts-Amherst, Amherst, MA, United States, Song Gao

We study the optimal routing of a fleet of vacant taxis that operate under rules set by a platform (such as Uber), with knowledge of spatial and temporal order distribution but not the exact detail until assigned to one by the platform. The problem is formulated as a Markov Decision Process where the state transition probabilities are determined endogenously, accounting for the dependence of taxi-passenger matching probabilities on taxi spatial distribution in the process of optimizing a stochastic policy that determines taxi spatial distribution. The stochastic policy is parameterized and the optimal policy parameter that maximizes the average reward is then obtained using a policy gradient method. A case study in Shanghai, China shows the promise of the the proposed approach in improving routing efficiency compared to a few base cases.

4 - Who Are The Beneficiaries Of Predictive Travel Information? Modeling Dynamic Stochastic User Equilibrium With Diverse Pre-Trip Information

Xiaoyu Ma, Rensselaer Polytechnic Institute, Troy, NY, United States, Xiaozheng He

Pre-trip traffic information significantly affects travelers' decisions on departure time and route, calling for modeling and analyzing information impact on traffic system performance. This research proposes a new stochastic dynamic traffic assignment model consisting of two classes of travelers, who receive predictive and instantaneous pre-trip travel time information, respectively. Findings show that, at equilibrium, travelers with predictive information gain benefits in travel time reliability but have to endure longer average travel time. This research advances our understanding of the impact of pre-trip information and provides insights into information provision strategies.

■ VMC84

Virtual Room 84

Daniel H. Wagner Prize for Excellence in the Practice of Advanced Analytics and Operations Research: III

Award Session

Chair: Margret V Bjarnadottir, University of Maryland, College Park, MD, 20742, United States

1 - Interpretable OR for High-Stakes Decisions: Designing the Greek COVID-19 Testing System

Vishal Gupta, USC Marshall School of Business, Los Angeles, CA, United States, Hamsa Sridhar Bastani, Kimon Drakopoulos

After the first wave of the COVID-19 pandemic abated, countries sought to ease restrictions on non-essential travel while still safeguarding public health. In collaboration with Greece, we designed and deployed a national-scale targeted testing system to dynamically allocate Greece's limiting testing resources to screen visitors at the border for COVID-19. The system combines responsive supply-chain design, a novel empirical Bayes estimation strategy, and a new batched, multi-armed bandit algorithm with constrained actions and delayed feedback. We detail the method and impact of our system.

■ VMC86-2

Virtual Room 86

Technology Tutorial: Multi-objective Optimization and its Pareto Extension

Technology Tutorial

1 - Multi-objective Optimization and its Pareto Extension

Ferenc Katai, IBM, Valbonne, 6560, France, Evgeny Shindin

In real life optimization problems, we often seek solutions representing the best trade-offs between conflicting objectives. Existing methods dealing with multi-objective optimization usually output a solution representing a single pre-defined trade-off. In order to produce additional meaningful trade-offs, we present Diversity Maximization Algorithm (DMA) for Multi-objective optimization. This algorithm outputs a set of diverse optimal solutions that lie on Pareto Frontier, thus allowing the user to efficiently explore the optimal solutions space.When you interact with IBM, this serves as your authorization to INFORMS or its vendor to provide your contact information to IBM in order for IBM to follow up on your interaction. IBM's use of your contact information is governed by the IBM Privacy Policy

Monday, 1:30PM - 2:30PM

■ Keynote 01

CC - Ballroom A /Virtual Theater 1

Keynote: Multiagent Reasoning for Social Impact: Results from Deployments for Public Health and Conservation

Keynote Session

1 - Multiagent Reasoning for Social Impact: Results from Deployments for Public Health and Conservation

Milind Tambe, University of Southern California, Los Angeles, CA, 90089, United States

With the maturing of AI and multiagent systems research, we have a tremendous opportunity to direct these advances towards addressing complex societal problems. I focus on the problems of public health and conservation, and address one key cross-cutting challenge: how to effectively deploy our limited intervention resources in these problem domains. I will present results from work around the globe in using AI for HIV prevention, Maternal and Child care interventions, TB prevention and COVID modeling, as well as for wildlife conservation. Achieving social impact in these domains often requires methodological advances. To that end, I will highlight key research advances in multiagent reasoning and learning, in particular in, computational game theory, restless bandits and influence maximization in social networks.In pushing this research agenda, our ultimate goal is to facilitate local communities and non-profits to directly benefit from advances in AI tools and techniques.

■ Keynote 02

CC - Ballroom B /Virtual Theater 2

Keynote: Stochastic First Order Oracles and Where to Find Them

Keynote Session

1 - Stochastic First Order Oracles and Where to Find Them

Katya Scheinberg, Cornell University, Ithaca, NY, 14853, United States

Continuous optimization is a mature field, which has recently undergone major expansion and change. One of the key new directions is the development of methods that do not require exact information about the objective function. Nevertheless majority of these methods, from stochastic gradient descent to "zero-th order" methods use some kind of approximate first order information. We will overview different methods of obtaining this information, including simple stochastic gradient via sampling, robust gradient estimation in adversarial settings, traditional and randomized finite difference methods and more. We will discuss what key properties of these inexact, stochastic first order oracles are useful for convergence analysis of optimization methods that use them.

■ Keynote 03

CC - Ballroom C /Virtual Theater 3

Omega Rho Distinguished Lecturer: A Journey through Public Sector Operations Research

Informs Special Session: Keynote

Informs Special Session Session

1 - A Journey through Public Sector Operations Research

Laura Albert, University of Wisconsin-Madison, Middleton, WI, 53562, United States

Societally important problems have driven the theory and application of operations research since its origins in World War II. Recent events have highlighted the enormous number of challenges that require expertise from operations research and analytics. The operations research community has a long history of stepping up to address challenging problems in the public sector through modeling, computation, and data analytics that has influenced policy and impacted practice. This has been a central theme of my academic career, which has focused on security, emergency response, public safety, and risk management. This talk discusses several research problems, focusing on how operations research has made a difference, and offers a blueprint for how the operations research community can tackle future challenges, impact society, and broadcast our message to the world.

■ Keynote 04

CC - Ballroom D /Virtual Theater 4

Keynote: A Dynamic Queueing Road Map from Communication Systems to Resource Sharing Services

Keynote Session

1 - A Dynamic Queueing Road Map from Communication Systems to Resource Sharing Services

William A. Massey, Professor, Princeton University, Princeton, NJ, 08544, United States

The field of operations research applies mathematics to the creation of quantitative languages designed for strategic decision making. Queueing theory was invented just over a century ago to design efficiency into communication systems. In the 21st century, it plays this same role in the design of resource sharing services. Rates for customer service demand can easily be dependent on the time of day, week, or seasonal effects. Hence dynamic rate queues are more realistic stochastic models than their traditional constant rate counterparts. Moreover, since they are not amenable to classical steady state analysis techniques, dynamic rate problems lead to greater mathematical challenges. Along with many collaborators, this talk covers a personal research journey to develop a dynamic rate queueing theory. We also show how the guideposts for our path evolved from communication systems to resource-sharing services.

Monday, 2:45PM - 4:15PM

■ MD01

CC - Ballroom A / Virtual Theater 1

Hybrid - Panel Discussion on Editor's Perspective in Publishing Data Science-Focused Papers

Sponsored: Quality, Statistics and Reliability

Sponsored Session

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

Co-Chair: Raed Al Kontar, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - Panelist
Yu Ding, Texas A&M University, College Station, TX, 77843-3131, United States

2 - Panelist
Jing Li, Georgia Institute of Technology, Tempe, AZ, 85287-8809, United States

3 - Panelist
Ramaswamy Ramesh, SUNY Buffalo, East Amherst, NY, 14051-1687, United States

4 - Panelist
L. Allison Jones-Farmer, Miami University, Oxford, OH, 45056, United States

■ MD02

CC - Ballroom B / Virtual Theater 2

Hybrid - Recent Advances in Planning and Scheduling Under Uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Karmel S. Shehadeh, Lehigh University, Bethlehem, PA, 18015-1518, United States

1 - Optimized Scenario Reduction: Solving Large-scale Stochastic Programs With Quality Guarantees
Wei Zhang, Faculty of Business, The Hong Kong Polytechnic University, Hong Kong, Alexandre Jacquillat, Kai Wang, Shuaian Wang

Stochastic programming involves large-scale optimization with exponentially many scenarios. We propose an optimization-based scenario reduction approach to generate high-quality solutions and tight lower bounds by only solving small-scale instances. First, we design a scenario subset selection model that minimizes the recourse approximation error over a pool of solutions. We provide theoretical results to support our formulation, and a tailored heuristic algorithm to solve it. Second, we propose a scenario assortment optimization approach that generates a lower bound—hence, a solution quality guarantee—by relaxing nonanticipativity constraints across scenario bundles. We formulate an optimization model to maximize this lower bound, and design exact row-generation and column-generation algorithms to solve it.

2 - Strategic Idling In Appointment Systems With Sequential Servers
You Hui Goh, Nanyang Technological University, Singapore, Singapore, Zhenzhen Yan

This paper studies an appointment scheduling problem with two sequential servers from a distributionally robust optimization (DRO) perspective. Conventionally, schedules are optimized to minimize the expected total cost including customers' waiting costs and servers' overtime costs. Yet, the schedule obtained can lead to imbalanced waiting times in two servers, concentrating on the downstream server. To ensure a balanced waiting time in two servers without rescheduling patients, we adopt an idea in the queueing literature to strategically idle the upstream server. We propose a DRO model to calculate the optimal strategic idling (SI) policy considering the correlations in service times.

3 - Distributionally Robust Home Service Routing And Appointment Scheduling With Random Travel And Service Times
Man Yiu Tsang, Lehigh University, Bethlehem, PA, United States, Karmel S. Shehadeh

We study an integrated routing and appointment scheduling (RAS) problem arising from home service practice. Given a set of customers within a region that an operator needs to serve, we seek for the operator's route and time schedule. The travel time and service time of each customer are random with unknown distributions. Only a possibly small set of historical data is available. To address this, we propose and analyze two distributionally robust home service RAS (DHRAS) models that search for decisions to minimize the worst-case expectation of operational costs over distributions residing within an ambiguity set. We use a moment based ambiguity set and a 1-Wasserstein distance based ambiguity set. We derive equivalent MILP reformulations of both models. In an extensive numerical experiment, we investigate the proposed models' performances and derive insights into DHRAS.

4 - Presenter
Chrysanthos Gounaris, Carnegie Mellon University, Pittsburgh, PA, United States

5 - Valid Inequalities For Approximating The Robust Surgery Scheduling Problem
Ankit Bansal, University of Minnesota, Minneapolis, MN, United States, Jean-Philippe P. Richard, Bjorn Berg, Yu-Li Huang

An approximation of the two-stage robust optimization surgery-to-OR allocation problem is presented. The second-stage problem is linearly relaxed and three types of valid inequalities which approximate the integer hull are derived. The resulting linear relaxation of the second stage problem is then dualized and integrated into the first-stage problem. A column-generation based approach is used to solve the resulting MILP, yielding an approximation of the problem. Data from an academic medical center is used to compare the computational performance of the approximate approach and its solution quality with the only known exact approach in the literature. Managerial insights are discussed.

■ MD03

CC - Ballroom C / Virtual Theater 3

Hybrid - Michael H. Rothkopf Junior Researcher Paper Prize

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Robert Day, University of Connecticut, Storrs, CT, 06269-1041, United States

1 - Designing Approximately Optimal Search On Matching Platforms
Alexander Wei, University of California-Berkeley, Berkeley, CA, United States

We study the design of a two-sided matching market in which agents' search is guided by a platform. The platform determines the rates at which agents of different types meet, while agents strategically accept or reject the potential partners whom they meet. We focus on the platform's problem of optimal search design in a continuum matching market model where agents have symmetric pairwise preferences. The platform's objective is to find meeting rates that maximize the equilibrium social welfare of the resulting game. Incentive issues arising from congestion and cannibalization make this design problem intricate. Nonetheless, we give an efficiently computable solution that achieves 1/4 the optimal social welfare. Our solution shows the platform can substantially limit choice while maintaining approximately optimal welfare through a carefully chosen search design.

2 - Award Presenter
Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, 94305-5008, United States

3 - When is Assortment Optimization Optimal?
Will Ma, Columbia University, New York, NY, 02139-3516, United States

A classical question in economics is whether complex, randomized selling protocols can improve a firm's revenue beyond that of simple, take-it-or-leave-it posted prices. Myerson (1981) answered this question with an emphatic ``No'' for a monopolist selling a single good. By contrast, for multiple goods, randomized lotteries can significantly increase revenue. We ask the same question for assortment optimization, where the firm cannot control the pricing but must decide on a set of substitute products to offer. To formalize such a question, we introduce a Bayesian mechanism design problem with fixed prices and ordinal customer preferences which captures assortment optimization. We show that generally, a top-k lottery can increase revenue, but for specific choice models the best deterministic assortment is revenue-optimal.

■ MD04

CC - Ballroom D / Virtual Theater 4

Hybrid - Online Platform Design and User Engagement

Sponsored: Information Systems

Sponsored Session

Chair: Qinglai He, Arizona State University, Tempe, AZ, 85281, United States

1 - Access To IT And Future Of Work In The U.S.

Leting Zhang, Temple University, Philadelphia, PA, 19122, United States, Taha Havakhor, Rajiv Sabherwal

These digital transformations in working conditions post-COVID-19 can be resource-intensive for less-ready businesses. Capitalizing on the opportunity provided by the staggered introduction of stay-at-home orders across 48 states in the U.S. during the first wave of COVID-19 and natural variations in availability of IT services and resources in different regional (county-level) areas, we examine if the lack of sufficient access to businesses to IT resources posed as a barrier in the seamless transformation to WFH during those stay-at-home periods. Our findings show that counties without adequate business access to IT resources experience higher rates of unemployment after stay-at-home orders. We also identify the types of IT resources that help and hurt during the WFH transformation.

2 - How Data Privacy Regulations Affect Competition: Emprical Evidence From Mobile Application Market

Xi Wu, Temple University,, PA, 19122, United States, Min-Seok Pang

Data has become a new type of asset for firms, provoking a discussion of data privacy and security. Government regulators start enacting privacy regulations to ensure the transparency of data collection and processing. How these regulations impact competition is a critical question that has not been thoroughly studied. Our study applies a DID framework to examine the effect of GDPR on the mobile app market. We find that the competition in the free app market has become more volatile after the implementation of GDPR than before. Interestingly, however, the opposite effect is found in the paid app market. Our results suggest that GDPR has significantly affected the competition in the app market. Also, the apps' pricing strategies influence this impact. Our work contributes to multiple streams of the IS literature and provides meaningful insights for policymakers and firms.

3 - Herding Effects Of Subjectivity On Emotional Polarization And Hate Speech In Online Political Discourse

Amin Sabzehzar, Arizona State University, Tempe, AZ, United States

A recent study by Pew Research Center shows that most Americans can only identify 60% of fact-based political statements from subjective opinions. This paper speaks to this issue by studying the influence of subjective comments on the quality of political discourse in the Reddit r/politics subreddit. Our results shed light on the effect of herding behavior in online political discourse by showing that the subjectivity of top-level comment triggers a subjective, high emotional, and low analytical political discourse. Further, we demonstrate the negative role of subjectivity on the quality of political discourse in terms of emotional polarization and hate speech. Our findings contribute to the discussion about social media use and political polarization, highlighting design implications for online platforms to battle political polarization.

4 - A Fair Framework for Unsupervised Outlier Detection Ensembles

Moez Farokhnia Hamedani, University of South Florida, Tampa, FL, United States

Outlier detection ensembles are among the most valuable ML-driven decision support systems. Extensive applications of performance metrics such as accuracy and computational complexity for the evaluation of ML-driven decisions have raised concerns about the fairness of the decisions with regards to different groups of entities. e.g. EMR system auditing might be biased toward specific positions in the system that leads to biased managerial decisions which are made on the basis of the algorithmic outcomes. To address fairness, we propose a fair-framework for debiasing unsupervised ensembles. The proposed framework can be generalized to any ensemble, regardless of the aggregation strategies.

■ MD05

CC - Ballroom E / Virtual Theater 5

Hybrid - A Day in the Life of a Practitioner

Informs Special Session: Informs Section on Practice

Informs Special Session Session

Chair: Sharon Arroyo, Boeing Company, Seattle, WA, 98124-2207, United States

1 - A Day in the Life of a Practitioner

Sharon Arroyo, Boeing Company, Seattle, WA, 98124-2207, United States

In this session, we will be discussing the various responsibilities of an OR practitioner's role in an organisation. This session will be highly informative for graduate students and early career professionals who are looking forward to building an OR practitioner's career.

2 - Panelist

Sharon Arroyo, Boeing Company, Po Box 3707, Seattle, WA, 98124-2207, United States

3 - Panelist

William Christian, Paygevity, Inc., Severn, MD, 21144-1905, United States

4 - Panelist

Rajeev Namboothiri, GE Research, Bangalore, 560066, India

Monday, 2:45pm-4:15pm

■ VMD01

Virtual Room 01

Advances in Comparative Analysis and Modeling

Sponsored: Data Mining

Sponsored Session

Chair: Yanran Liu, Georgia State University, Atlanta, GA, 30303, United States

1 - Collective Attention Allocation for Innovation Productivity in Open-Source Software Projects: A Configurational Perspective

Yanran Liu, Georgia State University, Atlanta, GA, 30303, United States

A thorny issue for open-source software projects is how to organize the collective's attention to achieve innovation objectives of speed, novelty, or both speed and novelty. We advance a collective attention view of partitioning and augmenting attention. Based on fuzzy-set qualitative comparative analyses with data from 363 GitHub machine-learning projects, we identify collective-attention configurations to achieve different innovation objectives.

2 - Visualizing Model Selection and Comparative Meta-models

Dawn He, University of Rochester, Rochester, NY, United States, Yaron Shaposhnik

This paper aims to study means for comparing models in an interpretable manner in order to provide insights into the underlying tradeoffs that govern model selection problems. To this end, we propose various methods that employ ideas from supervised learning, unsupervised learning, and visualization, and demonstrate how they can be used to inform model selection decisions.

3 - Real-time Predictive Analytics Over Space And Time: A Comparative Analysis For Delay Prediction In Railway Transportation

Léon Sobrie, Ghent University, Ghent, Belgium, Marijn Verschelde, Bart Roets, Veerle Hennebel

Predictive analytics are increasingly used in managerial decision-making. We propose a sequence-to-sequence LSTM to predict train delays in real-time that acknowledges the heterogeneity of train delays over space and time. This approach is compared with a rule-based prediction system which highlights its higher performance, especially in more complex settings. Moreover, we demonstrate the ability of this approach to cope with external shocks such as the covid-19 pandemic. The advocated deep learning approach is embedded in a decision support tool deployed in the control rooms of Infrabel.

■ VMD02

Virtual Room 02

Data Science for Complex Data in Healthcare

Sponsored: Data Mining

Sponsored Session

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

1 - MIO-based Decision Model To Learn Association Rules For Unplanned ICU Transfers

Chun-An Chou, Northeastern University, Boston, MA, 02115-5005, United States, Qingtao Cao, Yuchun Zou, Shao-Jen Weng, Che-Hung Tsai

Identifying unplanned ICU transfers is urgently needed for emergency medical physicians to achieve two-fold goals: improving critical care quality and preventing mortality. A priority task is to understand the crucial rationale behind diagnosis results of individual patients during stay in ED, which helps prepare for an early transfer to ICU. In this study, we present a MIO-based decision tool aiming to automatically discover rules associating diagnostic features with high-risk outcome (i.e., unplanned transfers) in different deterioration scenarios. We consider a case study that focuses on four mutually exclusive patient subgroups based on the principal reasons of ED visits: infections, cardiovascular/respiratory diseases, gastrointestinal diseases, and neurological/other diseases at a suburban teaching hospital in Taiwan.

2 - Predicting County-level Pandemic Risk And Relevant Risk Factors Using Machine Learning

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

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

3 - Modeling Of Multivariate Irregularly Sampled Time Series For Predicting Hospital Readmission

Dongping Du, Texas Tech University, Lubbock, TX, 79409-3061, United States, Adib Zaman

Critical care data can be difficult to analyze since they contain mixed data types such as patients' baseline characteristics and physiological measurements. The physiological measurements form high dimensional longitudinal time series with varying sampling rate for a single patient and among different patients. Standard time dependent models like Recurrent Neural Networks, and Long Short Time Memory (LSTM) Networks can only deal with equal time steps. This study presents a method combing Gated Recurrent Unit, Neural Ordinary Differential Equations, and Bayesian estimation to impute sporadically observed measurements in high dimensional time series. The imputed data along with patients' baseline characteristics are further used to predict hospital readmissions.

4 - A Mixed-latent Variable Approach For Modeling Temporally Evolving Service Demand Of A Heterogeneous Population Of Nursing Home Residents

Mingyang Li, University of South Florida, Tampa, FL, 33647-5133, United States, Xuxue Sun, Nan Kong, Meng Hongdao, Chris Masterson

Due the varied individual characteristics and time-varying health conditions, the service demand of nursing home (NH) residents will evolve over time individually differently. Accurate predicting the service demand of individual NH resident during his/her NH stay is the essential basis for proactive and resident-centered care delivery. In this work, we propose a generic modeling approach with mixed-type latent variables to characterize both the sub-population and individual-level temporal heterogeneity of residents' service demand. An effective estimation algorithm is further provided to jointly quantify the influence of varied observed factors on service demand trajectories as well as to estimate the mixed-type latent variables. A real NH case study is provided to illustrate the proposed work and investigate its benefits on improving staffing decisions.

5 - Interpreting Deep Learning Model Predictions Using Shapley Values

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

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

6 - Disease Spread Coupled With Evolutionary Social Distancing Dynamics Can Lead To Growing Oscillations

Ceyhun Eksin, Assistant Professor, Texas A&M University, College Station, TX, 77843, United States, Keith Paarporn, Hossein Khazaei

If the public's adherence to social distance measures remained steady during an outbreak, the number of cases would have a single peak followed by a sharp decline according to standard epidemiological models. Nonetheless, during COVID-19 the initial rise and fall in the number of cases followed new waves of cases in many localities. Here, we explore a standard susceptible-exposed-infected-recovered (SEIR) model coupled with an individual behavior response model that modulates the contact rate. We use replicator dynamics to model the population's response to changes in incentives. Using SEIR dynamics coupled with replicator dynamics, we identify a set of dynamics that can lead to growing oscillations in the number of cases until herd immunity is reached. We provide a proper tool to predict outbreaks, and study the effects of incentive-based public health policies.

■ VMD03

Virtual Room 03

Knowledge Graph and Machine Reading for Knowledge Synthesis from Fragmented Sources

Sponsored: Data Mining

Sponsored Session

Chair: Victor Zitian Chen, University of North Carolina, Charlotte, Charlotte, NC, 28277, United States

1 - Machine Reading Of Science

Gus Hahn-Powell, University of Arizona

2 - Building Probabilistic Causal Models Using Collective Intelligence

Olav Laudy, Ph.D., CausalityLink

In this presentation we show a novel approach to automatically generating Probabilistic Causal Models by applying Natural Language Processing (NLP) techniques to a corpus of millions of digitally published news articles in which views by different authors are expressed on the future states of economic and financial variables. The BNs that we will show how to derive will represent the wisdom-of-the-crowds forward-looking point-in-time views on various variables of interest and their dependencies. These Bayesian Networks are likely to be of interest to economists who want to gain a better understanding of the current drivers of an economy based upon a rigorous probabilistic methodology.

3 - Machine Reading Of Business Research At Scale For Enterprise Performance Management

Victor Zitian Chen, University of North Carolina, Charlotte, Charlotte, NC, 28277, United States, Gus Hahn-Powell

In this research, we cross reference scholarly research and company 10-K reports to detect, extract, and classify causal relationships from text.

4 - Building Domain-Specific Knowledge Graphs From Text

Mayank Kejriwal, University of Southern California

Domain-specific knowledge graph (KG) construction is an active and interdisciplinary research area that has recently witnessed impressive advances due to machine learning techniques like deep neural networks and word embeddings. Today, there is a vast amount of text data available, including text extracted from webpages, natural language documents, social media 'documents' such as tweets and memes, and even free-text descriptions in spreadsheets and CSV files. Constructing KGs over raw text data is a challenging problem that requires techniques from multiple fields, most notably Natural Language Processing. This talk will provide a high-level overview of KG construction from text, and promising directions for future research.

■ VMD04

Virtual Room 04

Data-driven Modeling in Uncertainty Quantification

Sponsored: Data Mining

Sponsored Session

Chair: Ozge Surer, Northwestern University, Northwestern University, Evanston, IL, 60201, United States

1 - Information Criterion For Approximate Bayesian Uncertainty Quantification

Nick Terry, University of Washington, Seattle, WA, United States, Youngjun Choe, Yen-Chi Chen

Approximating a density when it can be evaluated up to a normalizing constant at a limited number of points is called the Boltzmann approximation problem. Such problems are ubiquitous in statistics, with a prime example being approximating a posterior density in Bayesian inference. This posterior approximation is a central problem in Bayesian uncertainty quantification (UQ), where modeling requirements may make conjugacy infeasible. In this work, we develop a novel cross-entropy information criterion (CIC) for addressing this problem by minimizing the cross-entropy between the target distribution and a parametric approximation. We propose a data-driven method for minimizing the CIC to approximate a target distribution. We also provide experimental results which demonstrate how our method can be used for computationally efficient Bayesian UQ.

2 - Bayesian Optimization Of Functional Output In Inverse Problems

Chaofan Huang, Georgia Institute of Technology, Atlanta, GA, United States, Yi Ren, Emily K McGuinness, Mark D. Losego, Ryan P. Lively, V. Roshan Joseph

Motivated by the parameter identification problem of a reaction-diffusion transport model in a vapor phase infiltration processes, we propose a Bayesian optimization procedure for solving the inverse problem that aims to find an input setting that achieves a desired functional output. The proposed algorithm improves over the standard single-objective Bayesian optimization by (i) utilizing the generalized chi-square distribution as a more appropriate predictive distribution for the squared distance objective function in the inverse problems, and (ii) applying functional principal component analysis to reduce the dimensionality of the functional response data, which allows for efficient approximation of the predictive distribution and the subsequent computation of the expected improvement acquisition function.

3 - Uncertainty Quantified Functional Curve Comparisons And Its Application In Wind Energy

Yu Ding, Texas A&M University, College Station, TX, 77843-3131, United States, Abhinav Prakash, Rui Tuo

Wind turbine performance comparison can be framed as a data science problem, which is to compare nonparametric functional curves. This talk discusses how to quantify uncertainty for such nonparametric functional curve comparison and how to use the resulting method to track and compare performance changes of the same turbine over different periods or different wind turbines over the same period.

4 - Active Learning For Deep Gaussian Process Surrogates

Annie Sauer, Virginia Tech, Blacksburg, VA, United States

Deep Gaussian processes (DGPs) are increasingly popular as predictive models in machine learning (ML) for their non-stationary flexibility. Here we explore DGPs as surrogates for computer simulation experiments whose response surfaces exhibit regime shifts. In particular, we transport a DGP's automatic warping of the input space and full uncertainty quantification (UQ), via a novel elliptical slice sampling (ESS) Bayesian posterior inferential scheme, through to active learning (AL) strategies that distribute runs non-uniformly in the input space -- something an ordinary (stationary) GP could not do. Building up the design sequentially in this way allows smaller training sets, limiting both expensive evaluation of the simulator code and mitigating cubic costs of DGP inference. We provide an open source implementation in the "deepgp" package on CRAN.

5 - Calibration Using Emulation Of Filtered Simulation Results

Ozge Surer, Northwestern University, Evanston, IL, 60201, United States, Matthew Plumlee

A scalable method for calibration involves building an emulator after conducting an experiment on the simulation model. However, when the parameter space is large, the resulting simulator responses drastically differ from the observed data. One solution to this problem is to simply discard, or filter out, the parameters that gave unreasonable responses and then build an emulator only on the remaining simulator responses. In this article, we demonstrate the key mechanics for an approach that emulates filtered responses but also avoids unstable and incorrect inference.

■ VMD05

Virtual Room 05

DEA and Data Enabled Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Dariush Khezrimotlagh, Pennsylvania State University - Harrisburg, Middletown, PA, 17057-4846, United States

Co-Chair: Joe Zhu, Worcester Polytechnic Institute, Worcester, MA, 01609, United States

1 - Performance Evaluation of US Financial Institutions Using Extended Network Data Envelopment Analysis

Yu Shi, Worcester Polytechnic Institute, Worcester, MA, United States

In this study, a composite index incorporating financial sustainability indicators is built for the performance evaluation of US financial institutions, using extended network data envelopment analysis (DEA) (Liang et al., 2008). The model consists of two stages, lending efficiency stage and collecting efficiency stage. The extended network DEA model allows for additional inputs to the second stage, and credit risk (proxied by non-performing loans (NPLs)) is considered an undesirable output. Using this model, the performances of different US financial institutions are evaluated, under both the cooperative and the non-cooperative settings.

2 - Introducing The Multivariate Returns To Scale Technology

Dariush Khezrimotlagh, Pennsylvania State University - Harrisburg, Middletown, PA, 17057-4846, United States

In this study, the motivation and construction of the multivariate returns to scale technology (MRTS) are presented. A linear programming data envelopment analysis (DEA) model is suggested as a data-driven tool to measure the corresponding production function and measure the corresponding efficiency score of units. The corresponding technology includes the corresponding variable returns to scale (VRS) technology and is a subset of the constant returns to scale (CRS) technology. As a result, the proposed score is neither less than that of the corresponding CRS DEA model nor greater than that of the corresponding VRS DEA model. The method should be considered for real-life applications when datasets include more than one input and/or more than one output. The process to justify the returns to scale for a dataset is also illustrated.

3 - US Airlines' Performance Pre- and Post-pandemic

Sepideh Kaffash, Suffolk University, Boston, MA, 02108, United States

This paper analyzes U.S. airline performance in response to Covid-19. The study analyzes the efficiency of 10 U.S. airlines pre- and post-pandemic. The paper specifies and differentiates the U.S. airlines' strategic responses, outlines key implications for the post-COVID-19 airline's efficiency benchmarks U.S. airlines' performance and raises attention points for managers and policy makers.

4 - The Estimation of Productive Efficiency Through Machine Learning Techniques: Efficiency Analysis Trees

Juan Aparicio, University Miguel Hernandez of Elche (UMH), Elche, Spain, Miriam Esteve, Jesus J. Rodriguez-Sala, Jose L. Zofio

Many parametric and nonparametric approaches have been introduced in the last forty years for estimating production frontiers. However, few of these methodologies are based on machine learning techniques, despite being a growing field of research. Recently, a bridge has been built between these two literatures, through a new technique proposed in Esteve et al. (2020), called Efficiency Analysis Trees (EAT). The algorithm corresponding to EAT builds upon the Classification and Regression Trees (CART) technique. In this talk, we revise the fundamentals of this new methodology and extend it to the context of measuring productive efficiency under convexification, using the directional distance function.

■ VMD06

Virtual Room 06

Advances in Data-Driven Mechanism Design

Sponsored: Data Mining

Sponsored Session

Chair: Kiefer Joe Burgess, University of Waterloo, Waterloo, ON, N2L 0G7, Canada

1 - Informal Payments And Doctor Engagement In Online Health Community: An Empirical Investigation Using Generalized Synthetic Control

Qili Wang, Warrington College of Business, University of Florida, Gainesville, FL, United States, Liangfei Qiu, Wei Xu

Given the importance of doctor engagement, some online health communities have introduced informal payments to doctors to encourage knowledge sharing. Leveraging the launch of a gifting feature by a leading online health community as a natural experiment that exogenously provides doctors with extra monetary incentives, we empirically examine how informal payments affect doctor engagement. We find that the introduction of informal payments negatively affects doctors' responses to medical consultations. Our results indicate a crowding-out effect of informal payments on doctors' intrinsic motivation of contribution. In addition to contributing to the literature on informal payments, our results provide useful implications for online health communities that have implemented or are planning to implement digital gifting to stimulate user engagement.

2 - Generalization Guarantees For Multi-item Profit Maximization: Pricing, Auctions, And Randomized Mechanisms

Ellen Vitercik, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

We study the design of multi-item mechanisms that maximize expected profit with respect to a distribution over buyers' values. In practice, a full description of the distribution is typically unavailable. Therefore, we study a setting where we have only samples from the distribution and the goal is to find a high-profit mechanism within a class of mechanisms. This raises the question: how many samples are sufficient to ensure that for any mechanism in the class, its average profit over the samples is close to its expected profit? To answer this question, we find structure shared by many pricing, auction, and lottery mechanisms: for any set of buyers' values, profit is piecewise linear in the mechanism's parameters. We prove new bounds for classes not yet studied in the sample-based mechanism design literature and match or improve over the best-known bounds for many classes.

3 - Incentivizing Truthfulness Through Audits In Strategic Classification

Yevgeniy Vorobeychik, PhD, McKelvey School of Engineering, St. Louis, MO, United States

We study the problem of optimal auditing of agents in strategic classification. When decisions are made using a threshold on an agent's score, the optimal audit policy has a surprisingly simple structure, uniformly auditing all agents who could benefit from lying. We show that the scarce resource setting is more difficult, and exhibit an approximately optimal audit policy in this case. In addition, we show that in either setting verifying whether it is possible to incentivize exact truthfulness is hard even to approximate. However, we also exhibit sufficient conditions for solving this problem optimally, and for obtaining good approximations.

4 - Crowd-sourcing For Data Science And Quantifiable Challenges: Optimal Contest Design

Goutham Takasi, The University of Texas at Dallas, Richardson, TX, United States

We study the optimal design of a crowd-sourcing contest when output is quantifiable e.g., a data science challenge. This is in contrast to settings where output can only be assessed qualitatively, e.g designing a logo. Existing research focuses on ordinal contests: outputs are ranked by the organizer and awards are based on these ranks. Such contests are suited for the qualitative setting. For our setting, it is possible to design contests where awards are based on the actual outputs (not just ranks). We derive an easy-to-implement contest design for this setting and prove its optimality.

5 - A Discrete-event Simulation Model for the Bitcoin Blockchain Network with Strategic Miners and Mining Pool Managers

Yining Huang, North Carolina State University, Raleigh, NC, 27606, United States

As the first and most famous cryptocurrency-based blockchain technology, Bitcoin has attracted tremendous attention from both academic and industrial communities in the past decade. A Bitcoin network is comprised of two interactive parties: individual miners and mining pool managers, each of which strives to maximize its own utility. In particular, individual miners choose which mining pool to join and decide on how much mining power to commit under limited constraints on the mining budget and mining power capacity; managers of mining pools determine how to allocate the mining reward and how to adjust the membership fee. In this work, we investigate the miners' and mining pool managers' decisions in repeated Bitcoin mining competitions by building a Monte-Carlo discrete-event simulation model. Our simulation model (i) captures the behavior of these two parties and how their decisions affect each other, and (ii) characterizes the system-level dynamics of the blockchain in terms of the mining difficulty level and total mining power. In addition, we study the sensitivity of system performance metrics with respect to various control parameters. Our analysis may provide useful guidelines to mining activity participants in the Bitcoin network.

■ VMD07

Virtual Room 07

Modeling and Optimization for Decision Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Jay Michael Rosenberger, University of Texas-Arlington, Arlington, TX, 76019, United States

1 - Heatwave Prediction Using Classification And Regression Trees

Gazi Md Daud Iqbal, Coppin State University, Baltimore, MD, United States, Jay Michael Rosenberger, Lidan Ha, Sadie Gregory

Global temperature is increasing at an alarming rate, which increases the number of heatwaves. Many people die as a direct or indirect consequence of a heatwave, and elderly people are most affected by a heatwave. Predicting the occurrence of a heatwave can save lives. Because of its geographical location, Bangladesh is one country that is particularly vulnerable to heatwaves. The Bangladesh Meteorological Department collects temperature data at ten weather stations. Data shows that a majority of heatwaves occur in summer months, namely, April, May, and June. In this research, we develop Classification and Regression Tree (CART) models to predict the likelihood of a heatwave in the next 7 days and 28 days using previous two weeks daily temperature.

2 - Design Of Experiments For The Stochastic Unit Commitment With Economic Dispatch Models

Nahal Sakhavand, University of Texas at Arlington, Arlington, TX, 76034-3671, United States, Jay Michael Rosenberger, Victoria C. P. Chen, Harsha Gangammanavar

We present a demonstration of the design and analysis of computer experiments approach (DACE) to the two-stage stochastic planning and operations problems with the integration of renewable generation. In traditional cutting plane algorithms such as the L-shaped method, solving the sample average approximation of the true problem can become prohibitive for a large number of scenarios. To address this challenge, we use a multivariate adaptive regression splines algorithm to approximate the second stage of the stochastic unit commitment-economic dispatch problem with an endeavor to provide more computationally tractable solutions. We conduct the experiments on a modified IEEE118 test system and assess the quality of the solutions obtained from both the DACE and L-shaped method in a replicated procedure.

3 - A Novel Trajectory Data Mining Method For Massive Smartphone Location Data With Applications In Hurricane Evacuation Behavior Analysis

Xinglong Ju, Cornell University, Arlington, TX, 76013-2731, United States, Linda Nozick, Rachel Davidson

In this presentation, a novel trajectory data mining method for massive smartphone location data is introduced. The new method takes the size of the point of interest into consideration and takes advantage of the convolution operation. Compared to the traditional trajectory data mining methods, the proposed method is more time-efficient and can achieve high accuracy as well. The proposed method and the comparison methods are tested on one large hurricane dataset.

4 - Modeling Patrol Operations Using Agent-Based Simulation

Yasaman Ghasemi, The University of Texas at Arlington, Arlington, TX, United States, Yuan Zhou, Victoria C Chen, Kent Ryan Kerley

The complex nature of the policing system often makes it very challenging to manage and control. The dynamic and stochastic criminal behavior, compounded with limited policing resources, are rendered current police operations ineffective and inefficient. In this study, a computer simulation-optimization framework is developed to conquer these weaknesses by addressing the dynamically changing complexities and uncertainties in police operations and adaptively optimizing operational performance based on the state of the policing system. A real-world case study will be presented to illustrate how this framework is used in dynamic patrol deployment planning.

■ VMD08

Virtual Room 08

Data Mining I

Contributed Session

Chair: Anna Khalemsky, Maale Adumim, 9856227, Israel

1 - Measuring Dynamic Efficiency With Variable Time Lag Effects

Moon-Su Kim, SungKyunKwan University, Suwon, Korea, Republic of, Dong-Joon Lim

This study is focused on the effect of time lag on a two-stage dynamic network data envelopment analysis (DEA) where intermediate products produced in the first stage not only contribute to concurrent production in the second stage, but also affect operations in subsequent periods. It is concluded that existing treatments of estimating a uniform time lag parameter do not reflect various operational strategies deployed by individual decision making units (DMUs) over a period of time. As a remedy, we propose a two-stage dynamic network DEA model that can consider variable time lag effects, namely multiple carryover schemes, optimized for each DMU in efficiency measurement.

2 - Out-of-distribution Detection Using Uncertainty-aware Segment-sensor Attention Mechanism

Jiyoon Lee, Korea University, Seoul, Korea, Republic of, Seoung Bum Kim

Many practical problems where deep neural networks are applied pose a risk that unknown classes which were not present during training may appear during testing. For instance, while monitoring equipment status based on sensor data, the unseen status may appear newly. The unseen status must be classified into an unknown class for taking proper action. Therefore, we propose an uncertainty-aware attention mechanism that identifies critical sensors and quantifies their uncertainty in making predictions. This information can be used as an indicator of categorizing unknown classes. We conduct a simulation study to demonstrate the usefulness of our method.

3 - A Decision Support Tool To Estimate Rank In Plant Breeding Experiments

Reyhaneh Bijari, Ph.D. Student, Iowa State University, Ames, IA, United States, Hanisha Vemireddy, Sigurdur Olafsson

Plant breeders aim to select the genotypes with the best genetic properties. This decision may fall in ranking these genotypes based on some phenotypic traits. However, the uncertainty of the ranking makes this decision hard as it is only possible to observe each genotype in a few environments. Each genotype has significant genetics-by-environment effects, resulting in one genotype appearing better than its genetic potential or the other way around. We propose a bootstrapping approach to construct confidence intervals around rank, capturing its inherent uncertainty. We show that the tool is effective as the empirical coverage of the confidence interval closely matches the theoretical coverage.

4 - Large-scale Group Decision-making And Rank Clustering

Meysam Rabiee, University of Oregon, Eugene, OR, United States, Ali Fattahi, Babak Aslani

We study two classes of group decision-making (GDM) problems where the submitted votes as well as the final decisions are in the form of ranking (respectively, score) vectors, denoted by PR (respectively, PS). Because a group of decision-makers usually consists of clusters that are essentially different in how they evaluate options, identifying the clusters and their centroids is necessary. We prove the optimal value of the k-means problem is a lower bound that is within 50% of that of PR and PS. We prove PR and PS are NP-hard and present heuristics with polynomial time for each iteration.

5 - Online Segmentation Of Dynamic Data Stream Using Dynamic Classification Unit Model And Expandrogram Visualization

Anna Khalemsky, Lecturer, Hadassah Academic College, Jerusalem, Israel, Roy Gelbard

The incremental dynamic classifier DCU supports real-time segmentation processes in big and dynamic data environments. The model suggests using small data buffers, as an alternative to the reexamination of all past data for the updating of existing segments. To support the calibration of diverse domains, the model accommodates different forms of processing by using a wide range of parameters. The decision-making process strictly depends on the user's preferences or implementation requirements. Comprehensive visualization, named ExpanDrogram, can potentially improve the interpretation of sophisticated segmentation processes and allow the user to participate in decision-making.

■ VMD09

Virtual Room 09

Bonder Scholar Session

Sponsored: Health Applications Society

Sponsored Session

Chair: Arielle Elissa Anderer, The Wharton School, Wynnewood, PA, 19096-2455, United States

1 - Estimating The Value Of Incorporating Patient Behavior In Return To Play From Concussion

Gian-Gabriel P. Garcia, Harvard University, Boston, MA, 48103, United States

Concussion, the most common type of traumatic brain injury, is a major public health issue. For patients with sports-related concussion, the timing of return-to-play (RTP) is critical; premature RTP can increase likelihood of catastrophic injuries while delayed RTP can decrease benefits of physical activity. RTP decisions are complicated by the potential for strategic symptom-reporting. We formulate this decision problem as a partially observable stochastic game and analyze the equilibrium and doctor's best-response RTP strategy. We then use simulation to quantify the value of incorporating patient behavior by comparing this behavior-aware RTP strategy with practice-based RTP policies.

2 - Improving Diabetes Care With Thermal Imaging And Machine Learning

Jas Wodnicki, University of Wisconsin-Madison, Madison, WI, United States, Thor Larson

Diabetic foot ulcers (DFU) are among the most common and deadly complications of diabetes. Foot ulcers progress rapidly, leading to one million amputations globally which traditional risk assessments fail to prevent. Using thermal imaging, we are quantifying the inflammatory response behind DFU and developing machine learning algorithms for ulceration risk assessment. Our analysis leverages an ensemble of automated image processing methods, with practical use in mind. This technology is tailored to low and middle income countries and the unique cultural and systemic challenges they face.

3 - Statics And Dynamics Of Large-scale Infectious Disease Screening

Hadi El-Amine, George Mason University, Fairfax, VA, 22030, United States, Marwan Shams Eddin, Hrayer Aprahamian

Large-scale screening is an essential tool that arises in settings such as donated blood screening, newborn screening, and screening of subjects during pandemics. Over a given time horizon, many aspects are common: budgets, testing capacity, and medical staff/equipment are limited and many system parameters are uncertain, vary over time, and/or are decision-dependent. In this talk, we give an overview of work related to devising optimal screening policies under the aforementioned limited resources and time-varying parameters.

■ VMD10

Virtual Room 10

Learning vs Earning Trade-offs in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: Peter Jacko, Lancaster University, Lancaster, LA1 4YX, United Kingdom

1 - Evaluation And Mitigation Of Estimation Bias Of The Bayesian Beta-bernoulli Two-armed Bandit Problem With Binary Responses

Amin Yarahmadi, Lancaster University, Lancaster, United Kingdom, Peter Jacko

To derive a response-adaptive procedure as an optimal policy to a dynamic optimization problem, we consider the Bayesian Beta-Bernoulli finite-horizon two-armed bandit problem in which binary responses are modelled as Bernoulli random variables and the objective function is defined by maximising the Bayes-expected total number of patient successes in the trial which we call the patient benefit. We first evaluate the per-treatment bias of Maximum Likelihood Estimator (MLE) showing that it is unacceptably high and variable. We propose a new augmented estimator with the aim to mitigate the estimation bias. Using simulations we show that the proposed estimator can be tuned to provide results in which estimation bias and its variability is notably improved. We also investigate several novel modifications of the dynamics of the bandit problem to obtain further improvements.

2 - Adaptive Seamless Dose Finding Clinical Trials
Amin Khademi, Clemson University, Clemson, SC, 29634, United States, Ningyuan Chen

In this work, we study the adaptive design of dose-finding Phase II clinical trials, by simultaneously considering efficacy and toxicity. We formulate this problem as a non-parametric bandit problem and propose two policies. The first one is based on dose escalation principles and the second one is based on bisection search and UCB algorithms. We test the performance of these algorithms along with benchmarks on synthetic and real datasets.

3 - Response Adaptive Randomization In The Wild: The REMAP-CAP Trial In Covid-19
Elizabeth Lorenzi, Berry Consultants, Austin, TX, 27705, United States

The REMAP-CAP trial is an international, multi-factorial, adaptive platform trial designed to learn about effective treatment strategies for patients with severe pneumonia in both pandemic and non-pandemic settings. In REMAP-CAP, patients are randomized to multiple interventions from across domains preferentially through response adaptive randomization, assigning patients to those interventions that appear most favorable after adaptive analyses are performed. Adaptive stopping rules are also assessed, where arms may be discontinued or standard or care may change as a result. This talk will describe the design of REMAP-CAP in detail and the benefits and limitations of using response adaptive randomization and adaptive stopping rules in the fast-paced setting of a pandemic where patient characteristics, standard of care, and recruitment are rapidly shifting.

4 - Incorporating Ethics And Welfare Into Randomized Experiments
Yusuke Narita, Yale University, CT, United States

Randomized controlled trials (RCTs) enroll hundreds of millions of subjects and involve many human lives. To improve subjects' welfare, I propose a design of RCTs that I call Experiment-as-Market (EXAM). EXAM produces a welfare-maximizing allocation of treatment-assignment probabilities, is almost incentive-compatible for preference elicitation, and unbiasedly estimates any causal effect estimable with standard RCTs. I quantify these properties by applying EXAM to a water-cleaning experiment in Kenya. In this empirical setting, compared to standard RCTs, EXAM improves subjects' predicted well-being while reaching similar treatment-effect estimates with similar precision.

5 - On Quantification Of Ethics Of Learning In Sequential Experiments
Peter Jacko, Lancaster University, Lancaster, LA1 4YX, United Kingdom, Kert Viele

In sequential experiments, the key for addressing the learning vs earning trade-off are the procedures that allocate subjects between several imperfectly known interventions. Typically, the allocation decisions of earlier subjects are further away from optimality (if the interventions were perfectly known) but contribute to learning about the interventions, which is of benefit to subjects that join the experiment later. We consider a number of concepts that capture this notion of ethics and quantify them for a variety of allocation procedures, ranging from equal fixed randomization through Thompson sampling to Bayes-optimal policy.

■ VMD11

Virtual Room 11

Models to Inform Health Policy and Disease Control

Sponsored: Health Applications Society

Sponsored Session

Chair: Sze-chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States

1 - Optimal Prioritization And Discharge Policies For Medicaid Waiver Services
Qiushi Chen, Pennsylvania State University, University Park, PA, 16802-6817, United States, Can Zhang

We study the management of waitlists for Medicaid waiver programs that provide critical services for individuals with developmental disabilities like autism. Unlike other typical waitlists management problems in healthcare settings such as for organ transplant where the service process is usually exogenous, a unique feature of Medicaid waiver waitlists is that patients may remain on the waiver slots for extended periods until being discharged, which renders systematic decisions for both prioritization and discharge relevant in this context. In this paper, we formulate a Markov decision process model to effectively prioritize the allocation of waiver slots with possible early discharge of individuals being served on the waiver, and characterize the structure of the jointly optimal prioritization and discharge policies.

2 - Inverse Fractionation In Radiotherapy
Archis Ghate, University of Washington, Seattle, WA, 98155-5917, United States

The objective in cancer radiotherapy is to maximize tumor-kill while limiting toxic effects of radiation dose on nearby organs-at-risk. Given a fixed number of treatment sessions, planners thus face the problem of finding a dosing sequence that achieves this goal. This is called the fractionation problem. Mathematical formulations utilize the linear-quadratic (LQ) framework to characterize radiation dose-response of tumors and organs-at-risk. The optimal dosing plan in this forward problem depends on the parameters of the LQ model. Unfortunately, these parameters are difficult to estimate. Current debates thus focus on the following question: what parameter values will make specific dosing plans effective? I will present an inverse optimization approach to answer this question.

3 - Optimizing Social Distancing Policies: A Dynamic Programming Approach For Coupled High And Low Risk Populations
Peng Dai, Industrial and System Engineering University of Southern California, Los Angeles, CA, United States, Sze-chuan Suen

Reducing transmission may be an effective way to control disease, but it is not clear when and who needs to social distance in a pandemic scenario, particularly when policies are allowed to change dramatically over time and population subgroup. We construct a Markov decision process model and build an age-stratified SEIR model to identify the optimal policy to maximize social utility for COVID-19. We compare our optimal policies across several regimes and assess differences in resultant utility, number of infections, and deaths over the time horizon. Our results show that the additional flexibility of policies varying over time and population could generate substantial utility gain.

4 - Finding The Optimal Screening Policy For Chronic Kidney Disease Among Diabetics Using A Pomdp Framework
Chou-Chun Wu, University of Southern California, Los Angeles, CA, 90007-4221, United States, Sze-chuan Suen

The US CDC estimates that up to 90% of those with chronic kidney disease are undiagnosed, resulting in 30+ million unmanaged cases. To encourage timely diagnosis of at-risk patients, we develop screening guidelines stratified by age, proteinuria status, and prior test history among diabetics by race and gender. To do this, we adopt a Partially Observed Markov Decision Process (POMDP) framework to identify the optimal action (screen or wait) to take every three months from ages 30-85 that maximizes a patient's discounted lifetime net monetary benefit. We draw some of our POMDP model inputs from a microsimulation which estimates disease progression, lifetime quality-adjusted life years, and medical expenses. We find that the optimal policy recommends more frequent screening in all race and gender groups compared with the annual screening recommended in the status quo.

5 - Improving Tuberculosis Treatment Adherence Support: The Case For Targeted Behavioral Interventions
Justin J. Boutilier, University of Wisconsin - Madison, Madison, WI, 53706-1603, United States, Jonas Oddur Jonasson, Erez Yoeli

Tuberculosis (TB) is a global health priority and lack of patient adherence to treatment protocols is a main barrier to reducing the global disease burden of tuberculosis. In this talk, we will study the operational design of a treatment adherence support (TAS) platform that requires patients to verify their treatment adherence on a daily basis. To do this, we partner with a TB TAS provider in Kenya and use data from a completed randomized controlled trial. Our analysis establishes that patient engagement can be increased by personal sponsor outreach and that patient behavior data can be used to identify at-risk patients for targeted outreach.

■ VMD12

Virtual Room 12

Studies of the Pharmaceutical Supply Chain

Sponsored: Health Applications Society

Sponsored Session

Chair: Liang (Leon) Xu, University of Nebraska - Lincoln, Lincoln, NE, 68588-0491, United States

1 - The Interactions Of Crowding, Patient Severity, And Queue Rank At A Hospital Emergency Department
Lu Wang, Ball State University, Muncie, IN, United States, Mazhar Arikan, Suman Mallik

Utilizing the patient data from the ED of a large urban teaching hospital, we characterize the impacts of the change in patient queue rank on patient LOS. We study how arrivals of higher/lower severity patients influence patient LOS, and how changes in queue rank, severity, and crowding simultaneously affect LOS.

2 - International Drug Shortages: Associations Between Shortages Across Continents

Emily L Tucker, Assistant Professor, Clemson University, Clemson, SC, 29634, United States, Emilia Vann Yaroson, Shravan Anil Shinde, Martha L. Sabogal De La Pava

Drug shortages regularly occur around the globe. Beyond the immediate concerns of COVID-19 supply and demand pressures, supply chain issues have caused shortages for decades. Much of the research about drug shortages in the US has abstracted away the global context of these international supply chains. European researchers have begun to consider the effects of shortages across intra-continental borders, and in this work, we evaluate the associations between shortages in the US and other countries around the world. We consider whether particular causes increase the likelihood of occurrence in other countries and discuss potential ramifications for policy.

3 - A System Reliability Approach For Assessing The Vulnerability Of United States Pharmaceutical Supply Chains

Matthew Rosenberg, Food and Drug Administration, Silver Spring, MD, 20993, United States, Zachary Tillman, Roberto Delhy, Cesar Ruiz-Barnes, Nikki Tavasoli, Reza Kazemi

In this talk, we provide an overview of a system reliability model that the US Food and Drug Administration (FDA) is developing to quantify structural vulnerabilities in pharmaceutical supply chains. Early identification of supply chain vulnerabilities is crucial for preventing and mitigating drug shortages, which typically result from manufacturing problems. We provide an overview of how we define the structure of each supply chain using unique internal datasets, predict the probability of operation disruptions through a machine learning approach, and account for manufacturing dependencies in calculating risk scores and importance measures.

4 - How Do Patients Evaluate Waiting For Service?

Yunxia Zhu, University of Nebraska-Lincoln, Lincoln, NE, 68588-0491, United States, Rakesh Reddy Mallipeddi, Chiraag Mittal, Jon M. Stauffer

A common assumption in the operations management literature is that patients are homogenous to wait time (e.g. waiting for service at a healthcare facility), and based on this assumption researchers attempt to optimize scheduling from the perspective of health service providers. However, what if patients are heterogeneous and respond differently to wait time? In this study, we seek to provide an answer to this question by investigating whether patients' satisfaction of in-clinic wait times at healthcare facilities depends on when they scheduled their appointment.

5 - An Integrated Simulation-optimization Algorithmic Framework To Vaccine Distribution For Controlling The Covid-19

Xuecheng Yin, New Jersey Institute of Technology, Newark, NJ, 07102, United States, Sabah Bushaj, Esra Buyuktahtakin Toy

In this study, we introduce a simulation-optimization approach to addressing the vaccination facility location and allocation challenges of the COVID-19. We extend an agent-based model of the COVID-19 and incorporate it with a new vaccination center and vaccine-allocation optimization model. The proposed model simulates the disease transmission first and then minimizes the total number of infections over all the considered regions by choosing the optimal vaccine center locations and vaccine allocation to those centers.

■ VMD13

Virtual Room 13

Health Care IV

Contributed Session

Chair: Fatma Pakdil, Eastern Connecticut State University, Willimantic, CT, 06226, United States

1 - Generalized Bandits With Learning And Queueing In Split Liver Transplantation

Yanhan Tang, Carnegie Mellon University, Pittsburgh, PA, United States, Alan Scheller-Wolf, Sridhar R. Tayur, Andrew A. Li

We study liver allocation where surgeons with different abilities learn split liver transplantation. We formulate a multi-armed bandit with embedded learning curves to address the trade-off between discovering talents (exploration) and strengthening extant surgeons' skills (exploitation). Our QFL-UCB algorithm, enhanced with queueing dynamics, and fairness, has O(log T) regret. Our algorithms could be applied to help evaluate strategies to increase the use of SLT and other technically difficult procedures that require practice. Methodologically, our proposed MAB model and algorithms are generic and have broad applications.

2 - An Exact Algorithm For Multiple Appointment Patient Scheduling Problems

Farbod Farhadi, Roger Williams University, Bristol, RI, United States, Sina Ansari, Mohammad Reihaneh

Multiple appointment patient scheduling problem presents a unique setting. Unlike other appointment scheduling problems within the healthcare context, patients are scheduled for a series of treatment sessions instead of a single appointment. Missing any of the appointments has significant health consequences for the patients, and it is detrimental to the center's quality scores and their revenue.This patient scheduling problem (PSP) is formulated as a set-partitioning model that prioritizes patient choice and minimizes the missed appointments. We propose a branch-and-price (BP) algorithm for solving the PSP.

3 - Real-Time Delay Prediction Based Patient Diversion Across Healthcare Facility Networks

Najiya Fatma, Indian Institute of Technology-Delhi, Delhi, India, Varun Ramamohan

We investigate the use of real-time delay prediction in implementing patient diversion across networks of healthcare facilities within a discrete event simulation framework. We propose diversion mechanisms that make use of real-time delay predictions and implement diversion using actual delays and delay estimates generated by delay predictors for different service time distributions. We show that the proportion of patients waiting longer than a threshold wait time decreases when diversion is implemented and that the extent to which operational outcomes become equitably distributed across the PHC networks depends upon the accuracy of the delay predictor used.

4 - Cooperative Blood Inventory Ledger (CoBIL): A Decentralized Decision Making Framework For Improving Blood Product Management

Rishabh Bhandawat, University at Buffalo, Buffalo, NY, United States

Existing blood product supply management systems are limited by their segmentation, lack of detailed blood product information, and lack of real-time updating. We propose a novel architecture for blood product information sharing and a pseudo-collaborative decision-making mechanism (CoBIL) to overcome organizational competitive advantage, and to reduce outdates and shortages to benefit donors, patients/hospital, and demand nodes while minimizing operational costs. The work also presents the CoBIL framework along with an inventory routing algorithm to support the adoption of blockchain technology for blood product management.

5 - Multi-modal Transport In A Cold Supply Chain, Handling The Covid-19 Pandemic

Srinivasa Prasanna, IIIT-Bangalore, Bangalore, India, Abhilasha Aswal, Anushka Babu, Sunil K Vuppala

We present techniques to evaluate and optimize the use of multi-modal transport, to deliver vaccines, oxygen, and medications during this pandemic. The multi modal transport uses transportation of non perishable supplies using low cost roads and/or rail, and uses high speed drone transport for quick delivery of perishable items, and chooses an optimal mix of the two, to reduce overall cost, while limiting time restrictions.

The talk will present the overall problem in the context of the pandemic, the algorithmic techniques used, some real world results, and lessons learnt.

6 - A Longitudinal Analysis Of Length Of Stay And Readmission Rate Of Chronic Obstructive Pulmonary Disease Patients

Fatma Pakdil, Professor, Eastern Connecticut State University, Willimantic, CT, United States, Steve Muchiri, Nasibeh Azadeh Fard

Hospital length of stay (LOS) and readmission rate are commonly considered major patient outcomes for measuring quality and cost of healthcare services. This paper examines the relationship between readmission rate and LOS of COPD patients using a nationwide database, the Healthcare Cost and Utilization Project (HCUP) database between 2010-2017. The primary goal of this study is to analyze whether the changes in LOS have affected the 30-day readmission rates of COPD patients. Obtaining a further understanding of the relationships between LOS and readmission rates of COPD patients may provide insightful knowledge for policy and decision-makers.

■ VMD14

Virtual Room 14

Emerging Ropics in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Antoine Desir, INSEAD, Paris, 75011, France

1 - Price Discrimination With Fairness Constraints

Adam Elmachtoub, Columbia University, New York, NY, 10027-3241, United States, Maxime Cohen, Xiao Lei

Price discrimination allows sellers to increase their profits, but it also raises several concerns in terms of fairness which has received extensive attention from media, industry, and regulatory agencies. In this paper, we consider the problem of setting prices for different groups under fairness constraints. We first propose four definitions: fairness in price, demand, consumer surplus, and no-purchase valuation. We analyze the pricing strategy of a profit-maximizing seller and the impact of imposing fairness on the seller's profit, consumer surplus, and social welfare.

2 - Tacit Collusion By Price Algorithms Under A Multinomial Logit Model With Demand Learning

Thomas Loots, University of Amsterdam, Amsterdam, Netherlands

We show that tacit collusion between price algorithms of different firms is theoretically possible, specifically in the hub-and-spoke scenario, where competitors independently implement the same type of price algorithm. We adopt the widely used multinomial logit framework to model demand in a duopoly, and propose a sustainable form of collusion, called fair Pareto-optimal pricing, that ensures equal relative gains compared to the Nash equilibrium. Fair Pareto-optimal pricing is always favorable for both firms but detrimental for consumers. Next, we propose a price algorithm that learns the fair Pareto-optimal price if deployed by both firms. Our algorithm can operate in a setting where prices are public but observed demand is private information, by continuously reverse-engineering the most recent demand observation of the competitor from past prices.

3 - Fair Dynamic Rationing

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

Our paper studies a fundamental sequential resource allocation problem in which we aim to equitably and efficiently ration a divisible good to a sequence of agents with stochastic correlated demands. Focusing on the objective of maximizing the minimum fill rate, we show that an adaptive policy which is both simple and transparent simultaneously achieves the best possible ex-ante and ex-post guarantees. Our work is motivated by rationing social goods in situations where demands (needs) realize sequentially and are possibly correlated, such as a pandemic or a hurricane impacting multiple localities.

4 - Privacy-preserving Personalised Pricing And Assortment Optimization

Ruslan Momot, Kellogg School of Management, Northwestern University, Evanston, IL, 78000, United States, Murray Lei, Sentao Miao

We study privacy-preserving decision making with a focus on operations and revenue management. We explicitly accommodate consumer privacy constraints into the decision maker’s optimization model -- personalized pricing and personalized assortment optimization settings. We make the following contribution: (1) We develop algorithmic techniques which offer a practical, ready-to-use toolbox for decision makers looking to preserve consumer privacy. We explicitly quantify the performance of the developed algorithms and the gap in revenue that privacy preservation entails. (2) We show that preserving privacy does not significantly hurt firm’s revenue, and can be achieved almost “for free”, when the firm possesses sufficient amount of historical data and when privacy guarantee requirement is not too stringent.

■ VMD15

Virtual Room 15

Operations of Matching Markets

Sponsored: Revenue Management and Pricing

Sponsored Session

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

Co-Chair: Daniela Saban, Stanford University, Stanford, CA, United States

1 - Online Ranking Policies for Maximizing Engagement on Nonprofit Matching Platforms

Akshaya Suresh, Yale University, New Haven, CT, United States, Vahideh Manshadi, Daniela Saban, Scott Rodilitz

Nonprofit platforms that facilitate connections between volunteers and opportunities rely on their on-platform ranking engines as well as off-platform targeted promotion of opportunities to engage volunteers. In collaboration with VolunteerMatch, the largest of such platforms, we show that off-platform traffic constitutes a large portion of engagement but that opportunities enjoy disparate levels of such traffic. We develop ranking policies that effectively utilize off-platform traffic to maximize overall engagement and demonstrate their effectiveness by testing them on VolunteerMatch's data.

2 - Two-Sided Assortment Optimization

Ignacio Rios, Assistant Professor, The University of Texas at Dallas, Richardson, TX, United States

We consider a two-sided market mediated by platform, where agents on each side of the market see a subset of profiles in each period. Matches are generated if two users mutually like each other, possibly on different periods. The goal of the platform is to maximize the expected number of matches generated. We model this problem as a dynamic program, we analyze its properties, and we provide performance guarantees for some particular cases of special interest.

3 - Algorithmic Pricing, Platform Power And Collusionary Artificial Intelligence

Amandeep Singh, The Wharton School, Philadelphia, PA, 19104, United States, Gad Allon, Kenneth Moon

As machine learning and artificial intelligence tools become increasingly available, many sellers have adopted algorithms to execute dynamic pricing decisions. However, a nascent theoretical literature suggests that learning-based pricing algorithms can learn to coordinate anti-competitively with neither any explicit collusionary intent nor communication among sellers. In this paper, we empirically study these anti-competitive concerns in the market for short-term rentals. We explain market factors which lead algorithms to be able to coordinate in certain markets and not in others, develop data-driven methods to gauge a given market's susceptibility (in terms of incentive-compatibility) to algorithmic collusion, and propose effective policy prescriptions.

4 - Optimizing For Strategy Diversity In The Design Of Video Games

Will Ma, Columbia University, New York, NY, United States, Oussama Hanguir, Christopher Ryan

A situation common to video games is that a player, with limited resources, must choose a "loadout" of weapons to spend the resources on to maximize firepower. As the video game designer, is it possible to create weapons so that different players, at different stages of the game and possessing different resources, end up wielding different weapons in their loadout, as opposed to some weapons having so much firepower or being so cost-efficient that they are ubiquitous? In this work we show that there is a mathematical limit to the diversity in loadout strategies, and introduce an optimized weapon design which approaches this limit.

■ VMD16

Virtual Room 16

Information Economics and Consumer Behavior in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Shreyas Sekar, University of Toronto, Cambridge, MA, 02138-1024, United States

1 - Mechanism Design In Live-streaming E-commerce

Pin Gao, Chinese University of Hong Kong, Shenzhen, China, Ying-Ju Chen, Guillermo Gallego, Yang Li

Live-streaming advertising is a rapidly emerging trend in e-commerce. Both Amazon and Alibaba have used this new marketing tool by sequentially recommending different products to consumers through videos. In this paper, we use a mechanism design framework to demonstrate how a live-streaming platform can improve its advertising revenue relative to traditional position auctions. We show that the revenue loss from neglecting information provision can be arbitrarily large. However, solving for the optimal mechanism is NP-hard. We thus develop several heuristics with constant performance bounds relative to an upper bound on optimal revenue. We attribute the effectiveness of information provision to its discriminatory role in serving heterogeneous advertisers

2 - Providing Data Samples For Free

Kimon Drakopoulos, University of Southern California, Los Angeles, CA, 90305-1028, United States

We consider the problem of a data provider (Seller of information) who sells information to a firm (Buyer of information) regarding an unknown (to both parties) state of the world. Traditionally, the literature explores one-round strategies for selling information due to the Seller's hold-up problem: once a portion of the dataset is released, the Buyer's estimate improves and as a result the value of the remaining dataset drops. In this paper we show that this intuition is true when the Buyer's objective is to improve the precision of her estimate. On the other hand, we establish that when the Buyer's objective is to improve operational decisions (e.g. better pricing decisions on a market with unknown elasticity) and when the Buyer's initial estimate is misspecified, one-round strategies are outperformed by free-sample selling strategies and dynamic pricing.

3 - Bundle Optimization In Scale

Ozge Sahin, Johns Hopkins University, Baltimore, MD, 21202, United States, Ali Fattahi

We study the optimal design of bundle promotion sets in scale. The general bundle set selection problem is NP-hard. We develop polynomial-time algorithms and a linear time approximation with a performance guarantee under some assumptions. We test our algorithms in medium to large instances and show that their performance is close to optimal. We also present insights on when bundle promotions are most useful to the firm. We find that connectivity of product graphs and the strength of the connection are the main factors that derive the magnitude of the revenue improvement. We also find that allowing for multiple bundle sets can strictly increase the expected revenue, and the increase can be arbitrarily large. Last, we study the problem of offering product-personalized bundle promotions.

4 - Dynamically Aggregating Diverse Information

Xiaosheng Mu, Princeton University, Princeton, NJ, 02138, United States

An agent has access to multiple information sources, each of which provides information about a different attribute of an unknown state. Information is acquired continuously—where the agent chooses both which sources to sample from, and also how to allocate attention across them—until an endogenously chosen time, at which point a decision is taken. We provide an exact characterization of the optimal information acquisition strategy under weak conditions on the agent's prior belief about the different attributes. We then apply this characterization to derive new results regarding: (1) endogenous information acquisition for binary choice, (2) strategic information provision by biased news sources, and (3) the dynamic consequences of attention manipulation.

5 - Decision Authority And The Returns To Algorithms

Hyunjin Kim, INSEAD, Fontainebleau, 02163, France

Algorithms have the potential to improve managerial decisions—but the returns depend on how decision-makers use them. We explore a pilot run by an Inspectional Services Department to test a pair of predictive algorithms that vary in their sophistication and inputs, which the department used to help prioritize inspections. We find that both algorithms provide substantial gains on the department's measure of interest compared to human judgment - suggesting that using even simple data may be helpful. Despite these measurable gains, decision-makers are only half as likely to follow algorithmic recommendations compared to their own judgment. Our findings suggest that for algorithms to translate into improved managerial decisions, organizations must carefully manage how decision authority is allocated and used.

■ VMD17

Virtual Room 17

First-Price Auctions in Online Advertising Markets

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Santiago Balseiro, New York, NY, 10027, United States

Co-Chair: Christian Kroer, Carnegie Mellon University, New York, NY, 10027-6623, United States

1 - Learning New Auction Format By Bidders In Internet Display Ad Auctions

Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States, Shumpei Goke, Ralph Mastromonaco, Sam Seljan

Using data on internet display ad auctions, we study how bidders learn to bid when some sellers switch from second price auctions (SPAs) to first price auctions (FPA). Event study regression indicates that the revenue per sold impression (price) of publishers that switched to FPAs jumped immediately, from 35% to 75% of pre-treatment price level, and this lift in price dissipated over time. This suggests that bidders initially shaded their bids insufficiently compared to rational bidding strategy. Moreover, the lift in price dissipated more quickly in later format changes, suggesting long-term learning by bidders as to how to adjust their bids. We also provide evidence that "sophisticated" bidders shaded more than "unsophisticated" ones.

2 - Learning In Repeated First-price Auctions

Zhengyuan Zhou, Stern School of Business, New York University, New York, NY, 10012, United States

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

3 - Contextual First-Price Auctions With Budgets

Rachitesh Kumar, Columbia University, New York, NY, United States, Santiago Balseiro, Christian Kroer

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

4 - Reserve Price Optimization For First Price Auctions

Zhe Feng, Harvard University, Cambridge, MA, United States, Sebastien Lahaie, Jon Schneider, Jinchao Ye

The display advertising industry has recently transitioned from second- to first-price auctions as its primary mechanism for ad allocation and pricing. In light of this, publishers need to re-evaluate and optimize their auction parameters, notably reserve prices. In this paper, we propose a gradient-based algorithm to adaptively update and optimize reserve prices based on estimates of bidders' responsiveness to experimental shocks in reserves. We show that revenue in a first-price auction can be usefully decomposed into a demand component and a bidding component, and introduce techniques to reduce the variance of each component. We characterize the bias-variance trade-offs of these techniques and validate the performance of our proposed algorithm through experiments on synthetic data and real display ad auctions data from Google ad exchange.

■ VMD18

Virtual Room 18

Economics of Digital Platforms

Sponsored: Information Systems

Sponsored Session

Chair: Lin Hao, Fordham University, Seattle, WA, 98195, United States

1 - The Peril Of Free Product Sampling On Online Crowdfunding Platforms

Zibo Liu, University of Washington, Seattle, WA, 98105-5835, United States, Weijia You, Yong Tan

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

2 - Presenter

Qiaochu Wang, Carnegie Mellon University, Pittsburgh, PA, 15217-2315, United States, Yan Huang, Param Vir Singh

Data protection and privacy rights afforded to consumers by General Data Protection Regulation (GDPR) have presented a challenge to the firms that depend on consumer data for targeted pricing, product recommendations and other purposes. Using a simple analytical model that captures the benefits of data sharing and the privacy concerns for the consumers, we show that GDPR can actually benefit firms. GDPR serves to differentiate consumers based on their disutility for sharing data. The optimal equilibrium strategy for the firm is to increase the data collection on those that have low privacy sensitivity, give them better recommendations. At the same time, collect no data for highly privacy-sensitive consumers who exercise the GDPR rights. Overall, the results show that there are beneficial effects of GDPR to firms particularly when consumers care about privacy a lot.

3 - Efficient Mechanisms For Trading Differentiated Service With Two-sided Information Asymmetry In Sharing Economy

Chenglong Zhang, University of Texas-Dallas, Richardson, TX, 75080-3021, United States, Jianqing Chen, Srinivasan Raghunathan

Motivated by the non-uniform pricing on some ride sharing platforms (e.g., Didi), we derived the efficient mechanism for trading differentiated service with information asymmetry on both sides. Under the efficient mechanism that we derived, the price that a rider pays for the service does not directly depend on her reported time sensitivity but the highest among all the time sensitivities lower than her reported time sensitivity. On the driver side, the wage that a driver receives does not directly depend on his reported serving cost either if he is selected. Whether a driver is selected depends on if his reported serving cost is less than a certain threshold as well as what other drivers are available. We identify the equations for solving the interdependent thresholds.

4 - Exclusive Copyright Strategy Of Competing Music Platforms

Hongyan Xu, Chongqing University, Chongqing, 400030, China, Nengyue Zhu, He Huang

This research explores the exclusive copyright strategy of competing music platforms that offer online music services. We address two issues: the share of exclusive copyrights the platforms distribute and the procurement of opened copyrights by a rival.

■ VMD19

Virtual Room 19

Parallel Server Systems

Sponsored: Applied Probability Society

Sponsored Session

Chair: Neil Walton, University of Manchester, Manchester, England

1 - Heavy-traffic Universality Of Redundancy Systems With Data Locality Constraints

Ellen Cardinaels, Eindhoven University of Technology, Eindhoven, Netherlands, Sem Borst, Johan S. van Leeuwaarden

Heterogeneity and compatibility relations between jobs and servers are becoming ubiquitous in cloud computing platforms due to data locality and network topology constraints. These features strongly diverge from the inherent symmetry of the supermarket model as the baseline scenario for performance benchmarking in parallel-server systems. In this talk we will specifically focus on redundancy scheduling systems with compatibility constraints to gain insight from product-form distributions via a heavy-traffic limit. The asymptotics reveal a striking universality property, in the sense that the system achieves complete resource pooling and exhibits the same behavior across a broad range of scenarios. In particular, the performance of a fully flexible system can asymptotically be matched even with quite stringent compatibility constraints.

2 - Analysis and Comparison of Two-Sided Queues with Different Levels of Delay Information

Mohammad Delasay, Stony Brook University, Stony Brook, NY, 11733, United States, Mehmet Aydemir, Siddharth Singh, Mustafa Akan

We model an on-demand platform as a two-sided queueing system and study its delay information disclosure policy when the platform serves two classes of strategic users (consumers and providers) who seek matches to each other using the platform. Users on each side decide whether to join the system or balk based on their expected delay to be matched, conditional on the information provided by the platform to them. We consider different delay information-sharing regimes and compare the matching rates (a proxy for the platform's profit) under these regimes.

3 - Convergence Properties Of The Maximum Queue Length Of The N Server Fork-Join Queue

Dennis Schol, Eindhoven University of Technology, Eindhoven, Netherlands, Maria Vlasiou, Bert Zwart, Mirjam Meijer, Willem van Jaarsveld

In this talk, we present three convergence results of the maximum queue length of an N server fork-join queue, where N goes to infinity. First of all, we present a fluid limit of the N server fork-join queue with nearly deterministic arrival and service times. This fluid limit depends on the initial number of tasks. Secondly, we investigate a queueing system where all arrival and service processes are deterministic with random perturbations following Brownian motions. We prove that as N grows large, the scaled maximum of N steady-state queue lengths converges in distribution to a normally distributed random variable. Finally, we present results on the tail asymptotics of this maximum queue length.

4 - Stability Properties of Parallel Server Systems under State Dependent Policies

Gorkem Unlu, Booth School of Business, The University of Chicago, Chicago, IL, 60615, United States, Yuan Zhong

We consider the X-Model parallel server system and examine its stability properties under state dependent policies. State dependent policies are attractive because they require only the queue size information. However, they can lead to instability for relatively low system loads. For the X-Model system, we show that switching curve policies, where each server makes the service decision according to a non-decreasing function of queue sizes, can lead to instability. We conjecture that there does not exist a state dependent policy that stabilizes all underloaded parallel server systems.

5 - Asymptotic Optimality Of Approximation Based Load Balancing

Gal Mendelson, Stanford Graduate School of Business, Palo Alto, CA, 1794000, United States

Recent work has shown that using queue length approximations to inform load balancing decisions in systems with multiple dispatchers and parallel servers can lead to excellent performance with a small amount of communication. We consider a general time varying model of such systems and provide a sufficient condition on the approximations under which the queue lengths equalize in the diffusion scale limit. This, in turn, implies that the workload in the system is minimized yielding asymptotic optimality. We analyze several low communication approximation schemes and prove that the resulting approximations satisfy the sufficient condition.

■ VMD20

Virtual Room 20

Simulation, Learning and Queueing Theory

Sponsored: Applied Probability Society

Sponsored Session

Chair: Xinyun Chen, Chinese University of Hong Kong, Shenzhen, Chinese University of Hong Kong, Shenzhen, Shenzhen, 518172, China

1 - Stochastic Approximation of Symmetric Nash Equilibria in Queueing Games

Liron Ravner, University of Haifa, Haifa, Israel, Ran Snitkovsky

We suggest a novel stochastic approximation algorithm to compute a Symmetric Nash Equilibrium strategy in a general queueing game with a finite action space. The algorithm involves a single simulation of the queueing process with dynamic updating of the strategy at regeneration times. Under mild assumptions regarding the regenerative structure of the process the algorithm converges to a symmetric equilibrium strategy almost surely. This yields a powerful tool that can be used to approximate equilibrium strategies in a broad range of strategic queueing models in which direct analysis is impracticable.

2 - Online Learning And Pricing For Service Systems With Reusable Resources

Huiwen Jia, University of Michigan, Ann Arbor, MI, 48105-1181, United States, Cong Shi, Siqian Shen

We consider a price-based revenue management problem with finite reusable resources. The arrival and service rates depend on the posted price but the mappings are unknown. The firm makes adaptive pricing decisions to maximize the cumulative revenue. Compared with prior pricing and MAB literature, the salient difficulties are (i) unknown rate-and-price mappings, (ii) the dynamic nature of reusable resources being committed over time, (iii) the transient behavior of the system when price changes, and (iv) unbounded and heavy-tailed observed random variables. Our algorithms contain a Warm-up Phase to eliminate the heavy-tail effects and a Learning Phase to identify the optimal price. We prove that the cumulative regret is $O(\sqrt{PT} \log T)$, where T and P are the number of time periods and candidate prices, and this result matches the lower bound up to a logarithmic factor.

3 - Efficient Algorithms For Online Decision-making With Limited Action Changes

Yilun Chen, Cornell, Ithaca, NY, 14850-1854, United States

Many of today's online decision-making tasks (e.g. dynamic pricing, pandemic management) boil down to solving stochastic dynamic programs (DP) with high-dimensional / path-dependent underlying state, suffering from the ``curse of dimensionality''. We propose a new approach that overcomes this computational barrier for a fairly general class of problems, subject only to a ``limited-action-change'' constraint (translate to ``limited price change" for dynamic pricing). Our results come with strong theoretical guarantees (both runtime and accuracy) for models with arbitrary state transition and reward structures, guaranteeing an $(1-\epsilon)-$optimal policy in a runtime scaling polynomially in the time horizon and effectively independent of the dimension, The key building block of the approach is our recent algorithmic progress for optimal stopping.

4 - Managing Queues During Infectious Disease Outbreaks
Yunan Liu, North Carolina State University, Raleigh, NC, 27695-7906, United States, Kurtis Konrad, Xu Sun

As an aid to making capacity planning decisions in health systems treating infectious diseases, we develop a novel framework that integrates the classical SEIS model with a multi-server queue. Rather than developing forecasting tools for future trajectories of the compartments, our focus is on how to optimally design the service capacity (beds, staffs, etc.) with the objective of achieving acceptable quality of service. Our Study distinguishes from regular queues in that prolonged customer delay not only translates into low quality of service but also leads to significant increase in future arrivals, as a waiting customer (e.g., an unhospitalized infectious individual) can "invite" new future arrivals (by turning susceptible individuals into exposed ones). To analyze the performance of our new queueing system, we develop heavy-traffic fluid and diffusion limits.

5 - Online Learning For Queues With Hawkes Arrivals
Xinyun Chen, Chinese University of Hong Kong, Shenzhen, Shenzhen, 518172, China, Guiyu Hong, Xiuwen Wang

Recent studies show that arrival processes in many service systems exhibit self-excitement behavior. Hawkes processes are used widely to model arrivals with self-excitement. Analytic results on queues with Hawkes arrivals are only available for infinite-server systems. In this work, we study a numerical algorithm to solve optimal capacity sizing problem for single-server queues with Hawkes arrivals (Hawkes/GI/1 queue), in a data-driven and online fashion. We show that the algorithm is efficient and its total regret is of logarithm order in the number of customers served. Our analysis on the convergence rate to stationarity of Hawkes/GI/1 queue is of independent interest. In the end, our numerical results indicate that the optimal capacity size of Hawkes queue behaves very different from the classic square-root rule in heavy traffic and deserves further investigation.

■ VMD21

Virtual Room 21

Learning and Decision-Making on Networks

Sponsored: Applied Probability Society

Sponsored Session

Chair: Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States

Co-Chair: Daniela Saban, Stanford University, Aachen, United States

1 - Fast Rates For The Regret Of Offline Reinforcement Learning
Yichun Hu, Cornell University, New York, NY, United States, Nathan Kallus, Masatoshi Uehara

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

2 - Switching Behavior In Service Systems: An Empirical Analysis
Koushiki Sarkar, Northwestern University, Evanston, IL, 60201-4434, United States, Gad Allon, Achal Bassamboo, Kejia Hu

When choosing between different options with unknown payoffs, agents often choose the familiar option even when the new option may promise better rewards. In this paper, we focus on the following questions: how are switching costs generated in different contexts? Are there scenarios where a particular switching strategy could be considered rational? We conduct lab experiments where agents repeatedly choose between two routes. Using structural estimation and adversarial bandits' techniques, we develop a highly flexible method for estimating switching costs from data. We obtain evidence for switching costs in scenarios where customer decisions determine the payoff in each route. Based on our empirical analysis, we demonstrate that agents may feature both positive and negative switching costs.

3 - The Value Of Knowing Drivers' Opportunity Cost In Ride Sharing Systems
Ran I Snitkovsky, Columbia Business School, New York, NY, United States, Costis Maglaras, Jim Dai

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

4 - Learning The Scheduling Policy In Time-varying Multiclass Many Server Queues
Yueyang Zhong, The University of Chicago Booth School of Business, Chicago, IL, United States, John R. Birge, Amy R. Ward

We consider a scheduling problem with minimizing the long-run average abandonment and holding costs as objective, in a time-varying multiclass Mt/M/N+M queueing system, when the model parameters (arrival, service and reneging rates) are a priori unknown. We evaluate the performance by means of regret against the benchmark asymptotically optimal c / rule with parameter knowledge.

We propose a Learn-Then-Schedule algorithm over T periods, which is composed of a learning phase where maximum likelihood estimators of the parameters are formed, and an exploitation phase where an empirically learned c / rule is followed. We show that the smallest regret for static priority policies is O(log T), and that our algorithm achieves a regret upper bound of O(log T), which matches the lower bound. We extend the analysis to time-homogeneous multiclass GI/M/N+GI queues.

5 - Private Graph Search
Mine Su Erturk, Stanford University Graduate School of Business, Stanford, CA, 94305-7181, United States

Investigative genetic genealogy has emerged as a powerful technique to identify individuals by leveraging genetic information and genealogical networks. The current practice relies on a static data collection paradigm which has raised concerns regarding privacy. Inspired by these discussions, we introduce a framework to study privacy exposure in a graph search problem and study a trade-off between privacy and search costs. Our results show that a carefully designed sequential search procedure outperforms static data collection. Moreover, we provide a characterization of the optimal trade-off and propose a family of policies that achieve this optimal trade-off. Finally, we validate our theoretical results via numerical experiments on both real genealogical networks and synthetic networks and discuss the policy implications of our results.

■ VMD22

Virtual Room 22

QSR Student Introduction and Interaction Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

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

Co-Chair: Xiaolei Fang, North Carolina State University, Raleigh, NC, 27607, United States

1 - QSR Student Introduction and Interaction Session
Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL, 32608-1047, United States

The Student Introduction and Interaction Session is designed for QSR student members to build their professional network, show up their talents, and learn from invited guests. In this session, each student will be given two minutes to deliver an elevator speech about his/her research interests and accomplishments; Senior QSR members, junior faculty members, and industry guests are invited to interact with all attendees. A printed brochure will be prepared which includes all speakers' bio. The brochures will be distributed to all attendees and among the QSR community for publicity and exposure. Invitations to this session will be sent to department chairs and employers that have interests in recruiting QSR students.

2 - Panelist
Haitao Liao, University of Arkansas, Fayetteville, AR, 72703-9301, United States

3 - Panelist
Yisha Xiang, Texas Tech University, Lubbock, TX, 79409, United States

4 - Panelist
Tapas K. Das, University of South Florida, Tampa, FL, 33620-5350, United States

■ VMD23

Virtual Room 23

Big Data Analytics and Data-driven Decision Making

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xiaochen Xian, University of Florida, Madison, WI, 53719-2450, United States

1 - Parameter Calibration In Simulation Models With Big Data

Bingjie Liu, University of Michigan, Ann Arbor, MI, 48105-2223, United States, Xubo Yue, Raed Al Kontar, Eunshin Byon

This study presents a new approach to calibrate computer model parameters with field data. Typical calibration methods are based on surrogate modeling that imputes data under the assumption that physical and/or computer trials are computationally expensive. This, however, is not the case where large volumes of data can be collected during the operational stage. We develop a new calibration approach for big data settings. We cast the problem into a stochastic optimization framework and employ stochastic gradient descent to iteratively refine calibration parameters using randomly selected subsets of data. Further, we integrate a variance reduction scheme into the optimization process, to enable choosing more samples from influential sampling regions.

2 - Deep Reinforcement Learning For Condition Based Maintenance Planning Of Complex Systems

Wujun Si, Wichita State University, Wichita, KS, 67260, United States

In this talk, a new and flexible Condition Based Maintenance (CBM) model based on a customized deep reinforcement learning for complex multi-component systems will be presented. Both stochastic and economic dependencies among the components are considered in the proposed model. Specifically, different from the threshold-based decision making paradigm used in traditional CBM, the proposed model directly maps the multi-component degradation measurements at each inspection epoch to the maintenance decision space with a cost minimization objective, and the leverage of deep reinforcement learning enables high computational efficiencies and thus makes the proposed model suitable for both low and high dimensional CBM. Various numerical studies are conducted for model validations.

3 - A Subspace-based Approach for Dimensionality Reduction and Important Variable Selection

Di Bo, University of Tennessee, Knoxville, Knoxville, TN, United States, Corey Arndt, Hoon Hwangbo, Stephanie TerMaath, Vinit Sharma

In high-dimensional data analysis, dimensionality reduction techniques are not sufficient to provide the physical insight required for actual decision-making. The statistical model selection offers a way to identify critical physical variables, but it fails to capture important interactions due to the nature of a greedy search. This research proposes a new method that produces subspaces, reduced-dimensional physical spaces, through a randomized search and builds an ensemble of models for critical subspaces only. When applied to high-dimensional data collected from a material development process, the proposed method shows its superiority in prediction and important variable selection.

4 - Data-driven Pathwise Sampling Approaches For Online Anomaly Detection

Dongmin Li, University of Florida, Gainesville, FL, United States, Miao Bai, Xiaochen Xian

Moving Vehicle-based sensors (MVSs) have been increasingly used for real-time sensing and anomaly detection in various applications such as the detection of wildfire and oil spill. In this paper, we propose data-driven anomaly detection strategies for quickly identifying abrupt changes of an area of interest in real time with MVSs combined with pathwise sampling considerations. To tackle challenges due to variability and partial observability of online observations, we integrate instruments of statistical process control and mathematical optimization to monitor the global status of the area of interest and adaptively adjust paths of MVSs to sample from suspicious locations based on real-time data. We provide theoretical investigations and conduct simulations and case studies to validate the superior performance of the proposed methods.

5 - Constrained Bayesian Optimization On The Robust Parameter Design Of Stochastic Functions

Jaesung Lee, University of Wisconsin-Madison, Madison, WI, 53705, United States, Shiyu Zhou, Junhong Chen

Minimizing the quality measurement variations while guaranteeing their means up to certain levels, also known as Robust parameter design (RPD), is crucial in engineering system design. Existing works applied RPD to the deterministic simulation models, which are often limited. We propose a constrained Bayesian optimization method specially designed for stochastic functions with complex shapes and expensive evaluation costs. We build the dual stochastic response models of the mean and log variance by the Gaussian process (GP). The heterogeneous variance of the sample mean is modeled by the fitted log sample variance GP. We establish an acquisition that favors exploration over the feasible and improvable regions. The performance of the proposed method is validated by the numerical and case studies with the graphene-based field-effect transistor sensor data.

■ VMD24

Virtual Room 24

Data Analytics for Advanced Manufacturing

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Wenmeng Tian, Mississippi State University, Mississippi State, MS, 39762-9542, United States

Co-Chair: Chenang Liu, Oklahoma State University, Stillwater, OK, 74075-1290, United States

1 - Thompson Sampling For Bayesian Optimization Using Deep Gaussian Process

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

Design problems in manufacturing often involve optimizing a black-box function. Bayesian Optimization (BO) is a widely used sequential design method to optimize such functions. The conventional BO uses Gaussian Process (GP) model as a surrogate, which is not very suitable for modeling non-stationary functions. Deep Gaussian Process (DGP), with a compositional structure of multiple GPs, models such functions better but its application to BO is limited. We explore Thompson sampling as an acquisition function for the BO with DGP, by using an MCMC scheme to sample from the posterior distribution. The performance is evaluated on analytical test functions and a real case study.

2 - Defect Criticality On Fatigue Behavior In Additive Manufacturing Via Interpretable Machine Learning

Anyi Li, Auburn University, Auburn, AL, 36849, United States, Jia Liu

Volumetric defects innate in additive manufacturing (AM) components severely jeopardize their fatigue performance in structural applications. To study the relationship between the defects and the fatigue performance for AM components, we propose an integrated data-driven model with interpretable machine learning and content-based image retrieval (CBIR) feature descriptors for defect analysis. Moreover, machine learning is leveraged to identify the critical defect features and quantify their impact on fatigue performance. The experimental results reveal the considerable effects of volumetric defects on the fatigue life of AM parts. Our proposed integrated data-driven model can predict the fatigue behavior of AM components with high accuracy and interpretability, combining physical knowledge about the LB-PBF process.

3 - An Lstm-autoencoder Based Online Side Channel Monitoring Approach For Cyber-physical Attack Detection In Additive Manufacturing

Chenang Liu, Assistant Professor, Oklahoma State University, Stillwater, OK, 74075-1290, United States, Zhangyue Shi

Due to its predominant flexibility in fabricating complex geometries, additive manufacturing (AM) has gained increasing popularity in various applications. However, the vulnerability of cyber-physical AM systems, leading to potentially altered parts with compromised mechanical properties and functionalities. Therefore, how to effectively detect cyber-physical attacks is a very important problem for the broader adoption of AM. To address this issue, this study proposed a data-driven online side channel monitoring approach for process authentication based on LSTM-autoencoder with both supervised and unsupervised monitoring schemes. To validate the effectiveness of the proposed method, two case studies are conducted and the results demonstrate that the proposed method can effectively detect process alterations in a real-time manner.

4 - Layer-wise Certification for Direct Energy Deposition Processes based on Melt Pool Morphology Dynamic Analysis

Wenmeng Tian, Mississippi State University, Mississippi State, MS, 39762-9542, United States, Mahathir Bappy, Linkan Bian, Cheng Liu

The paper proposes a new layer-wise certification approach by leveraging morphology dynamics of layer-wise melt pool images. Specifically, the variability of intra-layer melt pool morphologies is formulated as the optimal transport problem, and the Wasserstein metric is used to characterize the minimum amount of work necessary to transport between two consecutive melt pools. Subsequently, multiple new layer-wise features are extracted, and supervised machine learning methods can be applied for anomaly detection. The proposed method is validated using the direct energy deposition (DED) process, which demonstrates satisfactory anomaly detection performance.

■ VMD25

Virtual Room 25

Delay Announcement Systems: Design and Practice

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Laurens G Debo, Dartmouth College, Hanover, NH, 03755-9000, United States

Co-Chair: Sina Ansari

1 - The Queue Behind The Curtain: Information Disclosure In Omnichannel Services

Abhishek Ghosh, Northwestern University, Evanston, IL, United States, Achal Bassamboo, Martin Lariviere

With evolving mobile technologies, increasing number of firms are running multiple channels to serve customers. Due to the novelty of these systems, questions related to the design of such omnichannel systems and their implications for the firm and customers remain open. In particular, the question of whether or not a firm should disclose queue information to its customers in an omnichannel setting, has not been extensively addressed in prior literature. In this paper, we address some of these open questions of design of omnichannel service system, especially focusing on the issue of congestion information disclosure and its impact on customer channel choice behavior. We benchmark the omnichannel model against a conventional single channel model, and compare these settings in terms of the firm's throughput and average consumer surplus.

2 - On The Granularity And Display Format Of Delay Information: A Large Scale Field Experiment On A Ridesharing Platform

Yiming Zhang, University of Washington-Seattle, Seattle, WA, 98110-1134, United States, Qiuping Yu, Yong-Pin Zhou

In collaboration with a major ride-sharing platform, we conducted a large-scale randomized field experiment to study the impact wait time information granularity on customers' abandonment behavior in virtual queues. We show that, when the congestion level is low, the point estimate is better than the interval estimate and we compare different display formats of the point estimates. When the congestion level is medium or high, the interval estimate is preferred and we further study how the design of the interval impacts customer's abandonment decision.

3 - Delay Announcement in Healthcare: Patient-provider Communication

Zhonghao Liu, Northwestern University, Evanston, IL, United States

In healthcare systems, patient-provider communication is an important topic. Such communication could impact both the system and the patients from different aspects. Delay announcement is well studied in OM literature using analytical models and methods, however its practice in healthcare systems is not frequently discussed. In this presentation, we discuss the existing study on the delay announcement and patient-provider communication in general in healthcare systems, and identifying the gap in literature and potential research opportunities.

4 - The Interrelation Between Leadtime Quotation And Satisfaction

Tava Olsen, University of Auckland, Auckland, 1142, New Zealand, Riccardo Mogre, Valery Pavlov

We study a lead-time quotation problem for a make-to-order manufacturer or service provider. Unlike previous research in this space, we allow the act of quotation to affect the customers' perceptions of delay. In particular, we explicitly model the interaction of quotes and delays on customer utility, which the provider then takes into account when quoting lead times. We build on previous empirical evidence to design an experiment that tests whether a quoted waiting time has an effect of a reference point. Then we use the findings from this experiment to build models, which we use to derive optimal static and dynamic quotation policies for a single-server queue.

■ VMD26

Virtual Room 26

Data-Driven Models and Algorithms

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Mike Mingcheng Wei, University at Buffalo, Buffalo, NY, 14260-4000, United States

1 - Combinatorial Neural Bandits

Taehyun Hwang, Seoul National University, Seoul, Korea, Republic of, Kyuwook Chai, Min-hwan Oh

We consider a combinatorial contextual bandit problem where in each round a learning agent selects a subset of arms and receives feedback on the selected arms according to their score. The score of an arm is an unknown function of the arm's feature. Approximating this unknown score function with deep neural networks, we propose UCB and Thompson sampling algorithms. We establish that both algorithms are provably statistically efficient achieving $O(\sqrt{T})$ regret, where T is the time horizon while utilizing the expressive power of a universal function approximator. To the best of our knowledge, these are the first combinatorial neural bandit algorithms with sub-linear regret guarantees.

2 - Multi-Product Dynamic Pricing In High-Dimensions With Heterogeneous Price Sensitivity

Simeng Shao, University of Southern California, Los Angeles, CA, United States

We consider the problem of multi-product dynamic pricing, in a contextual setting, for a seller of differentiated products. In this environment, the customers arrive over time and products are described by high-dimensional feature vectors. Each customer chooses a product according to the Multinomial Logit (MNL) choice model. Our model allows for heterogenous price sensitivities for products. The seller a-priori does not know the parameters of the choice model but can learn them through interactions with the customers. The seller's goal is to design a pricing policy that maximizes her cumulative revenue. We propose a pricing policy, named M3P, that achieves a T-period regret of $O(\log(Td)\ (\sqrt{T}+ d\ \log(T)))$ under heterogenous price sensitivity for products with features of dimension d. We also prove that no policy can achieve worst-case T-regret better than $\Omega(\sqrt{T})$.

3 - Word Embeddings For New Domains Via Group-Sparse Transfer Learning

Kan Xu, University of Pennsylvania, Philadelphia, PA, 19104, United States, Xuanyi Zhao, Hamsa Sridhar Bastani, Osbert Bastani

Unstructured text data provides decision-makers with rich information in many domains, e.g. retailing, healthcare. To exploit this information, words are translated into word embeddings--vectors that encode the semantic relations between words. However, learning word embeddings from new domains with limited training data is challenging, because words may have different meanings in new domains. We propose a novel two-stage estimator to transfer learn domain word embeddings by combining publicly available large text corpora such as Wikipedia with domain texts. We prove that our proposed estimator achieves the same accuracy with exponentially less domain data. Furthermore, we empirically evaluate its effectiveness, both in terms of prediction accuracy in a downstream prediction task of clinical trial eligibility as well as the interpretability of the estimator.

4 - Online Assortment Optimization With High Dimensional Data

Xue Wang, Damo Academy, Alibaba Group, Bellevue, WA, United States, Mike Mingcheng Wei, Tao Yao

In this research, we consider an online assortment optimization problem, where a decision-maker needs to sequentially offer assortments to users instantaneously upon their arrivals and users select products from offered assortments according to the multinomial logit choice model. We propose a computationally efficient Lasso-RP-MNL algorithm for the online assortment optimization problem under the cardinality constraint in high-dimensional settings. We demonstrate that for the feature dimension d and the sample size dimension T, the expected cumulative regret is upper bounded by $\tilde{\mathcal{O}}(T^{\frac{2}{3}}\log d)$. Moreover, with the strong enough signal, the upper bound improves to $\tilde{\mathcal{O}}(\sqrt{T}\log d)$. Finally, through experiments, we show that the proposed algorithm is efficient and outperforms other benchmarks.

■ VMD27

Virtual Room 27

Inventory Management I

Contributed Session

Chair: Ehsan Teymourian, Rutgers the State University of New Jersey, Harrison, NJ, 07029-2210, United States

1 - Designing Stockless Production Systems In The Presence Of Manufacturing Disruptions

Antonio Arreola-Risa, Texas A&M University, College Station, TX, United States, Jordi Fortuny-Santos, Carla Vintró-Sánchez

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

2 - Discrete-item Inventory Control Involving Fixed Setup Costs, Demand Censoring, And Unknown Distribution
Ehsan Teymourian, Rutgers, The State University of New Jersey, Newark & New Brunswick, NJ, United States, Jian Yang, Michael N. Katehakis

We investigate a dynamic inventory control problem in which orderings involve fixed setup costs and unsatisfied demands are lost. Stepping off from the traditional literature which stresses the randomness of demand realizations, we move on to tolerate ambiguity. Now even the demand distribution can come from a vast and definitely non-singleton set. Lost sales and demand ambiguity would together complicate the problem through censoring, namely, the inability of the firm to observe the lost portion of the demand. We design and analyze some simple and applicable policies for this setting. Our simulation, also, demonstrates the merits of the proposed policy ideas.

■ VMD28

Virtual Room 28

Minority Issues Forum Poster Session

Sponsored: Minority Issues Forum

Sponsored Session

Chair: Eduardo Perez, Texas State University, San Marcos, TX, 78666, United States

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

1 - Minority Issues Forum Virtual Poster Session
Eduardo Perez, Texas State University, San Marcos, TX, 78666, United States

Various posters to be presented.

■ VMD29

Virtual Room 29

Social Responsibility and Risk in Supply Chains

Sponsored: MSOM/iForm

Sponsored Session

Chair: Sanjith Gopalakrishnan, McGill University

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

1 - Internet Of Things-enabled Information, Dual Sourcing And Supplier Competition
Tao Lu, Ph.D., University of Connecticut, CT, United States, Brian Tomlin

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

2 - Reducing Waste In Online Retailing
Jiayu Chen, University of Calgary, Calgary, AB, T2N 1N4, Canada, Milind Dawande, Ganesh Janakiraman, Anyan Qi

To stimulate customer demand, online retailers offer subscription programs such as Amazon Prime. The lower marginal ordering cost under such programs may lead to more-frequent customer orders, resulting in more packaging and shipping waste. In this work, we build a parsimonious and tractable consumer-utility model and characterize an optimal online ordering policy for a consumer. Using this result as a building block, we analyze the decisions of the online retailer and design pricing mechanisms for subscription customers to reduce packaging costs and the negative environmental impact.

3 - Delays In Project Supply Chains: A Global Network Perspective
Vibhuti Dhingra, York University, Toronto, ON, V6T 1Z2, Canada, Harish Krishnan, Juan Serpa

When assigning responsibility for delays, project participants ignore a key fact: a project belongs to a large interconnected network of clients, contractors, and subcontractors. In this network, firms manage multiple projects concurrently. A disruption in one project forces all parties to reallocate resources from other concurrent projects, causing externalities across the wider project network. We use data from tens of thousands of U.S. public projects - and their networks - to quantify the importance of these network externalities. We show that a given project is delayed by 5-10%, on average, in the three-months following a disruption at concurrent projects of its client or subcontractor. This impact is greater when projects are nearing completion, have a low contract value, are non-competitively awarded, or do not include performance incentives.

4 - Cooperative Security Against Interdependent Risks
Sanjith Gopalakrishnan, McGill University, QC, Canada, Sriram Sankaranarayanan

Risk management in networks requires investing in security against interdependent risks, i.e. risks that are transferable across agents such as contamination in food supply chains, or data breaches in inter-firm networks. We develop a theory of how networked agents can cooperatively secure themselves against interdependent risks. A novel contribution is to employ cooperative game-theoretic tools and examine when and how firms can sustain network-wide cooperative security against interdependent risks by sharing the rewards of cooperation amongst themselves in a stable and fair manner.

■ VMD30

Virtual Room 30

Diversity, Equity, and Social Responsibility in Operations

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Ming Hu, University of Toronto, Toronto, ON, United States

Co-Chair: Setareh Farajollahzadeh, University of Toronto, Toronto, ON, M5R 2T8, Canada

1 - Help And Haggle: Expanding Social Reach With Dynamic, Randomized, And All-or-nothing Incentives
Chen Jin, National University of Singapore, Singapore, 117417, Singapore, Zhen Shao, Luyi Yang, Qinglong Gou

We study a novel ''help and haggle'' campaign that is widely adopted by technology giants such as Pinduoduo (NASDAQ: PDD).

2 - Potty Parity: Process Flexibility via Unisex Restrooms
Setareh Farajollahzadeh, University of Toronto, Toronto, ON, Canada, Ming Hu

We study the problem of inequitable access to public restrooms by women and the LGBTQ community. Individuals choose to enter a restroom based on their gender identity and the expected or observed wait time. We analytically show the benefits of having unisex restrooms from three angles: (1) improving potty parity of wait times, (2) enhancing individual welfare, and (3) increasing safety perception. In addition, we identify the optimal restroom designs based on location and restroom types.

3 - Off-Platform Threats in On-Demand Services
Eryn Juan He, National University of Singapore, Singapore, 117602, Singapore, Sergei Savin, Joel Goh, Chung-Piaw Teo

Online platforms that provide on-demand services are often threatened by the phenomenon of leakage, where the “customer-provider” pairs decide to transact “off-platform” to avoid the platform’s fee. We study the key characteristics of a service vulnerable or resistant to leakage, as well the leakage-curbing mechanisms.

■ VMD31

Virtual Room 31

Theoretical and Empirical Models in Service Operations

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Harish Guda

1 - The Economics of Process Transparency

Harish Guda, Arizona State University, Tempe, AZ, 85281, United States

We propose and analyze a novel framework to understand the role of non-instrumental information disclosure in service operations management - information shared by the firm not to affect consumers' actions, but to better manage their experience in the firm's process. In contrast to prior literature that exclusively considers the role of information sharing in influencing consumers' actions, our setting is one where consumers take no action - our goal is to study how the consumer-waiting experience is influenced by non-instrumental information disclosure, either directly or indirectly. Our work draws upon the recent literature on belief-based utility in Economics. We analyze and compare information-disclosure strategies that are commonly observed in real-life service processes.

2 - The Impact of Piracy on Movie Distribution

Franco Berbeglia, Professor, Purdue University, West Lafayette, IN, 15232-2962, United States, Timothy Derdenger, Michael D. Smith, Rahul Telang

We develop and estimate a dynamic discrete choice model that embeds piracy downloads as a substitute for legal distribution channels. In general, high quality pirated movies become available as soon as there is a home video released in some market, which then impacts demand in all other markets, as piracy belongs to a unique global market. The current problem in the industry is that home video releases are optimized locally, without considering the impacts created by piracy on other markets. Even though piracy may not be eliminated; it can be controlled by choosing the release timing of foreign releases more wisely. Through counterfactuals, our model can predict the impact on studio revenues of delaying piracy, which may inform business practitioners about the trade-off they face when optimizing local home video releases.

3 - Delegation With Technology Migration: An Empirical Analysis Of Mobile Virtual Network Operators

Fan Zou, University of South Carolina, West Columbia, SC, 29169, United States, Yan Dong, Kejia Hu, Sriram Venkataraman

This study examines the impact of mobile virtual network operators (MVNOs) on the performance of mobile network operators (MNOs) in the presence of overlapping generations of wireless mobile technologies (2G and 3G). MVNOs distribute MNOs' mobile services to customers without owning any spectrum or network infrastructures. Some MVNOs are wholly owned by MNOs with a revenue-sharing mechanism (branded MVNOs), while others operate through wholesale agreements with MNOs (third-party MVNOs). By focusing on the impact of MVNOs on MNOs' performance, we investigate governance issues, e.g., delegation vs. ownership, in value chains with overlapping generations of technologies.

4 - An Analysis of Operating Efficiency and Public Policy Implications in Last-Mile Transportation Following Amazon's Vertical Integration

Lina Wang, Arizona State University, Tempe, AZ, 85257, United States, Elliot Rabinovich, Harish Guda

We examine how Amazon's decision to vertically integrate its retail platform and last-mile delivery operations can lead to anticompetitive outcomes as a result of a deterioration in the operating efficiency in the routes served by a last-mile transportation firm. We also expand on public policy measures that can ameliorate these outcomes. Based on an operational analysis of the last mile transportation firm, we find that Amazon's decision to vertically integrate increased significantly the mileage necessary to deliver parcels in the ZIP code areas where this integration occurred. Moreover, this increase was significantly amplified by the remoteness and proportion of fast deliveries in these areas.

■ VMD32

Virtual Room 32

Emergency and Healthcare Operations in Developing Countries

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Andre Du Pin Calmon, Scheller College of Business, Georgia Institute of Technology, Atlanta, GA, 30308, United States

Co-Chair: Gonzalo Romero, Rotman, University of Toronto, Toronto, ON, M4K 1Y5, Canada

1 - Coordinate or Compete in a Market with Fragmented Supply

Gonzalo Romero, Rotman, University of Toronto, Toronto, ON, M4K 1Y5, Canada, Andreas Gernert, Andre Du Pin Calmon, Luk N. Van Wassenhove

Our goal in this paper is to derive guidelines for social entrepreneurs that want to enter into the emergency transportation system in developing countries. These entrepreneurs face the decision whether to integrate and coordinate existing ambulance providers or to set up an independent alternative. Additionally, they have to decide how many ambulances to own, if any. Using a game-theoretical model that captures, among other features, the spatial dimension of supply and demand, we derive the optimal investment strategy of the cooperative and competitive business models, respectively, and we characterize their profitability and impact on public welfare.

2 - Ambulance Platforms To Improve Response Times For Emergency Calls In Developing Countries

Pieter van den Berg, Rotterdam School of Management, Erasmus University, Rotterdam, 3062 Netherlands

Many developing countries lack the infrastructure for emergency response of the developed world. Often, the problem is not the lack of capacity, but the lack of coordination. To solve this coordination problem, multiple companies, for example Flare in Kenia and StanPlus in India, have started ambulance platforms to bring together demand and supply for emergency care. We study how the operational process of these platform services differs from traditional EMS providers and help to improve the service level of these companies.

3 - Changes In Emergency Medical Response Patterns And Implications For Ambulance Dispatch

F. Jordan Srour, Lebanese American University, Beirut, 1102 2801, Lebanon

Using field data on emergency response, we examine changes in emergency response experienced through out the Covid-19 crises in 2020. Based on the changes seen the implications for ambulance dispatch strategies are explored.

4 - Health Clinic Electrification In LMICs Via Vehicle-to-Microgrid Systems: Early Results And Next Steps

Rebecca Alcock, University of Wisconsin–Madison, Madison, WI, United States, Justin J. Boutilier

More than one billion people worldwide receive healthcare in a facility without electricity. Energy inequities in healthcare have many direct consequences, such as inability to power medical devices, as well as latent adverse health outcomes, including increased mortality and higher incidence of disease. To address this, we are investigating a vehicle-to-microgrid (V2 G) system that will equip health clinics in low- and middle-income countries (LMICs) with the electricity needed to keep them running, while enabling mobile health services via access to electric bicycles and motorbikes. In this talk, we will discuss the early findings of our local pilot project and the current state of the mathematical framework that will be used to optimize the higher-level system design.

5 - Sample Transport Optimization

Emma Gibson, MIT, Cambridge, MA, 02142-1307, United States, Jonas Oddur Jonasson, Kara Palamountain, Sarang Deo

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.

■ VMD33

Virtual Room 33

Innovation in Supply Chains

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Ersin Korpeoglu, University College London, London, E14 5AA, United Kingdom

1 - Dynamic Trade Finance In The Presence Of Information Frictions And FinTech

Yuxuan Zhang, University of International Business and Economics, Beijing, 100084, China, Hau L Lee, Christopher S. Tang, S. Alex Yang

We study the value of a type of innovative bank-intermediated trade finance contract, which we call dynamic trade finance (DTF, under which banks dynamically adjust loan interest rates as an order passes through different steps in the trade process) in the presence of information frictions related to process uncertainties, and its strategic interaction with FinTech. We construct a parsimonious model of a supply chain process consisting of two steps: the duration of each step is uncertain, and the process may fail at either step. The seller borrows from a bank to finance this 2-step process either through uniform financing or DTF. While lending, the bank faces either ex-post information opacity or ex-ante information asymmetry. FinTech may help to alleviate such information frictions.

2 - Sourcing Innovation And Production

Xiaoshuai Fan, Southern University of Science and Technology, Shenzhen, China, Ersin Korpeoglu, Cuihong Li

We consider a firm sources the design and production of an innovative product from two risk-neutral suppliers. The value of the design depends on the supplier's effort and buyer's subjective taste, while the production cost is private information of suppliers. Through comparing non-commitment, joint-sourcing, and separate-sourcing mechanisms, we find that 1) when the marginal innovation cost is large and the efficiency loss, which occurs when a supplier produces the design provided by another supplier, is small, the non-commitment mechanism generates the highest profit for the buyer; 2) when the marginal innovation cost is small, and the efficiency loss is large, the separate mechanism dominates others; otherwise, the joint mechanism is the best. The above results are derived by the tradeoff between allocation efficiency and effort incentives provided to suppliers.

3 - Shared Technological Knowledge And Innovation In Buyer-supplier Networks

Shubhobrata Palit, Georgia Institute of Technology, Atlanta, GA, 30308-1149, United States, Manpreet Singh Hora, Soumen Ghosh

We focus on the available technological knowledge in a firm's supplier network and examine the conditions under which a buyer firm accrues innovation benefits from such knowledge. Specifically, we examine technological distance, technological breadth, and extent of global sourcing and how these factors interrelate in influencing a firm's innovation performance. Drawing panel data from various sources, we verify the hypothesized relationships.

4 - Exclusive Or Not An Experimental Analysis Of Parallel Innovation Contests

Ramazan Kizilyildirim, UCL, London, United Kingdom, Ersin Korpeoglu, Gizem Korpeoglu, Mirko Kremer

Innovation contest emerges as a game changing mechanism to outsource innovation. In many instances, organizations publish multiple innovation contests at once. In ¬¬- some of these instances, organizations encourage solvers to participate in more than one contest, and in others, they discourage solvers from doing so. In this paper, we inquire in a lab experiment how solver effort and organizer profit are affected under both scenarios. We bridge theory and practice with a behavioural model. We provide insights into how organizers should choose the profit maximizing mechanism depending on the novelty required to solve their problems.

■ VMD34

Virtual Room 34

Business and Climate Change

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Christian Blanco, University of California-Los Angeles, Los Angeles, CA, United States

1 - Empirical Investigation Of Locational Demographics And Facility Emissions

Abhinav Shubham, PhD Student, Georgia Institute of Technology, Atlanta, GA, United States, Ravi Subramanian

Environmental Justice encapsulates the idea of fairness in protection for communities from environmental and health hazards, regardless of race, color, national origin, or income. It is relevant to the practice of OM in the form of inequities that result from disparate operational decisions or policies. The research question that we aim to address is: How disparate are facility-level emissions across communities with different racial makeups? To address this question, we draw data multiple sources. we address the confounding effects of pre-treatment factors through various methods to assess how facilities may differ in their emissions (outcome) between locations that differ in racial makeup. Our findings offer evidence for regulatory intervention and opportunities for firms to reconsider their ESG objectives with local considerations of fairness and equity.

2 - Reducing Lead Poisoning By Extending Battery Lifetime: Model, Analysis And Policy Recommendations

Qiong Wang, University of Illinois, Urbana, IL, 61801-2925, United States, Amrita Kundu, Erica Plambeck

We model the Lead Acid Battery (LAB) industry in Bangladesh, where informal recycling of LABs is causing catastrophic lead poisoning. We analyze how policy and financial innovation could reduce that lead poisoning, particularly by extending the lifetime of batteries, through improved battery quality and improved maintenance and charging practices. Import taxes and financial constraints influence the equilibrium price, quality, salvage value, and useful life of new and second-hand LABs. We characterize such influences to inform policy making and financial design.

3 - The Content of Climate Change Disclosures and Market Values

Christian Blanco, The Ohio State University, Columbus, OH, 43201, United States, Nimesh Patel

Is there an association between the content of climate change disclosures of risks and market values? We explore this question using over 6,300 climate change disclosures of 1,481 global firms from 2010-2016.

■ VMD35

Virtual Room 35

Recent Advancement of Optimization Methodology in Energy Systems

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Haoxiang Yang

1 - Parameter Estimation In An Energy Simulation Model Using Statistical Learning

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

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

2 - Data-driven Chance Constrained Planning For Renewable Distributed Generation

Kai Pan, Hong Kong Polytechnic University, Kowloon, Hong Kong, Shiyi Jiang, Jianqiang Cheng, Feng Qiu

Improper renewable distributed generation units (RDGs) placement may result in many problems. Besides, under uncertainties, some cascading problems may happen in the power grid. In this paper, we propose a novel two-stage data-driven chance constrained model to make optimal location and size planning of RDGs and energy storage considering multiple periods. First, we use chance constrained method to model the uncertainties presented in previous two-stage problem. Then, we use partial sample average approximation (PSAA) approach to approximate the chance constrained model. According to a real data set of the industry, we perform experiments and compare the performance of the PSAA with the SAA, where we find that PSAA outperforms the SAA in terms of time of optimizer and quality of the solution.

3 - Physics-informed Machine Learning For Accurate And Efficient Response To Abnormal Conditions

Wenting Li, Postdoc, Los Alamos National Laboratory, Los Alamos, NM, United States, Deepjyoti Deka

The ever-increasing distributed energy resources (DERs) require power grids to efficiently and accurately respond to abnormal conditions. Machine learning (ML) technology is promising to achieve this goal. Unfortunately, most ML algorithms are rooted in more statistical hypotheses with limited capability to incorporate or explain the underlying physics. Instead, we focus on embedding physics into our ML algorithms in two ways: (1) regulate outputs of neural networks with latent physical correlations; (2) encode physical structures with neural networks. Following the first principle, we detect high-impedance faults (HIF) with no labeled data for training. We apply the second principle to fault location when power grids have low observations, scarce labeled data, and abnormal conditions.

4 - Stochastic Planning Of Joint Power And Gas System Against Extreme Weather And Climate Events

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

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

■ VMD36

Virtual Room 36

Optimization Models and Methods for Improving Power System Resilience

Sponsored: ENRE/Electricity

Sponsored Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

1 - Efficient Algorithms For Power System Restoration

Sangho Shim, Robert Morris University, MoonTwp, PA, 15108, United States, Sunil Chopra, Feng Qiu

A parallel power system restoration (PPSR) plan sectionalizes the entire power system into subsystems with initial power sources and restores the subsystems in parallel minimizing the restoration time. The objective function of our PPSR problem is captured by the generator startup scheduling (GSS) problem to start the non-black start (NBS) generators which cannot be started on themselves. We identify the optimal PPSR plan on IEEE-118 within a reasonable time. We also develop a randomized rounding method to identify decent plans responding to an ultra large-scale power outage (on PEG-1354 and PEG-2383) in a very short computational time. We then discuss another challenging problem in restoration, i.e., the Power-multiple Vehicle Routing Problem (POWER-mVRP) where the upstream fault locations need to be visited before the downstream fault locations .

2 - Optimal Power Flow with Robust Feasibility and Stability Guarantees

Jianzhe Liu, Sterling Heights, MI, 48312-6490, United States

With high penetrations of IBRs, there is significant uncertainty associated with power flows in the power electronics intensive power systems such that stability and operational constraint satisfaction are of concern. Most existing optimal power flow (OPF) formulations assume exact knowledge of loading conditions and do not provide stability guarantees. In contrast, this presentation studies an OPF formulation which considers both stability and operational constraint satisfaction under uncertainty. The need to account for a range of uncertainty realizations in this presentation's robust optimization formulation results in a challenging semi-infinite program (SIP). The proposed solution algorithm reformulates this SIP into a computationally tractable problem by constructing a tight convex inner approximation of the stability set using sufficient conditions for the existence of a feasible and stable power flow solution. Optimal generator setpoints are obtained by optimizing over the proposed convex stability set. The validity and value of the proposed algorithm are demonstrated through various IEEE test cases.

3 - Hybrid Imitation Learning For Real-time Service Restoration In Resilient Distribution Systems

Yichen Zhang, Argonne National Laboratory, Lemont, IL, United States, Feng Qiu

Self-healing capability is a critical factor for a resilient distribution system, which requires intelligent agents to automatically perform service restoration online, including network reconfiguration and reactive power dispatch. The paper proposes the imitation learning framework for training such an agent, where the agent will interact with an expert built based on the mixed-integer program to learn its optimal policy, and therefore significantly improve the training efficiency compared with exploration-dominant reinforcement learning methods. This significantly improved training efficiency makes the training problem under N-k scenarios tractable. The 33-bus and 119-bus systems with N-k disturbances are employed to conduct the training.

4 - Private Risk And Social Resilience

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

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

■ VMD37

Virtual Room 37

Energy Equity

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Erin Baker, Univ of Massachusetts-Amherst, Amherst, MA, 1003, United States

1 - Net Energy Equity: A Net Energy Framework to Assess Energy Poverty for American Households

Eric Scheier, Founder, Emergi, Carrboro, NC, United States

Energy poverty in the United States is an issue of increasing prevalence. We develop a framework to observe systematic energy inequity and create a net energy return metric for the United States. We find substantial instances of energy poverty in the United States: 10% of households experience energy poverty as presently defined. We also identify and document further disparities in community net energy return, where energy expenditures in the US disproportionately burden minority communities. Further disparities suggest that for the energy transition to improve socioeconomic mobility, programs must reduce relative energy expenditures through improved access to distributed energy resources.

2 - The Energy Equity Gap: Unveiling Hidden Energy Poverty

Destenie Nock, Assistant Professor, Carnegie Mellon University, Pittsburgh, PA, 15207-1120, United States, Shuchen Cong, Lucy Yueming Qiu

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

3 - Environmental and Economic (In)Justice Considerations When Decarbonizing a Power System

Paola Furlanetto, University of Massachussets

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

4 - Hydrogen As A Transition Alternative For Oil- And Gas- Dependent Countries - A Nigeria Case Study

Ayoola Fola

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

5 - Air Pollution Consequences Of Vehicle Electrification In India
Tapas Peshin, Stanford University, Stanford, CA, United States

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

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

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

■ VMD38

Virtual Room 38

Energy systems integration (Macro-Energy Systems)

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Dharik Sanchan Mallapragada, MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

1 - Impact Of Space Cooling Demand On The Role For Energy Storage And Grid Decarbonization In India
Marc Barbar, Massachusetts Institute of Technology, Cambridge, MA, 02472, United States, Dharik Mallapragada, Robert Stoner

Energy sector decarbonization efforts are contingent on technology choices for energy production and end-use in developing countries such as India, where air conditioning is expected to be the driver for electricity demand growth. We quantify various impacts on long-term electricity system evolution. Under projected renewables and Li-ion storage cost declines, our modeling points to renewables contributing majorly to annual electricity demand in India by 2030. However, without appropriate policy measures to phase out existing coal generation, even such rapid adoption of renewable energy coupled with one or more technological levers such as low-cost energy storage and demand-side measures like improving AC efficiency standards, are insufficient to reduce annual CO2 emissions in 2050 because of the relatively higher growth rate of projected electricity demand.

2 - Modeling Potential Roles For Nuclear Power In Microgrid Settings With Integrated Heat And Power Systems
Ruaridh Macdonald, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, John E. Parsons

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

3 - Market-based Resource Adequacy Assessment Framework: The Impact Of Market Design On Long-run Resource Investment And Reliability
Jonghwan Kwon, Argonne National Laboratory, Argonne, IL, United States, Todd Levin, Zhi Zhou, Audun Botterud

This presentation will introduce a market-based resource adequacy assessment framework that can analyze the system generation portfolio that results in a competitive market environment. The model provides improved analysis of generation expansion and revenue sufficiency in a competitive market environment by capturing the strategic capacity investment decision-making of profit-maximizing generation companies. The modeling framework is based on Stackelberg leader-follower games and is formulated as a bi-level optimization problem, which is then transformed into a mathematical program with equilibrium constraints. A case study of the ERCOT system will be discussed. Lastly, our recent enhancement of the modeling framework will be presented.

4 - The Impact Of Flexible Operations And Energy Storage On The Long-term Deployment Potential Of Enhanced Geothermal Systems
Wilson Ricks, United States

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

5 - Examining Decarbonization Scenarios in the United States Using a Macro-scale Energy Systems Model
Aranya Venkatesh, Carnegie Mellon University, Pittsburgh, MA, United States, Katherine Jordan, Aditya Sinha, Joseph F. DeCarolis, Paulina Jaramillo

In this study, we examine infrastructure development across all energy sectors in decarbonization scenarios required to achieve stringent climate targets in the United States. To evaluate scenarios, we use the Temoa model, an open-source energy systems optimization model that minimizes the total (investment and operating) costs of energy technologies to meet exogenously specified service demands in the industrial, transportation, and buildings sectors. We provide insights on how the spatio-temporal modeling resolution selected may impact scenario outcomes. We also analyze how the climate targets can affect technology utilization, for example by evaluating the extent of stranded assets.

■ VMD39

Virtual Room 39

Sustainability, Transportation and Batteries

Sponsored: ENRE/Environment and Sustainability

Sponsored Session

Chair: Rebecca Ciez, Purdue University

1 - A Sustainable Cooperation Framework For Transit Bus Electrification
Mertcan Yetkin, Lehigh University, Bethlehem, PA, 18020, United States, Lawrence V Snyder

Electrification of transit systems, within the scope of smart cities, plays a crucial role in the reduction of greenhouse gas emissions. From the perspective of a social planner, we study electric buses in an urban area coupled with power system operations, and the necessary investment decisions by the transit party for a long-term sustainable operation. We present a tractable deterministic formulation with a practical level of sophistication between the transit system and the power system. We introduce several regulations for the transit party and analyze their effects.

2 - Distribution Model of Subsidy and Tax in Sustainable Energy Value-chain
Mohammad Amini, UT Austin, Austin, TX, United States, Shadi Goodarzi

The growing need of society for energy on the one hand and the increasing environmental problems, on the other hand, led policymakers designe different policies to limit the usage of fossil fuels and promote renewable energies(taxes and subsidies). However, designing an optimal policy that increases social welfare, promotes using renewable energy consumption, and reduces environmental pollution still remains a great challenge. This study aims to provide an appropriate tax/subsidy distribution model to promote renewable energy usage where the amount of tax collection and the payment subsidy have been determined using game theory. The components of the game have been determined based on conducted studies and the experiences of different countries.

3 - Single Machine Scheduling With Job Quality Levels For Battery Manufacturing
Sang-Wook Lee, KAIST, Daejeon, Korea, Republic of, Woojin Shin, Hyun-Jung Kim

We address a single machine scheduling problem in which the machine can process only the jobs which require a smaller quality level than the machine performance level. Each time the machine processes a job, its performance level is degraded, and the machine can have the best performance after the maintenance process. This problem has been motivated from pressing processes of battery manufacturing. A mixed integer programming model is proposed for this problem, and several properties are analyzed. We then develop the optimal and heuristic algorithms.

■ VMD40

Virtual Room 40

Modeling and Forecasting to Enhance Short-Term Power System Operations

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Benjamin Field Hobbs, Johns Hopkins University, Baltimore, MD, 21218, United States

1 - Multi-timescale Nuclear-renewable Hybrid Energy Systems Operations To Improve Electricity System Resilience, Reliability, And Economic Efficiency

Jie Zhang, The University of Texas at Dallas, Richardson, TX, United States, Jubeyer Rahman, Roshni Jacob, Jiaxin Wu, Dongze Li, Pingfeng Wang, Jordan Cox, William Becker, Mark Ruth

Advanced nuclear-renewable hybrid energy systems (N-R HES) composed of nuclear and renewable energy sources, industrial energy users, and energy storage systems are being evaluated for their economic benefit and technical feasibility. N-R HES has been proposed as a technology that can generate low-carbon, dispatchable electricity and provide low-carbon energy to industry at a lower cost. Beyond classic energy-shifting services, N-R HES may be able to provide a suite of services at finer time-scales to promote a safer and more reliable integration of renewable energy resources. In this talk, we will present a multi-timescale N-R HES operation framework to explore the market opportunities available for N-R HES to participate in energy and ancillary markets and develop optimal strategies for bidding N-R HES into the bulk grid or for industry thermal users.

2 - Distributionally Robust Joint Chance-Constrained Optimization for Networked Microgrids Considering Contingencies and Renewable Uncertainty

Yifu Ding, Oxford University, Oxford, United Kingdom, Thomas Morstyn, Malcolm McCulloch

The stochastic nature of renewables and unpredictable contingencies are difficult to address with the deterministic energy management framework. The paper proposes a distributionally robust joint chance-constrained (DR-JCC) framework that incorporates microgrid island, power flow, distributed batteries and voltage control constraints. The proposed method optimizes all chance constraints under solar generation uncertainty jointly and each one is assigned to an optimized violation rate so that the solution can achieve the desired trade-off between the operation cost and system reliability. Results show the proposed method can reduce the solution conservativeness (i.e. operation cost) by around 50% against the benchmark, Bonferroni Approximation, and secures the solution robustness verified in three data-driven ambiguity sets.

3 - Bayesian Method to Define Net Load Ramp Requirements from Probabilistic Solar Forecasts

Yijiao Wang, MS, Johns Hopkins University, Baltimore, MD, 21218, United States

Unconditional point forecasts based on historical data are presently used to define flexible ramping product (FRP) requirements for the CAISO. The study applies probabilistic solar power forecasts and consequent net-load ramp forecasts to dynamically procure weather-conditional FRP. Multivariate quantile regression and Kolmogorov-Smirnov tests are used to forecast net load ramp errors conditioned on weather classifiers. The effectiveness of quantile regression is studied from the perspectives of grid reliability and electricity production costs.

4 - An ISO-sponsored Market for Resource Availability Hedges: Auction Design and Equilibrium Properties

Benjamin Hobbs, PhD, Johns Hopkins University, Baltimore, MD, 21218, United States, Robin Hytowitz, Evangelia Spyrou, Mohamed Alashery, Siddharth Tyagi

Power market ISOs are introducing ramp and other products to manage net load uncertainties. We propose a complementary product called "flexibility options" in which individual resources with delivery uncertainty can buy hedges for their individual risks from flexible resources; these hedges are options that can be exercised if real-time capability differs from day-ahead schedules. We present the formulation of a day-ahead ISO market that matches buyers and sellers of this hedge in coordination with existing capabilities to schedule energy and ancillary services, and outline how their settlements mitigate delivery risk. We also examine the properties of market equilibria involving this hedge, interactions with energy and ramp products, risk management benefits relative to other hedging approaches, and benefits of participating in the flexibility options market.

■ VMD41

Virtual Room 41

Healthcare Delivery in Resource-Limited Settings

Sponsored: MSOM/Healthcare

Sponsored Session

Chair: Can Zhang, Duke University, Durham, NC, 27708-9972, United States

1 - Designing Physician Payments For Diagnostic Accuracy Under Limited Outcome Visibility

Elodie Adida, University of California - Riverside, Riverside, CA, 92521-9800, United States, Tinglong Dai

The prevailing payment system in the U.S. does not sufficiently incentivize physicians to exert diagnostic effort. Meanwhile, misdiagnosis remains frequent and hard to keep track of. In this paper, we develop a model to analyze the effect of a fee-for-service payment system on diagnostic accuracy, physician effort, and social welfare for a given condition. We consider a partially altruistic physician who may (1) exert costly but non-reimbursable effort and/or (2) order a reimbursable diagnostic test that is costly to the patient. Exerting effort generates an imperfect signal, whereas performing a test detects the patient's true condition. We also analyze a diagnosis-based payment system and study how to best approach the socially optimal outcome.

2 - Optimal Deployment Of Digital Technologies To Improve Medication Adherence

Vishwakant Malladi, Indian School of Business, Punjab, 140306, India, Sarang Deo, Milind Sohoni

Tuberculosis caused 1.4 million deaths in 2019, mostly in low and middle-income countries, largely driven by poor drug adherence. Several digital adherence technologies (DATs) are being developed to augment scarce healthcare worker (HCW) capacity in these settings. DATs, through patient engagement, generate noisy signals of adherence, which can be used by HCWs to visit patients with a high risk of non-adherence. We use a restless multi-armed bandit framework to design HCW deployment policies to maximize adherence and calibrate it with program data to quantify improvement over existing policies.

3 - Evaluation Of Government Interventions To Mitigate The US Drug Shortages

Hui Zhao, The Pennsylvania State University, University Park, PA, 16802, United States, In Joon Noh, Sergey Naumov

Using a two-stage system-dynamics model, we capture essential features of the pharmaceutical market and supply chains related to drug shortages in the US and evaluate a few existing and promising government interventions for shortage mitigation.

■ VMD42

Virtual Room 42

Quantum Computing in Industry

Sponsored: Computing Society

Sponsored Session

Chair: Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY, 10598, United States

Co-Chair: Ilya Safro, Clemson University, Clemson, SC, 29643, United States

1 - Optimization By Quantum Annealing: An Overview

Catherine McGeoch, Senior Scientist, D-Wave Systems, Burnaby, BC, Canada

Quantum annealing systems work on different principles than gate model quantum computers, which makes them ideally suited for applications in combinatorial optimization. This talk will present an overview of how quantum annealing works and survey what is known about system performance to date. The talk will focus on the Advantage system with 5000+ qubits, which was launched late in 2020.

2 - Bridging Constrained-optimization Users To Higher Classical And Quantum Performance

Steve P. Reinhardt, VP of Product Development, Quantum Computing Inc., Leesburg, VA, United States

Quantum computing (QC) is widely anticipated as an eventual accelerator for a variety of computing tasks. The timing of the acceleration's arrival and for which tasks remains controversial. Quantum Computing Inc. focuses on constrained optimization for real-world problems, in particular bridging from strong current (classical) performance to hybrid quantum-accelerated/classical performance when QCs deliver acceleration at its first practical moment. QCI also focuses on delivering this power to subject-matter experts who are not quantum experts, targeting logistics and cybersecurity as early vertical markets. Delivering to this demanding set of requirements requires considerable technical innovation; we will sketch recent and near-term steps in this presentation.

3 - Qiskit Runtime And IBM's Roadmap To Scale Quantum Computing

Stefan Woerner, IBM Quantum, Zurich, Switzerland

Quantum computing promises tremendous speed-ups for several applications relevant in business and in science. To be able to leverage this new technology requires not only advances of quantum hardware, but also developing new theory, algorithms, and models, as well as a complete software and control stack to access quantum computers and integrate them with classical systems. In this talk, we will discuss IBM's hardware and development roadmap, the Qiskit Runtime as a new way to call quantum computers, as well as related recent algorithmic advances with applications in optimization and machine learning.

■ VMD44

Virtual Room 44

Economics and Computation VI

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Alexander Wei, UC Berkeley

1 - Aggregative Efficiency Of Bayesian Learning In Networks

Krishna Dasaratha, Yale University, New Haven, CT, United States

In social-learning settings where individuals receive private signals and observe network neighbors' actions, the network structure often obstructs information aggregation. We consider sequential social learning with rational agents and Gaussian signals and ask how the efficiency of signal aggregation changes with the network. Rational actions in our model are a log-linear function of observations and admit a signal-counting interpretation of accuracy. Networks where agents observe multiple neighbors but not their common predecessors confound information, and we show confounding can make learning very inefficient.

2 - Data Tracking Under Competition

Ilan Morgenstern, Stanford University, Stanford, CA, United States, Kostas Bimpikis

We explore the implications of data tracking technologies that enable firms to collect consumer data and use it for price discrimination. We find that the absence of data tracking may lead to a decrease in consumer surplus, even if consumers are myopic. Importantly, this result relies on competition: consumer surplus is higher with data tracking only when multiple firms offer substitutable products to consumers. Our results contribute to the debate of whether to regulate firms' use of data tracking technologies by illustrating that their effect on consumers depends not only on their level of sophistication, but also on the degree of competition in the market.

3 - On Simple Mechanisms For Dependent Items

Argyris Oikonomou, Yale University, New Haven, CT, United States

We study the problem of selling n heterogeneous items to a single buyer, whose values for the items are dependent. With arbitrary dependence, no simple mechanism can achieve a non-negligible fraction of the optimal revenue. We consider the setting where the buyer's type is drawn from a correlated distribution that can be captured by a Markov Random Field (MRF), a prominent framework for modeling high-dimensional distributions with structure. We show how the performance of simple mechanisms degrades with respect to various parameters of the MRF for widely studied classes of valuations.

4 - Optimal Public Provision Of Private Goods

Zi Yang Kang, Stanford University, Stanford, CA, United States

How should a policymaker allocate a good to consumers via a public option when they are also able to purchase the good from a competitive private market? We consider a designer who has preferences over the outcomes of both the public option and the private market, but can design only the public option. However, her design affects the distribution of consumers who purchase in the private market—and hence equilibrium outcomes. We find that the optimal design involves rationing the public option with a small number of tiers, where the probability of allocation is constant in each tier. Tiered rationing remains optimal under a variety of different assumptions.

5 - Designing Approximately Optimal Search On Matching Platforms

Alexander Wei, UC Berkeley, Berkeley, CA, United States, Nicole Immorlica, Brendan Lucier, Vahideh Manshadi

We study the design of a two-sided matching market in which agents' search is guided by a platform. The platform determines rates at which agents of different types meet, while agents strategically accept/reject the potential partners whom they meet. We focus on optimal search design: setting meeting rates to maximize the equilibrium social welfare of the induced game. Incentive issues from congestion and cannibalization make this design problem intricate. Nonetheless, we give an efficiently computable solution that obtains ¼ the optimal welfare. Our solution shows that through careful search design, the platform can substantially limit choice but maintain approximately optimal welfare.

■ VMD45

Virtual Room 45

Behavioral Operations Best Working Paper Competition

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Leon Valdes, University of Pittsburgh, Pittsburgh, PA, 15260-7501, United States

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

Park Sinchaisri, Haas School of Business, UC Berkeley, Berkeley, CA, United States, Hamsa Sridhar Bastani, Osbert Bastani

A key aspect of human intelligence is their ability to convey their knowledge to others in succinct forms. However, despite their predictive power, current machine learning models are largely blackboxes, making it difficult for humans to extract useful insights. Focusing on sequential decision-making, we design a novel machine learning algorithm that conveys its insights to humans in the form of interpretable "tips". Our algorithm selects the tip that best bridges the gap in performance between human users and the optimal policy. We evaluate our approach through a series of randomized controlled user studies where participants manage a virtual kitchen. Our experiments show that the tips generated by our algorithm can significantly improve human performance relative to intuitive baselines. In addition, we discuss a number of empirical insights that can help inform the design of algorithms intended for human-AI collaboration. For instance, we find evidence that participants do not simply blindly follow our tips; instead, they combine them with their own experience to discover additional strategies for improving performance.

2 - To Earmark or Not to Earmark? The Role of Control, Transparency, Salience and Warm-Glow

Sebastian Villa, Indiana University, Bloomington, IN, United States, Ozalp Ozer, Gloria Urrea

Charities face tension when deciding whether or not to offer earmarking to donors—i.e., let donors restrict donations to a specific purpose. Research shows that earmarking decreases operational performance because it limits charities' flexibility to use donations. However, there is also a common belief that earmarking increases donations. To resolve this tension, we study how, when, and why earmarking affects donors' decisions. Our findings provide clear insights for how charities can design fundraising campaigns more effectively.

3 - Delay Information in Virtual Queues: A Large-Scale Field Experiment on a Major Ride-Sharing Platform

Qiuping Yu, Scheller College of Business, Georgia Tech, Atlanta, GA, 30308-1149, United States, Yiming Zhang, Yong-Pin Zhou

We study how the wait time information (WTI) - both its initial magnitude and its subsequent progress - impacts customers' abandonment by conducting a large scale (over 1,4 million rides) 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. We redesigned the WTI for the platform based our insights, which significantly improved their customer experience.

4 - On Customer (Dis)honesty in Priority Queues: The Role of Lying Aversion

Arturo Estrada Rodriguez, University College London, London, United Kingdom, Rouba Ibrahim, Dongyuan Zhan

We study priority queueing systems where the true priority classes are private information to customers. Customers have an incentive to misreport their true types to shorten their expected waiting times. However, they incur a psychological cost whenever they misreport. We study a two-priority M/G/1 queueing game where customers are both delay sensitive and lying averse. We find that lying aversion renders customers' reports informative in equilibrium, and gives rise to an optimal prioritization policy that deviates from the celebrated c\mu rule. We validate our theoretical results with controlled experiments.

5 - Wage Transparency, Negotiation, and Reference-dependent Utility

Hengchen Dai, University of California, Los Angeles, CA, United States, Xiaoyang Long, Dennis Zhang

Wage transparency has become increasingly prevalent across industries as a result of government mandates, companies' voluntary disclosure, and digitization. A commonly cited benefit of wage transparency is that it can prompt underpaid workers to negotiate and thus reduce wage inequality. To empirically address how peer wage information influences wage negotiation and the subsequent implications for wage inequality, we conducted two field experiments on online labor markets where we manipulated information about historical peer wages and assessed workers' responses to job offers. Contrary to predictions of the prior literature, workers become more likely to negotiate not only when they learn that they are paid lower than others (by 34%-132%), but also when they learn that they are paid the same wage as others (by 38%-88%). We conjecture that the latter finding occurs because at least some workers believe they should be paid more than the average due to (warranted or inflated) positive assessments about themselves. This conjecture is supported by a laboratory experiment. Based on our empirical findings, we build a reference-dependent model to describe worker behavior and use it to derive the long-term implications of wage transparency for wage inequality. Our model and the subsequent numerical study reveal that wage transparency may amplify wage inequality by prompting workers who are already highly paid to ask for more. Our work highlights that wage transparency is not necessarily a panacea for wage inequality, and discusses additional measures that governments and organizations may consider along with wage transparency to combat wage inequality.

■ VMD46

Virtual Room 46

Application of AI in Supply Chain Management

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Sha Zhu, ESCP Business School

Co-Chair: Guanlian Xiao, University of Calgary, Calgary, AB, Canada

1 - Artificial Intelligence For Worker Safety In Transportation

Matthias Klumpp, Prof., University of Göttingen, Göttingen, Germany

Driving professions are susceptible to high levels of workload and stress due to specific working conditions. AI and machine learning is applied to use a comprehensive and innovative dataset for the analysis of mental stress and strain. The objective is to use the AI-based analysis in order to mitigate and improve the work situation of driving professions.

2 - Artificial Intelligence: New Frontiers in Supply Chain Management

Alexandra Brintrup, University of Cambridge, Cambridge, United Kingdom

Artificial Intelligence (AI) in Supply Chains (SC) has become a popular topic, with a variety of applications that range from forecasting to automated contracts. In this talk we will first review "Supply Chain AI" and then discuss a use case in “Digital Supply Chain Risk Surveillance” where an intelligent agent proactively gathers data that allows a firm to track and analyse risk information related to its supply network. We conclude by discussing AI pitfalls and technical and ethical challenges that it can bring to risk surveillance.

3 - Artificial Intelligence in Supply Chain Management: A Systematic Literature Review

Ali Nazarpour, Maynooth University, Maynooth, Ireland, Reza Toorajipour, Sohrabpour Vahid, Pejvak Oghazi, Maria Fischl

To address the current scientific gap of AI in SCM, this study aimed to determine the current and potential AI techniques that can enhance both the study and practice of SCM. Gaps in the literature that need to be addressed through scientific research were also identified. More specifically, the following four aspects were covered: 1- the most prevalent AI techniques in SCM 2- the potential AI techniques for employment in SCM 3- the current AI-improved SCM subfields; and 4- the subfields that have high potential to be enhanced by AI. A specific set of inclusion and exclusion criteria are used to identify and examine papers from four SCM fields: logistics, marketing, supply chain and production.

4 - Applications of Text Analytics for Supply Chain Vulnerability Analysis

Gul Kremer, Iowa State University, Ames, IA, 50011, United States, Chi-Yuan Chu

Global supply chains enhance competitive advantages and reduce costs through a broader selection of suppliers. However, insufficient understanding of uncertain regional differences and changes often increases risks in supply chain operations. We propose a text-mining based global supply chain risk management framework, which was developed in two phases. First, relevant papers were collected to conduct term frequency and correlation analysis. A correlated topic model clustering resulted in a total of seven types of global supply chain risk factors. In the second phase, considering these risk factors, a sentiment analysis was conducted on online news articles for risk identification and evaluation. Two case studies are demonstrated the use of the presented risk management framework. The overall goal of this research is to develop a text-mining-based risk management framework, which is able to guide enterprises in building a resilient supply chain.

■ VMD47

Virtual Room 47

Green Finance

Committee Choice: Finance

Committee Choice Session

Chair: Aparna Gupta

1 - Climate And Credit Risk Prediction Of Firms By Building Benchmark Datasets And Multi-relational GCN Models

Sai Palepu, PhD Student, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, Aparna Gupta, Koushik Kar, Sijia Liu, Lucian Popa, Yada Zhu

This paper investigates if one can learn about firms degree of climate risk and credit risk exposure by extracting information about their fundamentals as well as their network connections. We tackle this problem by creating multi-relational financial network (MRFN) benchmark datasets and devise novel variations of graph convolutional networks (GCN) tailored to predict the risk of firms in a semi-supervised fashion. The MRFN datasets reflective of prowess of financial analysts and market sentiment of investors are defined as two-layered networks. A multilayered nature of MRFN motivates two formulations of multi-relational GCN (MRGCN), namely a GCN via network aggregation and a GCN via supra-graph. We show that the MR-GCN models outperform the conventional uni-relational GCN models in terms of higher classification accuracy for climate and credit risk predictions.

2 - How Should Climate Change Uncertainty Impact Social Valuation And Policy

Michael Barnett, Arizona State University, Tempe, AZ, United States

Mark Carney, former Governor of the Bank of England, described climate change as the ``Tragedy of the Horizon.'' Yet the magnitude of this ``potential tragedy'' and the horizon over which it will be realized are highly uncertain. Addressing the climate problem with a false sense of confidence in our understanding of the geo-scientific uncertainties and their unknown consequences for economic opportunity and social well being can be counterproductive. We explore quantitative stochastic dynamic equilibrium models enriched to include stylized specifications of carbon-climate dynamics to confront uncertainty, broadly conceived to include model ambiguity and misspecification concerns by incorporating recent advances in decision theory. Using this approach, we investigate policy questions related to the social cost of carbon and the subsidy of green technologies.

3 - Housing and Mortgage Markets with Climate-Change Risk: Evidence from Wildfires in California

Richard Stanton, University of California, Berkeley, CA, United States, Paulo Isser, Carles Vergara-Alert, Nancy Wallace

This paper studies the effects of climate-driven events on the housing and mortgage markets. We merge property-level data on all California wildfires from 2000 to 2018, mortgage and property characteristics, household finances, and weather. We find a significant increase in mortgage delinquency and foreclosure after a fire in the devastated areas, but these effects decrease in the size of the fire. We argue that this results from coordination externalities afforded by large firesand frictions in the insurance markets, which lead to rebuilding in the devastated areas and to increases in home sizes, house prices, income and wealth. Our results suggest that recent large losses, combined with regulatory distortions, cast doubt on the ability of insurance companies and mortgage lenders to absorb climate-related losses and assess mortgage risk.

■ VMD49

Virtual Room 49

Multicriteria Decision Models in Health Care

Sponsored: Multi Criteria Decision Making

Sponsored Session

Chair: Danielle Costa Morais, Universidade Federal de Pernambuco - UFPE, Recife - PE, 52020-212, Brazil

Co-Chair: Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Recife PE, 50740533, Brazil

1 - Multicriteria Decision Model For Screening Patients Considering Scarce Resources Under Covid-19 Pandemic

Danielle Morais, Universidade Federal de Pernambuco, Recife, Brazil, Eduarda Asfora Frej, Lucia Roselli, Rodrigo Ferreira, Alexandre Alberti, Adiel de Almeida

Considering the high impact caused by the COVID-19 pandemic in health systems worldwide, this work aims to propose a decision protocol for screening patients with suspected or confirmed COVID-19, considering scarce resources in healthcare systems. The proposed approach considers patients' clinical conditions information in order to derive a recommendation on which is the best alternative for the patient: isolation at home, ICU stay or hospital stay. The analysis is conducted based on a multicriteria decision model, considering the Multiattribute Utility Theory. The recommendation is computed based on a Monte-Carlo simulation model, which enables a robustness index to be obtained for each alternative.

■ VMD50

Virtual Room 50

Simulation-II

Sponsored: Simulation Society

Sponsored Session

Chair: Henry Lam, Columbia University, New York, NY, 10027-6601, United States

Co-Chair: Haofeng Zhang, Columbia University, New York, NY, 10027, United States

1 - Limit Theorems For Empirical Regenerative Processes And A Sample-based Method To Compute Convergence Bounds

Yanlin Qu, Stanford University, Stanford, CA, United States

We introduce a broad process class, wide-sense semi-regenerative processes (WSRP), where the regenerations have different types and may depend on history. Given a set of sample fragments of a WSRP, the empirical regenerative process (ERP) is defined as the average of all possible paths obtained by resampling. We show that the ERP, as an estimator of the entire expected path, enjoys strong consistency and asymptotic normality with respect to some exponentially weighted sup norm. With these limit theorems, we are able to estimate not only the exact exponential rate but also the optimal pre-exponential factor to bound the convergence of the original process.

2 - Adaptive Survivor Methods For Large-Scale Parallel Simulation Optimization

Linda Pei, Northwestern University, Chicago, IL, 60626, United States, Barry L Nelson, Susan R. Hunter

We apply a Parallel Adaptive Survivor Selection (PASS) framework to very large-scale simulation optimization problems with millions of feasible solutions, using the Message Passing Interface (MPI) and a master-worker architecture to coordinate parallel processors. Using the concept of a "standard" we quickly eliminate inferior solutions worse than the standard and retain good ones with a false-elimination-rate guarantee. We also explore computational issues such as across-processor communication, an important topic in the related parallel multi-armed bandit literature.

3 - Moderate Deviations Inequalities For Gaussian Process Regression

Jialin Li, University of Maryland, College Park, MD, 20770, United States

We derive moderate deviations theories for Gaussian process regression in the problem of simulating an unknown objective function. We prove a variant of Gartner-Ellis theorem with relaxed condition, and use that to establish moderate deviations inequalities which meanwhile disprove the existence of a large deviations principle. Applications of moderate deviations inequalities on novel error events reveal convergence rates for the probability of making type I statistical errors, i.e., reporting one solution as being better than another when in reality the opposite is true, and the probability of making large errors on estimating minimal function value. Finally the two convergence rates are instantiated in simulation settings of using a Gaussian kernel with either deterministic or random designs.

4 - Importance Sampling Meets Control Functional: Doubly Robust Stein-kernelized Estimators For Monte Carlo Error Reduction

Haofeng Zhang, Columbia University, New York, NY, 10027, United States, Henry Lam

Monte Carlo computation can sometimes encounter challenges in its convergence speed or the need to generate samples from biased models. Two recent techniques derived from integrating reproducing kernel Hilbert space and so-called Stein's identity, one via control variate and another via importance sampling, are proposed to reduce the variance or bias in Monte Carlo simulation. We investigate the challenges of applying such techniques in some general situations with multiple input models each under different knowledge levels that occur in practice. Then we present a more general framework to encompass both techniques, which we call doubly robust Stein-kernelized estimators. We show our estimators provably outperforms both methods in terms of MSE convergence rates in different scenarios. We demonstrate the superior performance of our method via numerical examples.

■ VMD51

Virtual Room 51

Economics of Retail Distribution Services

Sponsored: Service Science

Sponsored Session

Chair: Stanley Lim, University of San Diego School of Business, San Diego, CA, 92110-8001, United States

Co-Chair: Sheng Liu, University of Toronto

1 - Contingent Free Shipping: Drivers Of Bubble Purchases

Sahar Hemmati, University of Maryland, College Park, MD, United States, Wedad Elmaghraby, Ashish Kabra, Nitish Jain

Retailers often offer free shipping on orders above a pre-specified threshold (Contingent Free Shipping, CFS). In response, customers may pad below-threshold orders to avoid shipping fees. This behavior can economize logistics costs if customers do not engage in bubble purchases, padded orders with above-par return propensity. In this study, we empirically examine how the customers' engagement in bubble purchases relates to: 1. CFS policy's threshold and shipping fee and 2. ease of product return. We find that, in response to CFS policies, customers pad 12.4% to 28.4% of below-threshold orders. Both policy levers considerably affect their order padding and bubble purchase propensity. In markets with a customer-friendly return process, share of bubble purchases varies from 8.4% to 14.7% and is altogether eliminated in markets with inconveniences in the return process.

2 - Bundle Selection And Optimization In A Crowdsourced Delivery Platform

Qingchen Wang, Hong Kong

Crowdsourced delivery platforms have emerged as a growing alternative to deliver goods to consumers by using independent contractors. We employ a choice model to study drivers' preferences in selecting bundles, each containing at least one delivery job, and use the preference parameters to develop a bundling optimization procedure. The objective is to create "attractive" bundles to increase their selection probability.

3 - Delivery Time Forecasting And Promising In Online Retailing: A Data-driven Framework

Nooshin Salari, Rotman School of Management, Toronto, ON, Canada, Sheng Liu, Max Shen

Providing reliable delivery services is key to running a successful online retail business. To achieve a better delivery time guarantee policy, we study how to estimate and promise delivery time for new customer orders in real-time. We adapt machine learning based models to generate distributional forecasts by exploiting the complicated relationship between delivery time and relevant predictors to model the distribution center operations. We further propose a cost-sensitive classification decision rule to decide the promised delivery day from the predicted distribution. By testing on a real-world data set from a large online retailer, we demonstrate that the proposed framework has the potential to provide more accurate promised delivery time with less misclassification cost compared to the conventional promised time set by the online retailer.

4 - Capacity Flexibility Via On-demand Warehousing
Soraya Fatehi, University of Texas at Dallas, Richardson, TX, United States, Leela Aarthy Nageswaran, Michael R. Wagner

We study the on-demand warehousing business practice where firms who seek capacity for short term needs match with third-party warehouse providers who have excess capacity. We derive a firm's optimal capacity investment decision in the presence of the on-demand warehousing option. Motivated by the practice of on-demand warehousing players and prior work on sharing platforms, we also investigate the implications of two pricing strategies, surge pricing and bid pricing. Our results indicate that on-demand warehousing allows firms to absorb their demand fluctuations and increase their profit. Our findings provide valuable insight into when the different pricing strategies may be used by an on-demand warehousing platform. We also study whether platforms should share information regarding available capacity of providers and how it impacts the system performance.

5 - Estimating Stockout Costs and Optimal Stockout Rates to Improve the Management of Ugly Produce Inventory
Stanley Lim, Michigan State University, East Lansing, MI, 92110-8001, United States, Elliot Rabinovich, Sanghak Lee, Sungho Park

Efficiently managing inventories requires an accurate estimation of stockout costs. This estimation is complicated by challenges in determining how to compensate consumers monetarily to ensure that they will maintain the same level of utility they would have obtained had stockouts not occurred. This paper presents an analysis of these compensation costs, as applied to the design of optimal stockout rates by an online retailer marketing to consumers aesthetically substandard fruits and vegetables rejected by mainstream grocery chains.

■ VMD52

Virtual Room 52

Service Science Best Cluster Paper Competition (IV)

Sponsored: Service Science

Sponsored Session

Chair: Weiwei Chen, Rutgers University, Piscataway, NJ, 08854-8081, United States

Co-Chair: Robin Qiu, Penn State (The Pennsylvania State University), Malvern, PA, 19355-1488, United States

1 - Design of Covid-19 Testing Queues
Shiliang Cui, Georgetown University, McDonough School of Business, McLean, VA, 22101, United States

In the event of a virus outbreak such as COVID-19, testing is key. However, long waiting lines at testing facilities often discourage individuals from getting tested. This paper utilizes queueing-game-theoretic models to study how testing facilities should set scheduling and pricing policies to incentivize individuals to test, with the goal to identify the most cases of infection.

2 - Selecting Cover Images for Restaurant Reviews: AI vs. Wisdom of the Crowd
Warut Khern-am-nuai, McGill University, Montreal, QC, Canada

Restaurant review platforms routinely receive large numbers of photos in their review submissions. However, selecting these images as cover images can be time consuming and often requires human intervention. This paper discusses two image selection approaches, crowd-based and AI-based systems. We collaborated with a large review platform in Asia to conduct a randomized field experiment to show that the AI-based system outperforms the crowd-based counterpart in terms of stimulating user engagement. Underlying mechanisms that drive superior performance of the AI-based system are also discussed.

3 - Tax-Induced Inequalities in the Sharing Economy
Yao Cui, Cornell University, Ithaca, NY, 14853-6201, United States

We use a machine learning (causal forest) method to empirically study the heterogeneous treatment effects of the occupancy tax policy on Airbnb. We find that the tax adversely affects residential listings more than commercial listings, suggesting that the current tax policy may over-penalize the wrong type of listings. We further show that this unintended consequence is caused by customers' discriminatory tax aversion. We then conduct prescriptive analytics regarding how hosts should optimally adjust prices in response to the tax and how policy makers should set more appropriate tax rates.

4 - The Impact of Surgeon Daily Workload and its Implications for Operating Room Scheduling
Yiwen Shen, Columbia University, New York, NY, 10027-8385, United States

In service systems, workload can substantially impact service time and quality. We study this relationship in the context of cardiac surgery. Using a dataset of cardiac operations in a large hospital, we quantify how surgeon daily workload affects surgery duration and patient outcomes. We construct instrument variables by hospital operational factors. We find high daily workload is associated with longer incision times and worse patient outcomes. We develop a surgical scheduling model that incorporates such effects. We show the proposed schedule can substantially improve the surgery outcomes.

■ VMD53

Virtual Room 53

Social Media and Platform Economy

Sponsored: Social Media Analytics

Sponsored Session

Chair: Luna Zhang, University of Washington Tacoma, Tacoma, WA, 98402-3100, United States

1 - Does Ai-based Credit Scoring Improve Financial Inclusion
Chunxiao Li, Shanghai Jiao Tong University, Shanghai, 200030, China

Artificial intelligence (AI) has become ubiquitous in the consumer finance industry. One of the major AI applications in this industry is AI-based credit scoring models. We investigate whether AI applications improve financial inclusion, as measured by three seemingly contradictory metrics. Using data obtained from online lenders, we find that AI-based credit scoring models increase approval rate and reduce default rate simultaneously, which enhances both the magnitude and the quality of financial inclusion. AI-based credit scoring models also tend to reduce false rejection rate, suggesting that they can help provide access to capital to a previously underserved population. We plan to collect more data and conduct additional analyses in the future to enrich our current findings and explore for underlying mechanisms.

2 - My Review Just Got Highlighted! The Impact Of Featured Review On Reviewer Behavior
Tong Wu, University of Massachusetts Boston, Boston, MA, United States

This study investigates the effect of the Favorite Review (FR) feature on reviewer behavior in an online user-generated content (UGC) platform. Relying on difference-in-differences techniques, we find that the highlighted review shapes reviewer behavior. Our results indicate that the design of gamification features in a UGC platform might create a win-win-win environment for properties, users, and the platform.

3 - Impact of Multi-Staged Informational Interventions on Smart TV Viewers: Evidence from a Large-Scale Randomized Field Experiment
Raveesh Mayya, NYU Stern School of Business, New York, NY, United States, Siva Viswanathan

Recent advances in Smart TVs allow TV platforms to intervene in real-time and enhance multi-screen content consumption experience. We conduct a large-scale RCT to study the impact of multi-screen informational interventions on TV viewers' second-screen content consumption. We design the interventions using two unique aspects of broadcast TV viewing: temporal aspect (i.e., the content goes away in a while) and the social-proof aspect (i.e., similar viewers are responding to interventions). We demonstrate that multi-stage interventions are effective and document an interaction between various types of persuasive messages across stages. We discuss practical implications of our findings.

4 - The Impact of Reputation Systems on Peer Feedback in Social Media
Jin-Hee Huh, University of Calgary, Calgary, AB, Canada

In this paper, we investigate how a reputation system affects peer evaluations in an online community. In contrast to previous research on reputation systems, which has predominantly shown that reputation systems can induce posting activity and quality contributions, we study how reputation markers (achievement badges, for example) may affect changes in peer evaluations. We rely on a unique and detailed data set and employ a difference-in-differences approach, combined with propensity score matching. The results suggest that, all else equal, posters receive disproportionately-higher evaluations of their posts after they earn a reputation marker, irrespective of post quality.

5 - Revenue-sharing Designs For Platforms
Luna Zhang, University of Washington Tacoma, Tacoma, WA, 98402-3100, United States, Hemant K Bhargava, Kitty Wang

Platforms motivate value creators by sharing platform revenue with them. Major platforms today use a linear revenue-sharing scheme. We explore alternative designs for revenue-sharing between the platform and creators, and apply our insights to the tensions that have arisen between platforms and creator-partners.

■ VMD55

Virtual Room 55

Resilient Infrastructure and Community Networks

Sponsored: Public Sector OR

Sponsored Session

Chair: Gabriela Gongora-Svartzman, Carnegie Mellon University, Pittsburgh, PA, 15213-3725, United States

1 - Efficient Solution Approaches To The Isolated Community Evacuation Problem

Klaas Fiete Krutein, University of Washington, Seattle, WA, 98117, United States, Anne Goodchild

The Isolated Community Evacuation Problem (ICEP) is a recently introduced route optimization model that aims at minimizing the evacuation time for communities that have no road-based evacuation routes and rely on alternative transportation resources for evacuation. The stochastic version of the problem allows for making planning decisions for such events considering demand uncertainty through a set of disaster scenarios. However, since this adds additional complexity and computational effort, we present different approximate solution approaches to the ICEP that reduce the solution time and allow for better use in practice for evacuation planning and show the effect on example problems of varying sizes.

2 - Equitable and Sustainable Energy Transitions

Destenie S. Nock, Carnegie Mellon University, Pittsburgh, PA, 15207-1120, United States

In the fight against climate change countries have set strong electricity sector decarbonization targets. However, there is uncertainty regarding whether these policies will exacerbate social inequities, and how they will impact environmental sustainability across different income groups. Currently, most electricity planning models determine the least cost option, without considering how the recommended pathways impact distributional equity. This research will explore the sustainability and equity trade-offs between different energy transition pathways for the US. Specifically we tie a national least cost optimization model with and equity analysis. We show how decarbonization targets impact energy equity objectives.

3 - Social Cohesion And Emotion Analysis Of News And Tweets During 2020 Wildfires: A Case Study

Alexander Gilgur, Stevens Institute of Technology, Sunnyvale, CA, 94087-2939, United States, Jose E. Ramirez-Marquez

Wildfires are a fact of life in California, from San Diego to Mount Shasta. We used social and public media to analyze emotions, social cohesion, and resilience in the cities of the San Francisco Bay Area, CA before, during, and immediately after California wildfires of 2020. The effects of interactions with COVID and protests of 2020 have been analyzed as well.

4 - Structural Characteristics Of Equitable And Efficient Distributions

Ozgun Elci, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, John Hooker, Peter Zhang

This paper focuses on fair allocation of scarce resources. Combining the conflicting objectives of efficiency and fairness is important for good policymaking concerning the use of scarce resources. We address this issue by employing the Hooker-Williams social welfare function that combines utilitarianism and Rawlsian equity. We analyze the Hooker-Williams social welfare function in the presence of linear budget constraints. We begin our analysis by focusing on a case with a single linear budget constraint. We study the polyhedral structure of this formulation and show that there is a closed-form solution. We then extend our analysis to a case that incorporates individual lower and upper bounds on the utilities of the players. The results on the structure of the optimal solutions provide managerial insights to decision-makers.

■ VMD56

Virtual Room 56

Navigating the Big 3: Impostor Syndrome, Perfectionism and Comparisonitis

Sponsored: Women in O.R./MS (WORMS)

Sponsored Session

Chair: Angelika Leskovskaya, SMU Cox School of Business, Dallas, TX, 75275-0333, United States

1 - Navigating the Big 3: Imposter Syndrome, Perfectionism and Comparisonitis

Jessica Dowches-Wheeler, Bright Space Coaching, Alexandria, VA, United States

While societal and organizational changes are needed for more women to advance, you can take ownership of your career and create your own path. In this session, you'll learn strategies for navigating the three biggest challenges facing women in the workplace: impostor syndrome, perfectionism, and comparisonitis. You'll walk away with tools and resources to overcome these challenges and achieve your career goals.

■ VMD57

Virtual Room 57

Incentives for Collaborative Innovation

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

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

Co-Chair: Lakshmi Nittala

1 - Team Collaboration In Innovation Contests

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

In an innovation contest, an organizer elicits solutions to an innovation-related problem where solvers can make individual or team submissions. While some crowdsourcing platforms like InnoCentive encourage team submissions, others like Topcoder prohibit them. Motivated by different policies in practice, we analyze the conditions under which the organizer benefits and solvers benefit from team submissions. We show that the organizer benefits from team submissions when he seeks high novelty-solutions to a nondecomposable problem and solvers benefit from team submissions in the absence of synergy within teams.

2 - Best Or Right? - Positioning And Authentication In Online Matching Platforms

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

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

3 - Sequential Admission Decisions in Performance Management

Karthik Ramachandran, Georgia Institute of Technology, Atlanta, GA, United States, Morvarid Rahmani

We model the optimal behavior of a manager making sequential performance evaluation decisions with limited room for admission. We conduct an experiment to determine how a participant's behavior replicates the optimal behavior based on the characteristics of the evaluated population.

4 - Learning And Doing In Contests

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

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

■ VMD58

Virtual Room 58

Pricing in Shared Mobility Markets

Sponsored: Transportation Science and Logistics

Sponsored Session

Chair: Sina Bahrami, United States

1 - The Effect of Target-based Incentive on Ride-sourcing Divers' Labor Supply

Tianming Liu, University of Michigan, Ann Arbor, MI, United States

Ride-sourcing companies have been using rewards to incentivize their drivers to work longer, but their effects are largely unknown. This study focuses on the target-based driver incentive programs. In such programs, participants can receive a certain amount of reward if she finishes a given number of orders within a given period. To examine the effect of these incentives, we develop causal models and utilize a real-world service dataset to evaluate drivers' labor supply responses. Our results reveal the effectiveness and limitations of such incentives over different service circumstances.

2 - Dynamic Simulation Model for Planning and Real-time Management of System of EV Fast-Charging Stations

Dingtong Yang, University of California Irvine, Irvine, CA, 92697, United States

Motivated by the environmental benefits of and associated government regulations promoting electric vehicles (EVs), as well as the limited charging infrastructure to support EV travel in place, this study presents an agent-based stochastic dynamic modeling framework of a regional system of EV fast-charging stations to support the planning and real-time management of EV fast-charging stations. To model EV user fast-charging station choices, the framework incorporates a multinomial logit station choice model that considers station charging prices, expected wait times, and detour distances. Moreover, Each EV charging station is modeled as a multi-server queueing model. To manage the system of stations, this study proposes dynamic demand-responsive price adjustment (DDRPA) schemes based on station queue lengths. The computational results, based on a real-world system of EV charging stations in California, indicate that the best DDRPA scheme reduces average wait time by 26%, increases revenue by 5.8%, and increases social welfare by 2.7%. Moreover, the results illustrate how the modeling framework can identify stations that require additional chargers and areas that would benefit from additional fast-charging stations.

3 - Dynamic Parking Management For Automated Vehicles In Downtown Areas

Tara Radvand, Graduate Student Research Assistant, University of Michigan, Ann Arbor, MI, United States, Sina Bahrami, Yafeng Yin

This study proposes a dynamic model for the parking choice in a downtown area in the era of automated vehicles (AVs). Given the distribution of users' activity time in the downtown, we propose a system of ordinary differential equations to model their AVs' choice between an outskirt parking lot and cruising as a substitution for parking. Cruising may cause traffic congestion, which is captured by a network macroscopic fundamental diagram. With the proposed model, we further investigate dynamic time-based tolling strategies to optimize the system performance.

4 - The Three-sided Market Of On-demand Delivery

Sina Bahrami, Postdoctoral Fellow, University of Michigan, Ann Arbor, MI, United States, Mehdi Nourinejad, Yafeng Yin, Hai Wang

On-demand food delivery services are subject to cross-side interactions among customers, suppliers, and drivers in a three-sided market. Each customer places an order from a supplier via an on-demand delivery platform and the order is delivered by an ad-hoc driver who serves as system catalyst connecting suppliers to customers by acting as the delivery mechanism. This paper investigates the interplay of cross-side interactions and studies the commissions paid by suppliers and customers and the wage offered to drivers. All three players are price-sensitive but the customers are also time-sensitive as they avoid long delivery times. We use continuum approximation to derive customer waiting times.

5 - Modeling Framework for Pricing-consistent Subscription Services in Shared Mobility Systems

Eduardo Marino, University of California, Irvine, CA, United States, R. Jayakrishnan

As shared mobility systems and various new paradigms of associated ownership and subscription systems are taking hold now, costs and prices in such systems need to be analyzed in depth. The current cost models are based on average values and long life-cycles, which are insufficient as daily travel miles of vehicles may significantly change. We present the conceptual aspects of the interactions of new cost structures and system performance in these new mobility systems. We present the properly designed cost function, a framework to analyze the interactions and optimize the new systems and provide results from an agent-based simulation of candidate contexts.

■ VMD59

Virtual Room 59

Transportation-Freight II

Contributed Session

Chair: Bernardo Martin-Iradi, Technical University of Denmark, Denmark

1 - An Efficiency-vulnerability Trade-off For Information Layer Integration In Multimodal Transport Networks

Camill Harter, Erasmus University Rotterdam, Rotterdam, Netherlands, Otto Koppius, Rob A. Zuidwijk

Synchromodality tackles inefficiency in hinterland transport through a dynamic system allowing for flexible routes and use of transport modes. This requires extensive integration of digital infrastructure, resulting in an interdependent complex system with digital and physical layer. Such systems have shown high vulnerability to cascadic failure. Applying a multi-layer network approach to a network of all intermodal services in Europe, we analyze a trade-off between efficiency and vulnerability that comes with synchromodality. We show that the system benefits from synchromodal transport under light attack, but it collapses quickly under heavy and targeted attack to the information layer.

2 - Minimum Costs Paths In Intermodal Transportation Networks With Stochastictravel Times And Overbookings

Rob van der Mei, CWI, Amsterdam, Netherlands

In intermodal transportation, it is essential to balance the trade-o between the cost and (stochastic) duration of a route. We study a problem faced by a company that supports shippers with advice for the route selection. The challenge is to find Pareto-optimal solutions regarding the route's costs and the probability of arriving before a specific deadline. We show how this probability can be calculated in a network with scheduled departure times and the possibility of overbookings. To solve this problem, we develop a heuristic that produces, in a fraction of the optimal algorithm's running time, solutions of which the costs are only a few percent higher than the optimal costs.

3 - An Integrated Relay-point Location, Vehicle Routing And Truck Driver Scheduling Problem

Mohammad Maleki, Kansas State University, Manhattan, KS, United States, Ashesh Sinha

The truckload industry faces a high driver turnover rate mostly because of long periods of time truck drivers spend away from home. In this research we consider a relay network with three main components: A relay location problem to reduce drivers' away-from-home times, a routing problem to determine the sequence of nodes to be visited by each truck such that the empty mileage is minimized, and finally an assignment of drivers to each trip and their scheduling to satisfy the hours-of-service (HOS) regulations.

4 - The Multi-port Berth Allocation Problem With Speed Optimization: Exact Methods And A Cooperative Game Analysis

Bernardo Martin-Iradi, PhD student, Technical University of Denmark, Copenhagen, Denmark, Dario Pacino, Stefan Ropke

We study a variant of the Berth Allocation Problem (BAP), which aims at assigning berthing times and positions to vessels in container terminals. The problem extends the BAP to multiple ports where vessel traveling speeds are optimized, thus exploiting the potentials of collaboration between carriers and terminal operators. Using a graph representation of the problem, we present a set partitioning formulation where each variable refers to a ship's sequence of feasible berths. The proposed branch-and-cut-and-price method outperforms existing methods. Cost allocation methods from cooperative game theory show that both carriers and terminal operators would benefit from such collaboration.

■ VMD60

Virtual Room 60

Advances in Data-Driven Air Traffic Flow Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Lu Dai, University of California, 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.

■ VMD61

Virtual Room 61

Operations Management for Urban Air Mobility

Sponsored: Aviation Applications

Sponsored Session

Chair: Zhangchen Hu, Isenberg School of Management, University of Massachusetts, Amherst, MA, 1003, United States

1 - Large-scale simulation of Urban Air Mobility

Ali Shamshiripour

This research aims at investigating the impacts of urban air mobility (UAM) on transportation in the context of U.S. cities, and quantifies UAM demand and its relationship with service pricing, operational configurations and other city-specific characteristics. Towards this, we extend our state-of-the-art agent- and activity-based simulation laboratory, SimMobility, to model UAM services. This includes: (1) implementation of detailed models of demand, supply and their interactions, and (2) thorough calibrations to match to key behavioral outcomes and network performance measures, in different prototype cities. The results will provide insights into the impacts of UAM in various U.S. cities, and inform evidence-based policy recommendations.

2 - UAV Path Planning Under Weather Uncertainty And Environmental Impact Considerations

Zhangchen Hu, University of Massachusetts Amherst, Amherst, MA, 1003, United States, Heng Chen, Senay Solak

Unmanned aerial vehicles (UAVs) are expected to be widely used in the near future as an alternative transportation mode to mitigate congestion and pollution in a variety of applications. We design a dynamic and data-driven decision support system for UAV path planning through a stochastic programming based implementation, where both weather uncertainty and environmental impacts are directly considered.

3 - Presenter

Tengkuo Zhu, The University of Texas at Austin, Austin, TX, 78731-2232, United States

The past few years have witnessed the increasing adoption of drones in various industries. In this paper, we consider a short-term post-disaster UAV humanitarian relief application where first-aid products needs to be delivered to the customer demand points. The presented problem, two-stage robust facility location problem with drones, incorporates the demand uncertainty using demand scenarios. The objective of this problem is to find a location-allocation-assignment plan that has minimal two-stage total cost in the worst-case scenario. Two models of the problem are proposed that incorporates a realistic UAV electricity consumption model. The column-and-constraint generation method and Benders decomposition are used to solve the two models and a thorough comparison among the deterministic one-stage FLPD model and two proposed models are also presented.

4 - Truck and drone delivery on a circle

Bahar Dehqani Viniche, York University, Toronto, ON, Canada, Opher Baron, Oded Berman, Mehdi Nourinejad

A hybrid fleet of land and aerial vehicles can provide the required flexibility for cost-effective last-mile delivery. This research seeks to find optimal routes to serve a set of recipients using a fleet of trucks and drones. The fleet has operational restrictions that shall not be violated during the course of delivery. The movement of trucks and drones should be fully coordinated. Given complexities of this setting, we develop a stylized model with the recipients distributed on a circle while the depot is at the center. Using this circular model allows us to develop analytical derivations of the delivery costs. We optimize the non-linear mathematical model under certain uncertainties in the number of recipients.

■ VMD62

Virtual Room 62

Scheduling 3

Informs Special Session: Scheduling and Project Management

Informs Special Session Session

Chair: Yumei Huo, City University of New York, Staten Island, NY, 10314-6609, United States

1 - Shared Processed Multitasking Scheduling With Controllable Processing Times

Yan Wang, Northwestern Polytechnical University, Xian, 710072, China, Jun-Qiang Wang

We study a single-machine multitasking scheduling via shared processed subject to limited continuous resources. The job processing times are controllable as a linear function of the amount of resources allocated to the jobs. The objective is to determine the optimal compressions of the processing times and the optimal sequence of jobs so as to minimize a cost function containing makespan (total completion time) and total compression costs. We provide structural properties of the optimal schedules and polynomial-time algorithms for the considered problems.

2 - Due Date Assignment Problem With Late Work Criteria

Yaowen Sang, Northwestern Polytechnical University, Xian, 710072, China, Junqiang Wang

We study the scheduling problem of minimizing due date assignment costs and total late work penalties. We prove that the problem is strongly NP-hard and give an optimal due date assignment for any given job sequence. Furthermore, we investigate some special cases.

3 - Minimizing Total Completion Time On Multitasking Shared Processing Machines

Yumei Huo, City University of New York, College of Staten Island & The Graduate Center, Staten Island, NY, 10314-6609, United States

We study parallel machine multitasking scheduling problem with shared processing. Each machine has some disjoint intervals where primary jobs and routinely scheduled jobs can share the processing. Since for each routinely scheduled job, the time window and the processing capacity assigned to it has been predetermined, our goal is to find the optimal schedule for primary jobs and minimize their total completion time. We prove that there is no any approximation algorithm for two machine scheduling problem when the sharing ratios, which are the fractions of the processing capacity assigned to primary jobs, are arbitrary for all machines unless P equals to NP. Then for the problem that the sharing ratios on some machines have a positive constant lower bound, we analyze the performance of SPT-ECT rule and develop an approximation scheme.

4 - A New History-Guided Multi-Objective Evolutionary Algorithm Based On Decomposition For Batching Scheduling

Zhaohong Jia, Anhui University, Heifei, 230039, China

In this paper, a multi-objective scheduling problem on parallel batching machines is investigated with three objectives, the minimization of the makespan, the total weighted earliness/tardiness penalty and the total energy consumption, simultaneously. It is known that the batch scheduling problem is a type of NP-hard problems and the solutions to this problem have quite valuable structural features that are difficult to be formulated. One of the main issues is to make full use of the structural features of the existing solutions. Aiming at this issue, two effective strategies, local competition and internal replacement, are designed. Firstly, the local competition searches for the competitive neighboring solutions to accelerate convergence, through adjusting job positions based on two structural indicators. Secondly, the internal replacement uniformly retains half of the population as elites by elitist preservation based on decomposition. Thereafter, the other half of the population is replaced by the new solutions generated under the guidance of historical information. Moreover, the historical information is updated with the structural features extracted from the elites. As a result, a history-guided evolutionary algorithm based on decomposition with the above two strategies is proposed. To verify the performance of the proposed algorithm, extensive experiments are conducted on 18 groups of instances, in comparison with four state-of-the-art multi-objective optimization algorithms. Experimental results demonstrate that the proposed algorithm shows considerable competitiveness in addressing the studied multi-objective scheduling problems.

5 - Submodular Batch Scheduling On Identical Machines

Tao Sun, Northwestern Polytechnic University, Xi'an, China, Jun-Qiang Wang

We study a new submodular batch scheduling problem that arises in p-batch, s-batch, mixed batch and submodular partitioning problem. A submodular batch machine can process at most a given number of jobs simultaneously. The processing time function of a batch is submodular, where a function f: 2^V R_+ is submodular if for any set A,B V,f(A B)+f(A B)≤f(A)+f(B). The objective is to minimize the makespan. We first prove that the batch processing time functions of p-batch, s-batch and mixed-batch are submodular. Then, based on some properties of the submodular function, we analyze the worst case performance ratio of the list scheduling rule, full batch longest processing time rule and longest processing time-greedy rule, respectively.

■ VMD63

Virtual Room 63

Computational Optimization and Applications

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Bissan Ghaddar, Ivey Business School, London, ON, N6G 0N1, Canada

1 - Sparse Simultaneous Component Analysis Using Alternating Maximization

Juan C. Vera, Tilburg University, Tilburg, 5000 LE, Netherlands, Rosember I. Guerra Urzola, Katrijn Van Deun

Often information from different sources is collected and joined as one -e.g., psychological questionnaire data and genetic risk scores. Thus, more and more data consist of multiples data blocks sharing the same observations. Simultaneous component analysis (SCA) is traditionally used for integrative analysis of such kind of data. However, using all variables makes the interpretation difficult, especially in high-dimensional settings. Therefore, looking for a sparse structure is natural; it identifies the common and distinctive source of variation across all data blocks. We solve both the cardinality-constraint and the adaptive lasso penalty formulations of SCA via alternating maximization. We numerically assess our methodologies; they allow finding high-quality feasible solutions in seconds for large dimensions.

2 - Lagrangian Duality In Polynomial Optimization

Luis F. Zuluaga, Lehigh University, Bethlehem, PA, 18015-1518, United States, Juan C Vera

The Lagrangean function associated with an optimization problem has and continuous to be of the utmost importance to develop algorithmic solution approaches for optimization problems. This is particularly the case when the problem of interest is convex, as in that case, optimizing the Lagrangean function provides a dual problem (Lagrangean dual) to the primal (original) one, satisfying strong duality. Here, using techniques borrowed from both polynomial optimization, copositive programming, and algebraic geometry, we show that the classical Lagrangean function associated with an optimization problem can be used to obtain a Lagrangean dual of the problem that satisfies strong duality, even when the problem is non-convex, as long as some qualification assumptions on the constraints and feasible set of the problem are satisfied.

3 - Adjustable Robust Two-Stage Optimal Power Flow

Bissan Ghaddar, Ivey Business School, London, ON, N6G 0N1, Canada

This talk proposes a solution approach to the robust AC Optimal Power Flow (ACOPF) problem based on polynomial optimization (PO). The growing use of renewable energy challenges the reliability of electric power system operations since the power generation from renewables can be heavily uncertain. First, we construct PO certificates of robust feasibility and infeasibility of ACOPF. Then we propose an iterative PO-based algorithm to build a sequence of robustly feasible solutions to ACOPF with an improving objective value. The algorithm does not impose restrictive assumptions on the network topology or the device capabilities at each bus. We demonstrate the certificates and the proposed algorithm on MATPOWER test cases.

4 - Methods For Community Detection In Multilayer Networks

Sara Venturini, University of Padua, Padua, Italy, Andrea Cristofari, Francesco Rinaldi, Francesco Tudisco

Networks have emerged as effective tools for modelling and analyzing complex systems of interacting entities. Graphs arise naturally in many disciplines, such as social, information, and biological networks. Many complex systems are composed of coupled networks through different layers, where each layer represents one type of interaction. One out of many issues is to extract communities in multilayer networks. Community detection is a very hard problem and not yet satisfactorily solved, despite the extensive studies in the literature. We propose methods for community detection that simultaneously consider multiple layers. We tested them on both artificial and real-world networks.

■ VMD64

Virtual Room 64

Convexification in the Context of Global Optimization

Sponsored: OPT/Global Optimization

Sponsored Session

Chair: Emily Speakman, University of Colorado Denver, Denver, CO, 80217-3364, United States

1 - Gaining Or Losing Perspective For Piecewise-linear Under-estimators Of Convex Univariate Functions

Emily Speakman, University of Colorado Denver, Denver, CO, 80217-3364, United States, Jon Lee, Daphne Skipper, Luze Xu

We study a well-known MINLO (mixed-integer nonlinear optimization) formulation of the disjunction $x \in \{ 0 \} \cup [l,u]$, where z is a binary indicator of $x \in [l,u]$, and y ``captures'' x^p, for $p>1$. This model is useful when activities have operating ranges, we pay a fixed cost for carrying out each activity, and costs on the levels of activities are strictly convex. The `perspective reformulation' is a well-known method for tightening the convex relaxation of the obvious MINLO formulation. Using volume as a measure to compare convex bodies, we investigate optimal placement of a fixed number of linearization points for building a best piecewise-linear convex under-estimator (in the context of the perspective reformulation).

2 - Convex Hull Of Quadratic Inequalities Via Aggregations

Santanu Subhas Dey, ISyE Georgia Tech, Atlanta, GA, 30318, United States, Gonzalo Munoz, Felipe Serrano

In this work, we study the case of a set described by three or more quadratic inequalities. We show that, under technical assumptions, the convex hull of a set described by three quadratic inequalities can be obtained via (potentially infinitely many) aggregated inequalities.

3 - Convexification Of Disjoint Bilinear Programs

Hyun-Ju Oh, Graduate Student, Purdue University, West Lafayette, IN, United States, Mohit Tawarmalani

In this paper, we construct a hierarchy of relaxations for disjoint bilinear programs using double description (DD) method. We show that, at each level, our relaxations are at least as tight as the corresponding lift-and-project (L&P) relaxation. In contrast to L&P relaxations, our relaxations converge to the convex hull of the bilinear set in a finite number of iterations. We discuss various ways to tighten relaxations using vertex decompositions and discuss applications of our results to max-min problems.

4 - Cutting Plane Algorithms For Continuous Dr-Submodular Maximization

Izuwa Ahanor, University of Tennessee-Knoxville, Knoxville, TN, United States, Hugh Medal

We present cutting plane algorithms for maximizing continuous DR-submodular functions subject to constraints. The cutting planes are based on the properties of the epigraph of such functions. Algorithms are presented for both non-decreasing and non-monotone functions and preliminary computational results are presented for a variety of test problems.

■ VMD65

Virtual Room 65

Binary Decision Diagrams for Optimization

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Moira MacNeil, University of Toronto, Toronto, ON, M4Y 1E5, Canada

1 - Improving Branch-and-bound Using Decision Diagrams And Reinforcement Learning

Augustin Parjadis, PhD Candidate, Polytechnique Montreal, Montreal, QC, Canada, David Bergman, Quentin Cappart, Louis-Martin Rousseau

Most exact approaches for solving combinatorial problems use relaxations to derive bounds on the objective function. Decision diagrams provide an approach for obtaining bounds that, in some cases, can be significantly better than those obtained with a standard linear programming relaxation. We study a reinforcement learning approach for variable ordering to build decision diagrams yielding tight bounds to be used in a branch-and-bound solver. This approach shows that those bounds can drastically reduce the tree search size on the maximum independent set problem.

2 - Graph Coloring With Decision Diagrams: An Analysis Of Variable Ordering

Anthony Karahalios, Carnegie Mellon University, Pittsburgh, PA, United States, Willem-Jan van Hoeve

A decision diagram approach was recently introduced to generate lower bounds for the graph coloring problem. It uses compilation via iterative refinement, which requires a variable ordering to be specified in advance. Oftentimes no single variable ordering dominates all others for a set of problem instances. This work provides an analysis and experimental evaluation of different variable ordering strategies including using portfolios of variable orderings.

4 - Deepest Cuts For Benders Decomposition

Mojtaba Hosseini, Paul Merage School of Business, UCI, Irvine, CA, United States

Benders Decomposition (BD) has been successfully applied to a wide range of large-scale mixed-integer (linear) problems. We introduce deepest Benders cuts, a new unifying Benders cut selection technique based on a geometric interpretation of cut "depth", and provide a comprehensive study of their properties. We further propose a generalization of the Benders separation problem that brings several well-known cut selection strategies under one umbrella. We propose the Guided Projections Algorithm for producing deepest Benders cuts and demonstrate their effectiveness in improving the convergence of the BD algorithm.

3 - Solving The Stochastic Minimum Weight Dominating Set Problem Using Binary Decision Diagrams

Moira MacNeil, University of Toronto, Toronto, ON, M4Y 1E5, Canada, Merve Bodur

The minimum weight dominating set (MWDS) is a classical graph optimization problem where a minimum-weight subset of graph nodes which are adjacent to, and thus dominate, every other node in the graph must be selected. The MWDS has a wide array of applications including wireless sensor network design and disease suppression and control, which motivates the study of this problem in the stochastic setting. We present the first study of MWDS with both stochastic node weights and probabilistic node failures. We solve this problem using a two-stage decomposition, however because the second stage variables are binary, standard Benders decomposition does not apply. We use binary decision diagrams (BDDs) to solve the second stage subproblems and derive cuts. We compare the BDD-based methods with the more traditional integer L-shaped method.

4 - Deepest Cuts For Benders Decomposition

John G Turner

Benders Decomposition (BD) has been successfully applied to a wide range of large-scale mixed-integer (linear) problems. We introduce deepest Benders cuts, a new unifying Benders cut selection technique based on a geometric interpretation of cut "depth", and provide a comprehensive study of their properties. We further propose a generalization of the Benders separation problem that brings several well-known cut selection strategies under one umbrella. We propose the Guided Projections Algorithm for producing deepest Benders cuts and demonstrate their effectiveness in improving the convergence of the BD algorithm.

■ VMD66

Virtual Room 66

Network Optimization: Network influence

Sponsored: OPT/Network Optimization

Sponsored Session

Chair: Majid Akhgar

1 - Influence-Coverage Optimization Problem

Majid Akhgar Farsani, Oklahoma State University, Stillwater, OK, United States, Juan Sebastian Borrero

We introduce the problem of influence-coverage optimization, where the Influence Optimization and the Maximum Coverage problems are merged into one network optimization problem. In this problem, we have a social network where nodes get activated either by their active in-neighbors or by getting at least a point of their piecewise linear paths covered by external factors. Depending on the application, external factors could be facilities, flyers, billboards, Geo-fences, street art paintings, campaigns, social movements and so on. The aim is to minimize the time until all nodes are active, which depends on the locations of external factors and the value of in-neighbors influence rates. In this regard, we apply an exact approach as well as heuristic approaches providing both decent lower and upper bounds for the proposed MIP problem.

2 - A Randomized Solution Approach For Finding Groups With Maximum Betweenness Centrality

Tomas Lagos, PhD Student, Swanson School of Engineering, University of Pittsburgh, Pittsburgh, PA, United States

Group betweenness centrality (GBC) indices are widely used to quantify the importance of nodes relatively to the structure of a network. For a given group of nodes, it is defined as the proportion of pairwise shortest paths in a network that each contains at least one node from the group. The problem of finding the group (of some given cardinality) that maximizes GBC is known to be NP-hard. In this talk we discuss a randomized solution approach for solving this problem with some theoretical performance guarantees. The performance of our approach is demonstrated in a numerical study with real-life and randomly generated test instances.

3 - The Stochastic Pseudo-star Degree Centrality Problem

Chrysafis Vogiatzis, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Mustafa Can Camur, Thomas Sharkey

We introduce the stochastic pseudo-star degree centrality problem and propose methods to solve it. The goal is to find an induced pseudo-star, defined as a set of nodes which form a star with certain probability, such that it maximizes the sum of the probabilities in the unique assignments between the star and its open neighborhood. Here, we are specifically interested in a feasible pseudo-star, where feasibility is measured as the product of the existence probabilities of edges between the center and leaf nodes and the product of one minus the existence probabilities of edges among the leaf nodes. We present solution techniques and show an application in protein-protein interaction networks.

4 - Percolation-based Measures Of Network Centrality For Managing Communication And Contagion

Robert Hill, George Washington University SEAS, Pinecrest, FL, United States

This research develops two new measures of centrality useful for understanding contagion and epidemic spreading in large, complex networks. The first, percolation threshold centrality, measures the influence of individual nodes on network resilience and connectivity, complementing the existing notion of percolation centrality. The second, degree correlation centrality, closely relates to the first and captures the contribution of individual nodes to the efficiency of communication and, thus, epidemic spreading in a network. In identifying key nodes for removal, in the context of infectious diseases, this work may have useful implications for the problem of Covid-19 vaccine hesitancy.

■ VMD67

Virtual Room 67

Advances in Nonlinear and Stochastic Optimization I

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Baoyu Zhou, Lehigh University, Bethlehem, PA, 18015, United States

1 - Newton-type Methods With Complexity Guarantees

Clement W Royer, Universite Paris-Dauphine, Paris, 75016, France

In this talk, we derive complexity results for a class of matrix-free Newton-type methods. Our approach covers several globalization techniques such as line search and trust region, and leads to optimal iteration complexity guarantees. By carefully studying the associated subproblems (solving a linear system, optimizing a quadratic function over a trust region), we also obtain computational complexity bounds for our method, that match the best known results for second-order methods in nonconvex optimization. Numerical expertiments illustrate that the proposed methods retain the attractive practical behavior of classical matrix-free algorithms.

2 - Generalized Cyclic Stochastic Approximation and its Application In Multi-agent Systems

Jiahao Shi, University of Michigan, Ann Arbor, MI, United States, Karla Hernandez, James Spall

Stochastic approximation (SA) is a powerful class of iterative algorithms for minimizing a loss function, L( ), when only noisy observations of L( ) or its gradient are available. In this talk, we will present a generalized cyclic SA (GCSA) algorithm, a variant of SA procedures, where is divided into multiple subvectors that are updated one at a time. The subvector to update may be selected according to a random variable or according to a predetermined pattern. The convergence of GCSA, asymptotic normality of GCSA, and efficiency of GCSA relative to its non-cyclic counterpart are investigated. Finally, we apply the GCSA algorithm to a multi-agent stochastic optimization problem.

3 - A Smoothing-based Decomposition Algorithm For Nonlinear Two-state Problems

Andreas Waechter, Northwestern University, Evanston, IL, 60208-0834, United States

A decomposition algorithm for nonlinear two-stage optimization problems is presented. The second-stage value function is smoothed by means of a barrier term. As a result, the first-stage problem can be solved directly with a nonlinear optimization algorithm. Fast local convergence is achieved by lifting second-stage constraints to avoid ill-conditioning near the optimal solution.

4 - A Stochastic Subgradient Method For Distributionally Robust Non-convex Learning

Landi Zhu, Rutgers University, Piscataway, NJ, United States, Mert Gurbuzbalaban, Andrzej Ruszczynski

We consider a distributionally robust formulation of stochastic optimization problems. Our formulation uses semi-deviation risk for quantifying uncertainty, allowing us to compute solutions that are robust against perturbations in the population data distribution. We consider a broad class of generalized differentiable loss functions that can be non-convex and non-smooth and we develop an efficient stochastic subgradient method for distributionally robust problems with such functions. We prove that it converges to an optimal point. Our method allows for control of the desired level of robustness with little extra computational cost compared to population risk minimization with stochastic gradient methods. We also illustrate the performance of our algorithm on real datasets arising in convex and non-convex supervised learning problems.

5 - A Smoothing-based Decomposition Algorithm For Nonlinear Two-state Problems, Shenyinying Tu, Ermin Wei

A decomposition algorithm for nonlinear two-stage optimization problems is presented. The second-stage value function is smoothed by means of a barrier term. As a result, the first-stage problem can be solved directly with a nonlinear optimization algorithm. Fast local convergence is achieved by lifting second-stage constraints to avoid ill-conditioning near the optimal solution.

■ VMD68

Virtual Room 68

Efficiency in Distributed ML Environments: Data Parallel, Model Parallel and Federated Learning Solutions

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Anastasios Kyrillidis, Rice University, Houston, TX, 77005-1827, United States

Co-Chair: Christopher Jermaine, University of Florida, CLSE Department, Gainesville, FL, 32611-6120, United States

1 - The Benefit of Heterogeneity in Collaborative Learning: Federated and Distributed Best-Arm Identification

Hamed Hassani, University of Pennsylvania, Philadelphia, PA, 19104, United States

We study a federated variant of the best-arm identification problem in stochastic multi-armed bandits: a set of clients, each of whom can sample only a subset of the arms, collaborate via a server to identify the best arm (i.e., the arm with the highest mean reward) with prescribed confidence. For this problem, we propose \texttt{Fed-SEL}, a simple communication-efficient algorithm that builds on successive elimination techniques and involves local sampling steps at the clients. To study the performance of \texttt{Fed-SEL}, we introduce a notion of arm-heterogeneity that captures the level of dissimilarity between distributions of arms corresponding to different clients. Interestingly, our analysis reveals the benefits of arm-heterogeneity in reducing both the sample- and communication-complexity of \texttt{Fed-SEL}. As a special case of our analysis, we show that for certain heterogeneous problem instances, \texttt{Fed-SEL} outputs the best-arm after just one round of communication. Our findings have the following key implication: unlike federated supervised learning where recent work has shown that statistical heterogeneity can lead to poor performance, one can provably reap the benefits of both local computation and heterogeneity for federated best-arm identification. As our final contribution, we develop variants of \texttt{Fed-SEL}, both for federated and peer-to-peer settings, that are robust to the presence of Byzantine clients, and hence suitable for deployment in harsh, adversarial environments.

2 - Model Aggregation In Federated Learning: Security And Efficiency

Salman Avertimehr, University of Southern California, Los Angeles, CA, United States

Model aggregation is a critical component of federated learning. In this talk, I will discuss several shortcomings in the state-of-the-art approaches for model aggregation, in terms of their security and efficiency, and propose new techniques to overcome those barriers.

3 - Exploiting Shared Representations For Personalized Federated Learning

Liam Collins, University of Texas at Austin, Austin, TX, United States

Neural networks have shown the ability to extract universal feature representations from data such as images and text that have been useful for a variety of learning tasks. However, the fruits of representation learning have yet to be fully-realized in federated learning (FL). In this talk, we propose FedRep: a novel federated learning framework and algorithm for learning a shared data representation across clients and unique local heads for each client. We prove that FedRep learns the ground-truth representation with per-user sample complexity that diminishes with the number of users in a linear setting, demonstrating that FedRep harnesses the benefits of collaboration in FL. Finally, we discuss experimental results showing that FedRep outperforms a variety of personalized FL methods on multiple data-heterogeneous FL benchmarks.

4 - GIST: Distributed Training For Large-scale Graph Convolutional Networks

Cameron Wolfe, Rice University, Houston, TX, United States

Training graph convolutional networks (GCN) is notoriously difficult to scale. Although some work has explored training on large-scale graphs (e.g., GraphSAGE, ClusterGCN, etc.), we pioneer training large-scale GCN models (i.e., ultra-wide, overparameterized models) with a novel, distributed training framework. Our training methodology, called GIST, disjointly partitions the parameters of a GCN model into several, smaller sub-GCNs that are trained independently and in parallel. GIST improves model performance, scales to training on arbitrarily large graphs, significantly decreases wall-clock training time, and enables the training of markedly overparameterized GCN models. With GIST, we train a 32,768-dimensional GraphSAGE model, which exceeds the capacity of a single GPU by a factor of 8X, to SOTA performance on the Amazon2M dataset.

■ VMD69

Virtual Room 69

Reinforcement Learning for OR

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Zhiwei Qin

1 - Competitive Pricing In Airline Revenue Management With Multi-agent Reinforcement Learning

Shulu Chen, George Washington University, Washington D.C, United States, Syed A. Shihab, Peng Wei

We explore the application of multi-agent reinforcement learning (MARL) in airline revenue management (RM) in a competitive market. By extending our group's research of DRL in airline pricing, this research uses multi-agent reinforcement learning to observe certain competitors' information and make learning-based decisions under uncertainty. We model two competitive agents in MARL frame as two competitive airline companies. At each time step, two airline companies will choose their price points respectively, according to their own remaining seats, time to departure, and competitor's price. We expect that the competitive MARL agents would have a better performance than the previous methods because of additional information and learning-based adaptive decision making.

2 - A Linear-programming And Reinforcement Learning Based Policy For Vehicle Repositioning In Ride-hailing Systems

Honghao Wei, University of Michigan, Ann Arbor, MI, United States, Zixian Yang, Lei Ying, Xiaocheng Tang, Zhiwei Qin

We study the vehicle repositioning problem in ride-hailing systems and propose a lookahead repositioning policy based on linear programming (LP) and prediction. Our LP explicitly models the fraction of controllable vehicles and considers a nonstationary system. The objective function of the LP consists of the average completion rate over T time slots as well as a weighted value function learned by reinforcement learning (RL) methods. Neural-network-based demand prediction, which exploits the spatiotemporal correlation of passenger demands, is integrated into the lookahead LP. Simulation results based on the real-world data show that our algorithm is robust to prediction errors and achieves a much higher completion rate than baseline policies.

3 - Learning To Assign: Towards Fair Task Assignment In Large-scale Ride Hailing

Dingyuan Shi, Beihang University, Beijing, China

Ride hailing is a widespread shared mobility application where the central issue is to assign taxi requests to drivers with various objectives. Despite extensive research on task assignment in ride hailing, the fairness of earnings among drivers is largely neglected. Pioneer studies on fair task assignment in ride hailing are ineffective and inefficient due to their myopic optimization perspective and time-consuming assignment techniques. In this work, we propose LAF, an effective and efficient task assignment scheme that optimizes both utility and fairness. We adopt reinforcement learning to make assignments in a holistic manner and propose a set of acceleration techniques to enable fast fair assignment on large-scale data. Exper- iments show that LAF outperforms the state-of-the-arts by up to 86.7%, 29.1%, 797% on fairness, utility and efficiency, respectively.

4 - Reinforcement Learning For Stochastic Job Shop Scheduling Problems

Tao Li, Lehigh University, Bethlehem, PA, 18015-5087, United States, Lawrence V Snyder, Martin Takac

We propose a reinforcement learning (RL) model to solve the job shop scheduling problem (JSSP). We embed the processing times in reverse order with an LSTM network for each job and represent the states as the future job embedding and the earliest time that each job can process the next operation. We first solve deterministic job shop problems with different RL algorithms such as A2C, DQN, PPO, and then compare them with heuristics such as a genetic algorithm (GA) and a greedy randomized adaptive search procedure (GRASP). We also extend our RL algorithm to solve the stochastic JSSP whose processing time are related to some features such as the status of the machines.

■ VMD70

Virtual Room 70

Robust Optimization for Machine Learning

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Phebe Vayanos, University of Southern California, University of Southern California, Los Angeles, CA, 90089, United States

1 - Learning Feasible Regions Through Inverse Optimization

Ke Ren, University of Pittsburgh, Pittsburgh, PA, 15213, United States, Angelos Georghiou, Peyman Esfahani

In inverse optimization with unknown feasible regions, decision-makers aim to learn the constraints faced by an agent who solves a parametric optimization problem depending on some exogenous signals. In this study, we propose two data-driven models that are capable of learning the unknown constraint sets based on observed signals (in the objective function/unknown constraints) and the corresponding optimal actions. When the unknown constraint set is a scaled and/or shifted version of a basic primitive set, we show that the proposed learning models admit exact tractable reformulations. Inspired by the smoothing techniques from the optimization literature, we further propose an iterative algorithm to allow the rotation of the primitive set. Extensive numerical tests validate the proposed models under noisy/noiseless data environments.

2 - Optimal Robust Classification Trees

Nathan Justin, University of Southern California, Los Angeles, CA, United States, Andres Gomez, Phebe Vayanos, Sina Aghaei

In many high-stakes domains, the data used to drive machine learning algorithms is noisy (due to e.g., the sensitive nature of the data being collected, limited resources available to validate the data, etc). In this paper, motivated by the need for interpretability and robustness in these domains, we present an efficient MIP-based method for learning optimal classification trees that are robust to perturbations in the data features. We evaluate the performance of our approach on numerous publicly available datasets and show significant improvements over the state-of-the-art.

3 - Risk Bounds and Calibration in the Predict-then-optimize Framework

Heyuan Liu, UC Berkeley, Berkeley, CA, 94720, United States, Paul Grigas

The predict-then-optimize framework is essential in solving stochastic decision-making problems. In Elmachtoub and Grigas (2021), the authors introduced the SPO+ loss function, which is a convex surrogate of the empirical regret incurred by the prediction, and provided the Fisher consistency. In this talk, we provide a quantitative way to transfer the excess surrogate risk to excess true risk. With the generalization bounds, we show the empirical minimizer of the SPO+ loss achieves low excess true risk in a high probability. In particular, we utilize uniform calibration and work with the cases when the feasible region of decision variables is a polyhedron or a level-set of a strongly convex function. We also empirically examine the performance of the SPO method and 1 and 2 loss on the shortest path, cost-sensitive classification, and portfolio allocation problems.

4 - Robust and Distributionally Robust Optimization for Support Vector Machine

Daniel Faccini, University of Bergamo, Bergamo, Italy, Francesca Maggioni, Florian Potra

We present novel optimization models for Support Vector Machine, with the aim of linearly separating two sets of points with non-disjoint convex closures. Traditional classification algorithms assume that the training points are always known exactly. However, real-life data are often subject to noise. To handle uncertainty, we formulate robust models with uncertainty sets in the form of hyperrectangles or hyperellipsoids, and propose distributionally robust optimization models enforcing limits on observations' first-order deviations along principal directions. Experiments show that robust classifiers are especially beneficial for small-dimensional data sets. As the dimension of the data sets increases, features behavior is gradually learned and higher levels of accuracy can be achieved via distributionally robust optimization methods.

■ VMD71

Virtual Room 71

Artificial Intelligence in Railway Transportation

Sponsored: Railway Applications

Sponsored Session

Chair: Nikola Besinovic, Delft University of Technology, Delft, 2628 CN, Netherlands

1 - Dealing With Limited Data: Enabling AI In Railways By Transfer Learning

Lorenzo De Donato, PhD Student, University of Naples Federico II, Naples, Italy, Stefano Marrone, Valeria Vittorini, Francesco Flammini, Claudio Mazzariello, Frédéric Bernaudin

The availability of large amounts of data is crucial to the adoption of Artificial Intelligence (AI) and Machine Learning in many domains, including railways, where experimentation with those approaches started recently. Within learning paradigms, the so-called Transfer Learning allows good performance with small datasets, and therefore we believe that could contribute to a faster take-up of AI in the rail sector. To support that claim, we present a Deep Learning case study based on Transfer Learning, addressing the automatic recognition of alert bell audio signal at rail level crossings.

2 - Traffic Delay Predictions in Disrupted Railway Networks using a Graph Neural Network Model

Christopher Szymula, Technische Universitat Dresden, Leipzig, 4317, Germany

This presentation addresses the problem of railway disruption delay prediction by proposing a data-driven encoder-decoder model. It combines specific railway and general network properties, using a graph- and timeseries related approach, and is trained and tested on a medium size railway network. Its capabilities of capturing operational characteristics and its internal mechanisms are evaluated. The results show the models capability of processing network related information. While its practical application reveals significant shortcomings, the interpretability analysis reveals encouraging insights.

3 - Artificial Intelligence In Railway Transport: Taxonomy, Regulations And Applications

Nikola Besinovic, Delft University of Technology, Delft, 2628 CN, Netherlands

Artificial Intelligence (AI) is becoming pervasive in most engineering domains, and railway transport is no exception. The scope of this paper is to introduce the basic concepts and possible applications of AI to railway academics and practitioners. To that aim, this paper presents a structured taxonomy to guide researchers and practitioners to understand AI, both in general and in close connection with railway applications such as traffic management, maintenance, and autonomous driving. The important aspects of ethics and explainability of AI in railways are also introduced. The connection between AI concepts and railway subdomains has been supported by relevant research addressing existing and planned applications in order to provide some pointers to promising directions.

■ VMD72

Virtual Room 72

Algorithmic Advances in Location Science for Spatial Demands

Sponsored: Location Analysis

Sponsored Session

Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24061-1019, United States

Co-Chair: Parshin Shojaee, United States

1 - Generalizations Of Planar Maximum Coverage Location Problem With Partial Coverage And Two-Dimensional Spatial Demand Zones

Manish Bansal, Virginia Tech., Blacksburg, VA, 24061-1019, United States, Parshin Shojaee

We consider a generalization of the classical planar maximum coverage location problem (PMCLP) in which partial coverage is allowed, facilities have adjustable quality of service (QoS) or service range, and demand zones and service zone of each facility are represented by two-dimensional spatial objects. We denote this generalization by PMCLP-PC-QoS. A key challenge in this problem is to simultaneously decide position of multiple facilities on a continuous two-dimensional plane and their QoS. We present a greedy algorithm and a pseudo-greedy algorithm for it. We investigate theoretical properties and propose exact algorithm for solving PMCLP-PC-QoS where demand and service zones are represented by axis-parallel rectangles, which has applications in camera surveillance and satellite imaging. Furthermore, we present results of our computational experiments.

2 - Attacker-defender Maximum Coverage Location Problem With Partial Coverage And Spatial Demand

Sumin Kang, Virginia Tech, Blacksburg, VA, United States, Manish Bansal

In this talk, we present solution approaches for maximum coverage location problem with partial coverage and spatial demand in the presence of an attacker whose aim is to attack regions such that the total weighted coverage is minimized. We also provide results of our computational experiments.

3 - A Spatial Algorithm to Identify All Non-dominated Solutions in Coverage and Access Optimization

Alan Murray, Professor, University of California at Santa Barbara, CA, United States, Jiwoon Baik

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

4 - Predicting Ambulance Call Demand By Space And Time: A Machine Learning Approach

R. Justin Martin, Assistant Teaching Professor, Wake Forest University, Winston Salem, NC, United States, Cem Saydam

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

■ VMD73

Virtual Room 73

Reference-dependent utility

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Robert F. Bordley, University of Michigan, Ann Arbor, Troy, MI, 48085-4767, United States

1 - A Reference-Dependent extension of Conventional HARA Utilities

Robert F. Bordley, University of Michigan Ann Arbor, Troy, MI, 48085-4767, United States

Many managers are assigned both threshold and aspirational targets by their sponsors. The goal is volatile, i.e., the sponsor may unexpectedly change the threshold after the manager has started work. The utility function is assumed to satisfy a new property called decreasing absolute risk sensitivity and converge to a concave utility when goal volatility is extreme. We prove that a second-order Laplace approximation of the utility is proportional to a cumulative lognormal probability with an added location parameter. This will also be a continuous approximation of the prospect theory value function (where the reference point is determined by the threshold and a subjective probability replaces the probability weighting function.)

2 - Range-Dependent Preferences over Risky Payoff Streams:

Michal Lewandowski, Warsaw School of Economics, Warsaw, Poland

We provide the axiomatic foundations of a behavioral preference model for risky payoff streams, a broad domain having lotteries, income streams under certainty, and repeated lotteries as special cases. For an individual who cares not only about total profit at the end, but also about partial profits, a standard set of rational axioms yield Bell's (1974) discounted incremental utility model. The model captures the intuition of time as inherently uncertain. To this bedrock, we add the notion that preferences are affected by range effects.The result is a behavioral model with a broad domain and consistent with a plethora of phenomena (bias towards short payback periods, the four-foldpatterns for risk and time, preference reversals for risk and time, temporal patterns of decreasing or increasing impatience, and magnitude effects).

3 - Development and Assessment of Resilient Telecoms Systems

Jeremy Muniz, Graduate Research Assistant, University of Arkansas, Fayetteville, AR, United States

Ensuring resiliency of the emergency telecommunication infrastructure is critical for regions with an increased likelihood of natural disasters. We developed an integrated modeling framework for assessing telecommunication systems using performance models for system architectures. The models assess value using a multiple objective decision analysis value model. After constructing a life cycle cost model, we conducted Value vs. Cost trade-off analysis.

■ VMD74

Virtual Room 74

Advances in Prescriptive and Descriptive Utility Approaches

Sponsored: Decision Analysis Society

Sponsored Session

Chair: Manel Baucells, University of Virginia, Charlottesville, VA, 22903-1760, United States

1 - Attention Utility Theory

Songfa Zhong, National University of Singapore, Singapore, Singapore, Soo Hong Chew, Wenquan Wang

We offer an attention-augmented utility model with a stable utility function and an unstable attention function which delivers decision weights resembling the divisive normalization form in the miserly-brain literature. For uniform finite lotteries, our axiomatization delivers attention-dependent decision weights which can accommodate the highly volatile nature of the attentional process. The value of our model is demonstrated in terms of how it can account for a rich range of choice anomalies with shared roots in attentional limitations and at the same time accommodate behavior often associated with the idea of 'rational' choice under high attentiveness. The model can further account for recent evidence on continuity of decision weights, and discontinuity of certainty equivalent in event-splitting, pointing to effects of complexity aversion.

2 - Leveraging Probability Distortion To Target Prevention? Evidence From A Lottery Experiment On Cardiovascular Risk

Aurelien Baillon, Erasmus University Rotterdam, Rotterdam, 3000 DR, Netherlands, Joseph J Capuno, Aleli D. Kraft, Jenny Kudymowa, Owen O'Donnell

Targeting is critical to making disease prevention programs cost-effective. We use a randomized experiment in the Philippines to test whether a lottery incentive for a medical check-up succeeds in targeting those who would otherwise underinvest in prevention because they distort probabilities. A lottery is expected to appeal more to those who display inverse S-shaped probability distortion, which is also a characteristic that discourages prevention of intermediate risks. We find that probability distortion partly explains underprevention at baseline. The intervention provided partial support for the predictions. Lottery attracted those with inverse S-shaped probability distortion only to some extent.

3 - Optimal Control of the Business Activity during a Pandemic

Lin Zhao, Southwestern University of Finance and Economics, Beijing, China, Manel Baucells

The Covid-19 pandemic has put in the forefront the need to balance the health benefits and the economic costs when it comes to imposing constraints on business activity. A tricky aspect of the problem is that opening up business has an immediate positive effect in the economic metrics, but a delayed and lingering negative effect on the health costs. We formulate a continuous objective function to capture this tricky aspect, and find conditions under which these two components become exchangeable. We obtain closed-form solutions of the optimal control policy. The structural solutions rule out many sub-optimal decisions, while at the same time offering a variety of solutions depending on parameters.

4 - Reference Point Formation Under Social Comparisons

Tian Wang, Colorado State University, Fort Collins, CO, United States, Manel Baucells, Lin Zhao

Well-established studies have demonstrated that when evaluating payoffs, people take not only their own payoffs into account, but also the payoffs of others in their social environment. In this research, we hypothesize that people evaluate their reference points in a social comparison contexts where the payoffs of others also serve to form the reference point. We contribute to the literature with a framework that considers both individual and social comparison explanations of reference point formation. In addition, we also develop an experiment to investigates the impact of social contextual information on reference point formation.

■ VMD75

Virtual Room 75

Transportation Science and Technology

Informs Special Session: Practice Curated Track

Informs Special Session Session

Chair: Nilay Noyan, Amazon, Seattle, WA, 98109-5314, United States

Co-Chair: Mauricio C. Resende, Amazon.com, Inc., Seattle, WA, 98109-5314, United States

1 - Mitigating Spot Market Premiums

Idil Arsik, Amazon, Seattle, WA, 98109, United States, Philip Kaminsky, Tara Mardan

Amazon uses both committed capacity acquired weeks ahead of use, and a spot market to procure truckload capacity. The committed capacity is secured in the form of blocks of driver shifts with pre-specified start times and starting/ending location, and several hours to a day ahead of time, specific routes are assigned to these shifts. The delay in this assignment allows Amazon to effectively adapt to changing demand, but it also delays sending loads that are not planned into routes to the spot market, leading to higher premiums. We present a novel approach that is designed to mitigate this risk by offering the loads in the spot market at a reduced price while simultaneously considering them for routing.

2 - Designing Carrier-initiated Matching In A Freight Marketplace

Bo Zhang, Amazon, Seattle, WA, United States, Philip Kaminsky

In a digital freight marketplace, a carrier-initiated matching mechanism can be designed where carriers first express their work intent by specifying as a work order their available capacity and minimum acceptable payout for providing the capacity at a certain place on some future dates. These work orders are then considered for matching with eligible work opportunities. We discuss tradeoffs that need to be considered in designing such a mechanism when it co-exists with a 'buy-it-now' mechanism. We also present OR methods and tools that are used to address these tradeoffs.

3 - Capacitated Vehicle Routing With Time Windows Using Reinforcement Learning

Sharmin Pathan, Amazon, Seattle, WA, United States, Ivan Oliveria

We train a reinforcement learning agent to find near optimal solutions for multiple vehicle routing which includes vehicles of different types and capacities, while allowing split-pickups and hard constraints like pickup and drop-off windows, and visiting all customer nodes with the least number of vehicles. We use proximal policy optimization to optimize model parameters. The model generates a sequence of actions in real-time which correspond to customer nodes to be visited, without having to retrain for every new customer node. We demonstrate our results on a real-world customer dataset for pickups, where every customer has a demand and needs to be serviced within the pickup window.

4 - Large-scale Speed Optimization In Amazon's Network: A Case For Submodular Optimization

Tiphaine Rougerie, Amazon, Luxembourg, Luxembourg, Amit Kumar, Georgios Paschos, Mauricio C. Resende

We study the impact of truck scheduling on customer experience in Amazon's middle-mile. The departure time of the last truck is designed to cover the maximum next day demand, while additionally satisfying operational limitations in the form of constraints. We characterize this design problem as a constrained submodular maximization problem, where the marginal gain of a decision decreases as we build up the schedule due to the shared inventory between warehouses. To solve this large-scale optimization problem over large inventory datasets, our work leverages the theory of submodular optimization to solve the entire EU network in less than five minutes.

5 - Block Time Planning with Atmospheric Wind Information

Xiaofeng Wei, Amazon / Air Science and Technology, Bellevue, WA, United States, Rui Sun, Na An

In today's Cargo airline operations, block times are playing a critical role in the entire network, from planning fleet schedules, fuel cost and CO2 emissions to optimizing package shipment flows. Block time is composed of three components: taxi out time, flight time and taxi in time. In this paper, we develop forecast models using machine learning tools to predict each component of block time separately. Our model can apply the flight and taxi time patterns we learn from the existing OD pairs to forecast the flight and taxi times for new OD pairs and takes into account seasonal atmospheric wind patter for flight time. We test our forecast model using historical on-time performance data, and show that our model results outperform the benchmark forecast results compare to the other block time forecast methods.

■ VMD76

Virtual Room 76

Artificial Intelligence IV

Contributed Session

Chair: Soomin Lee

1 - Welfare-based Fairness Through Optimization In Artificial Intelligence Applications

Violet Xinying Chen, Carnegie Mellon University, Pittsburgh, PA, United States, John Hooker

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

2 - AI-driven Policy Optimization For Transparent And Operationally Effective Pricing

Shivaram Subramanian, Research Staff Member, IBM, Yorktown Heights, NY, United States, Wei Sun, Youssef Drissi, Markus Ettl

Interpretability and Operational Effectiveness are two practical limitations of current AI based price optimization. The rationale behind price changes is unclear and the projected gains from offline studies often disappear in live tests. We present an automated, dynamic prescriptive policy optimizer that combines 'Blackbox' machine learning and mathematical programming models to identify near-optimal and transparent pricing recommendations that can perform effectively in practice.

3 - A Strongly Polynomial Algorithm For Risk Constrained Problems

Alexander Zadorojniy, IBM Research, Haifa, Israel, Takayuki Osogami

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

4 - Robust Learning Of Recurrent Neural Networks In Presence Of Exogenous Noises

Arash Amini, Lehigh University, Bethlehem, PA, United States, Guangyi Liu, Nader Motee

In this work, we will use ideas from control and estimation theories to propose a tractable robustness analysis for recurrent neural networks (RNN) that are subject to input noise. The covariance of the output of the noisy system is adopted as a robustness measure to quantify the impact of noise on learning. It is shown that the robustness measure can be estimated efficiently using linearization techniques. Using these results, we proposed a learning method to enhance the robustness of an RNN with respect to Gaussian noise with known statistics. Our extensive simulations on benchmark problems reveal that our proposed methodology significantly improves the robustness of recurrent neural networks.

5 - Distributed Asset Fleet Maintenance Rescheduling

Pavankumar Murali, Research Scientist, IBM Research, Yorktown Heights, NY, United States, Nianjun Zhou, Dzung Phan, Lam M. Nguyen

We present an approach for dynamic asset fleet maintenance scheduling that allows for rescheduling of planned maintenance based on the trajectory of asset health degradation. For scenarios wherein asset health is continually monitored, we propose a Bayesian framework to characterize the stochastic degradation process. Based on temporal asset performance degradation and failure probabilities, the scheduling optimization problem is decomposed into a master problem that solves the dynamic rescheduling problem, and a subproblem that addresses power network generation and demand fulfillment optimization.

6 - Deep Learning-based Cutting Force Prediction With Machining Process Monitoring Data

Soomin Lee, Chungnam National University, Daejeon, Korea, Republic of, Wonkeun Jo, Dongil Kim, hyein kim, Jeongin Koo

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

■ VMD77

Virtual Room 77

Innovation and Design Management

Informs Special Session: New Product Development

Informs Special Session Session

Chair: Zhaohui Jiang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Agile Development Is Not (Always) A Panacea: An Experimental Study

Evgeny Kagan, Johns Hopkins Carey Business School, Baltimore, MD, 21202-4673, United States, Tobias Lieberum, Sebastian Schiffels

We experimentally study the effects of Agile project planning techniques on performance in two tasks: (1) a creative task reflective of product innovation with an open solution space and limitless creative possibilities, and (2) a search task reflective of business model innovation, in which subject search through a finite (but complex) solution landscape. Our results suggest that Agile techniques significantly improve performance in the first (creative) task, but harm performance in the second (search) task.

2 - Sourcing Innovation: When Is Supplier Ownership Good For Innovation?

Jurgen Mihm, Insead, Fontainebleau, 77300, France

One of the central questions in the strategic procurement of innovative goods is whether a buyer should own a stake in a critical supplier or not. In this study, we analyze when a buyer should source from independent suppliers exclusively and when it should (partially) own one of the suppliers.

3 - Business Method Innovation In Us Manufacturing And Trade

Tian Chan, Emory University's Goizueta Business School, Atlanta, GA, 30030, United States, Anandhi S. Bharadwaj, Deepa Varadarajan

What kind of business method innovation do firms in the manufacturing and trade sectors engage in? Does engagement in business method innovation create value? Using classification and text analysis of the business method patents, we show that business method innovation in these sectors is primarily aimed at improving the ways in which tangible products are marketed, delivered, or enhanced through service offerings. Leveraging the exogenous shock of the State Street ruling, which first recognized business methods as a patentable category, we show that the value of firms with business method patents relative to comparable peers with no such patents to be higher by 9% after State Street. We further show that manufacturers gained a smaller 7% increase, relative to a 25% gain for firms in the trade sectors; and only firms with broad innovation scope see a significant value bump.

4 - Product Development In Crowdfunding: Theoretical And Empirical Analysis

Sidika Tunc Candogan, UCL School of Management, London, United Kingdom, Philipp Benjamin Cornelius, Bilal Gokpinar, Ersin Korpeoglu, Christopher S. Tang

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

■ VMD78

Virtual Room 78

Understanding Disparities and Equity in Well-being through Data-Driven Approaches

Committee Choice: Committee's Choice

Committee Choice Session

Chair: Danika Dorris, Raleigh, NC, 27606, United States

1 - Designing Efficient And Equitable Housing Allocation Policies From Data Collected In Deployment

Aida Rahmattalabi, University of Southern California, Los Angeles, CA, 90007-2375, United States, Phebe Vayanos, Eric Rice, Kathryn Dullerud

The VI-SPDAT is a triage tool used to assess the needs of individuals experiencing homelessness and to prioritize them for scarce housing resources. Yet the current tool does not fully leverage the available historical data, implying that resources may be allocated less efficiently and potentially result in inequitable outcomes. We propose to learn housing intervention effectiveness from data using tools from causal inference. We then incorporate these estimates into a queueing system to design a policy that allocates resources both efficiently and equitably. We evaluate our approach on data from the homeless management information system, where we show that our policies result in significant improvements in both efficiency (i.e., increase in the number of individuals that are stably housed and reduction in wait times) and equity compared to the current policy.

2 - Can't Wait: Reducing Treatment Delay For Psychiatric Patients

Nathan Adeyemi, Northeastern University, Boston, MA, United States, Nasibeh Zanjirani Farahani, Amanda Graham, Kalyan Pasupathy, Kayse Lee Maass

Hospital emergency departments (ED) are often heavily backlogged by patients in need of care but awaiting placement in an inpatient bed (IP) either at their current hospital or transfer to another facility. This is known as ED boarding and disproportionately affects patients requiring psychiatric care and to a greater extent, its subpopulation of pediatric patients. Our goal is to find novel modifications for the current system that are effective in reducing ED boarding due to lack of available IP beds, distance-related transfer restrictions, and patient-characteristic related inclusion and exclusion criteria that minimize disparities by age and geographic region.

3 - Using University Data to Understand Engineering Student Well-being and to Predict Dropout

Danika Dorris, North Carolina State University, Raleigh, NC, United States

This paper analyzes student information system (SIS) data collected by a university tounderstand how the COVID-19 pandemic has affected the well-being of undergraduateengineering students and their risk of dropping out. Various types of learning are used tocharacterize the dropout population and predict how influential factors of dropout may changeover time.

4 - Identifying Disparities In Access To Psychosocial Services For The Medicaid-insured Children In Georgia

Yujia Xie, Georgia Tech, Atlanta, GA, United States

The shortage of workforce providing psychosocial services is one of the most cited barriers of access to mental health treatment, resulting in long travel distances or wait times for those seeking care. However, the lack of access does not affect the population evenly. We quantify such access disparity for communities through developing an optimization model with estimated potential supply (caseload of psychosocial services) and demand (community-level psychotherapy visit counts) for Medicaid-insured children in Georgia. The statistical inference based on the model output is then used to provide policy recommendations on interventions for addressing psychosocial services' access disparities.

■ VMD79

Virtual Room 79

Agriculture Applications II

Contributed Session

Chair: Qing Li, Huazhong Agricultural University, Wuhan, 430070, China

1 - Grape Processing Capacity Planning Under Weather Uncertainty At Wineries

Jorge R. Vera, Pontificia Universidad Católica de Chile, Santiago, Chile, Carlos Monardes, Alejandro MacCawley

We present a tactical stochastic model for planning capacity of fermentation tanks in Wineries. Our objective is to minimizes total expected cost, involving blending, quality effect, and renting costs. The main climate factor which affects the plan is rain, especially at the beginning of the season. We develop a stochastic integer model for the tank assignment problem, based on yield, harvesting windows and fermentation time. The uncertain factor is represented by a scenario analysis of rain dates. The model assists winemakers in generating the capacity plan, including the possibility to rent external tanks. We show results based on real industrial data.

2 - Water Quality Impacts Of Optimal Crop Insurance Policy Selection

Gorkem Emirhuseyinoglu, Iowa State University, Ames, IA, vUnited States, Sarah M. Ryan

Crop yield and prices are the major uncertainties affecting farm revenue. Farm yield is a function of nitrogen (N) and random weather elements. However, farmland runoff of N negatively impacts biodiversity via water quality. Insurance programs target yield and/or price uncertainty to mitigate farming risks. From a farmer's viewpoint, we generate weather scenarios and build stochastic programs for insurance and N application decisions to maximize risk-adjusted farm profits. We investigate how insurance programs affect N fertilizer application and the consequent surface water quality impacts.

3 - Food Flows Between US Counties Through Time

Deniz Berfin Karakoc, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Junren Wang, Megan Konar

Food supply chains are essential for distributing goods from production to consumption points. Recent research has developed novel methods to estimate food flows with high spatial resolution. Yet, we do not currently understand how fine-grained food supply chains vary in time. In this study, we develop a time-series analysis of food flows between the counties in the United States. We use the Food Flow Model to estimate food flows across all food commodity groups (approximately 70 million links) for the years 2007, 2012, and 2017. We then determine the core nodes and links in the US food supply chain, which may prove useful for future research, policy, and decision-making.

4 - Crop Selection And Scheduling For Green Production With Intercropping And Rotation

Thomas G. Yeung, IMT-Atlantique, Nantes, France, Canan Pehlivan, Aine Suzette Alvarado Munguia

We address an agricultural crop selection and scheduling problem employing two cropping systems, crop rotation and intercropping, simultaneously on a given parcel of land. Moreover, we also consider other ecological sustainability practices such as the use of fallow and green manure. We propose a 0-1 linear programming model to maximize revenue by determining the optimal combinations of crops in space (crops to be planted as neighbors) and in time (crop rotation schedule) while meeting the yearly demand of each crop. A realistic numerical example is presented to demonstrate the performance of the model.

5 - Join The Cooperative Or Not : How Information Sharing Affects Farmers' Decisions

Qing Li, Huazhong Agricultural University, Wuhan, China

Though cooperative helps farmers share the risk of yield uncertainty and decrease the demand uncertainty by information sharing, cooperative is undesirable for farmers sometimes since it increases farmers' competition. Considering that farmers in the cooperative can get private demand information of all cooperative members and public demand information and individual farmers cannot know other farmers' private information, we focus on the farmers' decision of whether to join the agricultural cooperatives under yield uncertainty and demand uncertainty and explore the impact of public information and private information on farmers' decision, with the objective to increase farmers' payoffs.

■ VMD80

Virtual Room 80

INFORMS TutORial - Storytelling with Sports Analytics

Tutorial Session

Chair: Douglas R. Shier, Clemson University, Clemson, NC, 27312-8612, United States

1 - Storytelling with Sports Analytics

Elizabeth Bouzarth, Furman University, Greenville, SC, 29613, United States, Ben Grannan, John Harris, Kevin Hutson, Peter Keating

As the use of analytics grows in the sports industry, debates about the usefulness of analytical models in sports has also grown. There is no doubt that analytics have impacted the sports industry in many positive ways, but it is an evolving story as analysts seek better models of player/team performance evaluation, forecasting, and decision-making. Communicating new results in these areas requires analysts to connect with organizations and fans by putting the results in context to tell a more complete story. In this work, we give examples from our own work and the work of others showing how to frame analytics within a story. At the same time, we give a brief history of the evolution in the descriptive, predictive, and prescriptive areas of sports analytics. While this work is not meant to be exhaustive, it highlights some of the major issues that analysts face in building useful models in these areas. The paper also represents a decade-long collaboration between academics and sports writers, and we highlight some of the lessons we've learned from that collaboration.

■ VMD81

Virtual Room 81

Demand Management For Last-Mile Logistics And On-Demand Mobility

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Robert Klein, Augsburg University, Ettringen, 86833, Germany

Co-Chair: Arne Karsten Strauss, WHU Otto Beisheim School of Management, Vallendar, 56179, Germany

Co-Chair: Claudius Steinhardt, Bundeswehr University Munich, Neubiberg, 85577, Germany

1 - Dynamic Multi-Period Vehicle Routing With Touting

Merve Keskin, Research Associate, Lancaster University, Lancaster, United Kingdom, Juergen Branke, Vladimir Deineko, A rne K. Strauss

This study introduces a dynamic vehicle routing problem with touting as a demand management technique, where future customers can be approached to be serviced sooner. Touting the convenient customers, for example, those located nearby customers who already placed orders, allows for more efficient routes over time. To tackle this problem, we propose several touting strategies to decide which customers to tout and combine these with a rolling-time horizon vehicle routing algorithm. Different strategies are empirically compared in a simulation based on a real-world waste collection problem. We demonstrate that touting correct customers helps to reduce the travel distance significantly.

2 - Feeding The Nation - E-groceries In Times Of Crisis

Jonas Schwamberger, University of Mannheim, Mannheim, Germany, Moritz Fleischmann, Arne Karsten Strauss

At the outbreak of the Corona pandemic, demand for online grocery orders for both Click & Collect and attended home delivery by far outstripped supply. In the UK, the booking system of some retailers could not even handle the flood of incoming requests, forcing retailers to instead proactively reach out to certain priority customer segments with the aim of serving as many high priority customers as possible. In this paper, we investigate how to best manage demand in this new environment, and we give an outlook on how these techniques can be valuable after the pandemic as well.

3 - Crowdshopping - Social Service or Viable Business Model?

Leonie Hutter, University of Augsburg, Augsburg, Germany, Robert Klein, Simone Neumann

"Crowdshipping" is a relatively new last-mile concept that outsources deliveries to individuals on an occasional basis. By adding a dimension to this concept, the idea of "crowdshopping" emerges, where individuals can serve as "fellow shoppers", who shop for and/or deliver groceries and other everyday products to others. Drawing on a survey-based choice experiment with more than 1,000 participants in Germany and the USA, we empirically analyze how different factors affect the willingness of individuals to both act as and use such fellow shoppers. Based on theses results, we examine how a viable business model for crowdshopping should be designed.

4 - Policy-based Dynamic Pricing In Shared Mobility Systems

Matthias Soppert, Bundeswehr University Munich, Munich, Germany, Claudius Steinhardt

Shared mobility systems have become a wide-spread alternative within the inner-city mobility. Modern systems offer one-way trips, which yield high flexibility to the customer but also cause imbalances between supply and demand that need to be rebalanced for profitable operation. Pricing has turned out to be a promising means. We consider the on-line problem of a shared mobility system provider to simultaneously set discrete minute prices for all zones of the operating area. The action space of this stochastic dynamic decision problem grows exponentially with the number of zones, such that value-based approaches do not scale. Instead, we propose a policy-based approach, adapted from the realm of deep reinforcement learning, which can handle the large actions space. Preliminary results indicate that our approach surpasses the optimal static as well as dynamic benchmarks.

5 - Implications Of Different Dynamic Modelling Approaches For Integrated Demand Management And Vehicle Routing Problems

Vienna Klein, Bundeswehr University Munich, Neubiberg, Germany, David Fleckenstein, Claudius Steinhardt, Robert Klein

Demand control problems in the field of vehicle routing are characterized by a stream of customers arriving dynamically over a booking horizon and requesting logistical services which are fulfilled by a given fleet of vehicles. Demand management methods can be applied to exploit heterogeneous customer preferences in order to optimize the booking process with the aim of maximizing total profit. As the quality of demand management decisions depends to a large extent on an accurate estimation of opportunity cost, we formalize its definition specifically for vehicle routing applications. Furthermore, we discuss their properties for different dynamic modelling approaches to derive and discuss implications for approximate dynamic programming solution approaches.

■ VMD82

Virtual Room 82

Queueing Models

Contributed Session

Chair: Wei You, Hong Kong University of Science and Technology, Hong Kong, NA, Hong Kong

1 - Optimal Investment Plans For Electric Vehicles Battery Swapping Station

Peng Li, Rutgers University, Piscataway, NJ, United States, peng.li.scm@rutgers.edu, Chunliu Zhou, Lian Qi

Recent years, Electric Vehicle has mitigated carbon emission and air pollution in many countries. However, the limited range, inconvenient recharge process and high battery cost of EVs have greatly constrained customer adoptions. Although the battery swapping and charging station (BSCS) can partially address these issues, how to optimize operations and reduce the high inventory cost of batteries should still be considered in detail for swapping stations. To address these issues, we investigate the investment plan on swapping servers, charging bays and replacement batteries at a swapping station, along with the consequent operations plans of this station.

2 - Fluid Limits For Shortest Job First With Aging

Yonatan Shadmi, Technion, Haifa, Israel

We investigate fluid scaling of single server queues operating under a version of shortest job first (SJF) where the priority level undergoes aging. That is, a job's priority level is initialized by its size and varies smoothly in time according to an ordinary differential equation. Linear and exponential aging rules are special cases of this model. This policy can be regarded as an interpolation between FIFO and SJF. We use the measure-valued Skorokhod map to characterize the fluid model and establish convergence under fluid scale. We treat in detail examples of linear and exponential aging rules and provide a performance criterion based on our main result.

3 - Appointment-driven Queueing Systems With Non-punctual Customers

Bingnan Lu, University of Minnesota, Minneapolis, MN, United States, Oualid Jouini, Saif Benjaafar, SIQIAO LI, Benjamin Legros

We consider a single server queueing system where a finite number of customers arrive over time. Arrivals are driven by appointments, but customers are not necessarily punctual or may not show up at all. Customers are also not homogeneous in their punctuality and show up behavior. Service times are assumed to be random with a -Cox distribution. We develop both exact and approximate approaches for characterizing the distribution of waiting time. We prove that the approximation provides an upper bound for the expected customer waiting time. We also examine the impact of non-punctuality on system performance and illustrate how our approach can be used to support individualized appointment scheduling.

4 - Asymmetric "Power-of-d" Dispatching

Jazeem Abdul Jaleel, PhD Candidate, University of Minnesota, Minneapolis, MN, United States, Sherwin Doroudi, Kristen Gardner

The traditional "power-of-d" load balancing policies are symmetric in the sense that they do not differentiate between servers of the same speed when querying or when deciding where to assign a job among servers of same speed with equal queue length. We study asymmetric policies in a homogeneous server setting by grouping servers into different classes ahead of time, and querying non-uniformly across these groups on job arrival; we explore a variety of ways for making such choices. We also employ a complementary asymmetry in the assignment decision. Our work is novel to studying asymmetry in a queueing setting and necessitates an entirely distinct set of analytic techniques.

5 - Universal Approximation For Single-server Queues With Abandonment Via Robust Queueing

Wei You, Assistant Professor, Hong Kong University of Science and Technology, Hong Kong, Hong Kong

In this talk, we show how the Robust Queueing (RQ) technique can be applied to queueing models with customer abandonment to obtain approximations for the steady-state performance measures. We formulate a Robust Queueing approximation as a fixed-point solution to a one-dimensional optimization problem. We show that the RQ solution captures the exact order of magnitude for the performance measures, regardless of the particular heavy-traffic regime and the underlying distributions in use, hence providing a universal approximation. Numerical examples demonstrate outstanding approximation accuracy.

■ VMD83

Virtual Room 83

Traffic Control and Flow Modeling in the Era of Connected and Automated Vehicles

Sponsored: TSL/Intelligent Transportation Systems

Sponsored Session

Chair: Ali Hajbabaie, North Carolina State University, Raleigh, NC, 27695-7908, United States

1 - Signalized Intersection Control In A Connected Vehicle Environment

Vikash Gayah, Pennsylvania State University, University Park, PA, 16802, United States, Joyce Liang, Ilgin Guler

This talk describes a decentralized signal control algorithm that leverages connected vehicle information to improve traffic operations along arterials and with pedestrian present. The proposed algorithm obtains real-time vehicle locations and speeds, as well as information on pedestrians waiting to cross individual intersections, to optimize signal phasing and timing plans. Signal timing is optimized at individual intersections; however, information about vehicle platoons passing a given intersection is shared with neighboring intersections to facilitate natural coordination between adjacent intersections. The talk will also describe how signal timings can distribute delay more equitable across vehicles.

2 - Improving Traffic Delays in the Era of Autonomous and Connected Vehicles With Real-time Proactive Traffic Control and Platooning

Viswanath Potluri, Arizona State University, Mesa, AZ, United States, Pitu B. Mirchandani

Since, improved traffic congestion is not a direct ramification of autonomous and connected vehicles (CAV), this talk will discuss a cyber-physical system, referred to as MIDAS, that proactively optimizes traffic control and vehicle platooning decisions in real-time. The control algorithm uses dynamic programming and reinforcement learning to minimize the delays and maximize the throughput at intersections. MIDAS predicts future arrivals and estimates queues at the intersection by capturing GPS data from CAVs; it then provides optimal signal controls as well as platoon guidance for self-driving cars.

3 - A Multiclass Link Transmission Model For Dynamic Network Loading Of Mixed Legacy And Automated Vehicle Flow

Michael W. Levin, University of Minnesota, Minneapolis, MN, United States, Di Kang

Many cities will experience a mixed traffic flow consisting of both legacy and automated vehicles. Although the overall market penetration may be known, the proportion of automated vehicles may vary in space and time. Since automated vehicles are expected to behave differently than legacy vehicles, this results in a flow-density relationship that varies in both time and space with the local proportion of automated vehicles. We model this scenario using a multiclass kinematic wave theory. We develop a multiclass Newell's method for finding exact solutions to the multiclass kinematic wave theory. We then extend this method to a multiclass link transmission model. Numerical results from dynamic traffic assignment on the downtown Austin network demonstrate the computational tractability of this method and explore the effects of automated vehicles on traffic congestion.

4 - Intersection Control With Connected Automated Vehicles And Pedestrians

Ali Hajbabaie, North Carolina State University, Raleigh, NC, 27695-7908, United States, Ramin Niroumand, Leila Hajibabai

This study introduces a methodology to control signalized intersections with a mixed flow of connected automated vehicles, human-driven vehicles, and pedestrians. To reduce the number of phase transitions and lost time, our previously introduced “white phase” is used. This talk will go over the details of the methodology and highlights the key findings.

■ VMD84

Virtual Room 84

INFORMS TutORial - Game Theory and the COVID-19 Pandemic

Tutorial Session

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

1 - Game Theory and the COVID-19 Pandemic

Anna B. Nagurney, University of Massachusetts-Amherst, Amherst, MA, 1003, United States

The world is now faced with the COVID-19 pandemic, a healthcare disaster, not limited to time or location. The COVID-19 pandemic has demonstrated the importance of operations research and related analytical tools, with the research and practitioner communities channeling and harnessing their expertise. It has inspired associated investigations and modeling and methodological advances in order to support deeper insights and enhanced decision-making as well as the provision of guidance to policymakers. In this tutorial, I overview some of the novel advances and applications, inspired by the COVID-19 pandemic, utilizing game theory. The focus of the tutorial is on supply chain networks, although the scope is broader. The tutorial first presents an overview of variational inequality theory, which is the methodology utilized for the formulation, qualitative analysis, and solution of the described models. The supply chain network models presented are recently introduced ones that capture, respectively: the inclusion of labor into supply chain networks, enabling the quantitative assessment of disruptions to labor; the fierce competition among entities for medical supplies in the pandemic from PPEs to, now, vaccines; and, finally, the calculation of the potential synergy associated with the teaming, that is, the cooperation, among organizations in the pandemic, under cost and demand uncertainty, to provide needed supplies. Suggestions for future research are provided.

■ VMD85

Virtual Room 85

Decarbonization and Climate Policy

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Yongyang Cai, Ohio State University, Columbus, OH, 43210-1010, United States

1 - Monetary Policy For Climate Change

Ziqian Gong, Ohio State University, Columbus, OH, 43202, United States, Yongyang Cai

Climate change has been recognized as the most significant externality of today's global economy. Current research has been predominantly focused on fiscal policy, which will subject to the political environment. This paper establishes a New Keynesian dynamic stochastic general equilibrium(DSGE) model of a closed economy to find the optimal monetary policy under climate change to reduce carbon emissions and encourage the application of renewable energy. Combining the Green collateral framework and a dynamic stochastic model, we can evaluate how renewable energy firms, fossil fuel energy firms, and final goods production firms will respond to the different monetary policies from the central bank. As an application, the result could provide the government a reliable and precise policy.

2 - Carbon Neutrality And Regional Heterogeneity In The United States

Junyoung Jeong, The Ohio State University, Columbus, OH, United States

The US government released its climate plan for an emission-free power sector by 2035 and net zero carbon emissions no later than 2050. Despite the environmental and economic benefits of the decarbonization plan, burdens emerging in the transition would not be shared equally across different states. Currently, however, research on the economic impacts of carbon neutrality plan on different regions are scarce. This study investigates carbon neutrality target and its economic and welfare implications for the 50 states in the US. The suggested model, incorporating regional heterogeneities in carbon dependency and climate induced damage, solves a social planner’s problem under the constraints of US climate plan goals. The results show which region is more affected by the transition and would provide insight into mitigating the negative effects on regional economies.

3 - Climate Change Impact on Economic Growth: Regional Climate Policy under Cooperation and Noncooperation

Yongyang Cai, Ohio State University, Columbus, OH, 43210-1010, United States, William A. Brock, Anastasios Xepapadeas

We compute regional social cost of carbon (SCC) in the face of climate change impact on regional economic growth under cooperation and noncooperation between regions with heat transport dynamics. Climate damage on economic growth incurs serious challenges for many countries, particularly in the tropic region. We find that in the presence of climate damage to economic growth regional SCC is very high in a cooperative world, but the developed countries in the high northern latitudes have negative regional SCC in the initial periods in a noncooperative world. Moreover, relatively to cooperation, noncooperation makes the developed countries in the high northern latitudes to gain only little gross domestic product but leads to significant loss for the developing countries in the tropic region.

Monday, 4:30PM - 6:00PM

■ ME01

CC - Ballroom A / Virtual Theater 1

Hybrid - QSR Best Refereed Paper Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Fugee Tsung, HKUST, Kowloon, 852, Hong Kong

Co-Chair: Kamran Paynabar, ISyE Georgia Tech, Atlanta, GA, 30332-0205, United States

1 - An Approach for Group and Individual Fairness in Federated Learning

Xubo Yue, University of Michigan, Ann Arbor, Ann Arbor, MI, 48105-2179, United States, Raed Al Kontar, Maher Nouiehed

2 - Partitioned Active Learning for Heterogeneous Systems

Cheolhei Lee, Virginia Tech, Blacksburg, VA, 24060, United States, Kaiwen Wang, Jianguo Wu, Wenjun Cai, Xiaowei Yue

3 - GPS: Gaussian Process Subspace Regression for Model Reduction

Ruda Zhang, The Statistical and Applied Mathematical Sciences Institute, Cary, NC, 27519, United States, Simon Mak, David Dunson

Subspace-valued functions arise in a wide range of problems, including parametric reduced order modeling (PROM). In PROM, each parameter point can be associated with a subspace, which is used for Petrov-Galerkin projections of large system matrices. Previous efforts to approximate such functions use interpolations on manifolds, which can be inaccurate and slow. To tackle this, we propose a novel Bayesian nonparametric model for subspace prediction: the Gaussian Process Subspace regression (GPS) model. This method is extrinsic and intrinsic at the same time: with multivariate Gaussian distributions on the Euclidean space, it induces a joint probability model on the Grassmann manifold, the set of fixed-dimensional subspaces. The GPS adopts a simple yet general correlation structure, and a principled approach for model selection. Its predictive distribution admits an analytical form, which allows for efficient subspace prediction over the parameter space. For PROM, the GPS provides a probabilistic prediction at a new parameter point that retains the accuracy of local reduced models, at a computational complexity that does not depend on system dimension, and thus is suitable for online computation. We give four numerical examples to compare our method to subspace interpolation, as well as two methods that interpolate local reduced models. Overall, GPS is the most data efficient, more computationally efficient than subspace interpolation, and gives smooth predictions with uncertainty quantification.

4 - Data-driven Pathwise Sampling Approaches for Online Anomaly Detection

Dongmin Li, University of Florida, Gainesville, FL, United States, Miao Bai, Xiaochen Xian

We propose a data-driven strategy for quick anomaly detection with Moving Vehicle-based sensors. We integrate statistical process control and mathematicaloptimization to monitor the system and adaptively sample from suspicious locations based on real-time data. We provide theoretical investigations and present its performance in a numerical study on wildfire detection.

■ ME02

CC - Ballroom B / Virtual Theater 2

Hybrid - Decision analytics in electricity markets

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Bruno Fanzeres

Co-Chair: Nuran Cihangir, Pontifical Catholic University of Rio de Janeiro

1 - Approximation And Decomposition Techniques For Stochastic Energy And Reserve Scheduling: Algorithmic Efficiency And Pricing

Nuran Cihangir Martin, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil, Bruno Fanzeres dos Santos

This work evaluates the computational performance, solution quality, convergence features and pricing under Sample Average Approximation as well as Benders decomposition and Lagrangian-based relaxations applied to an energy and reserve scheduling problem. Characterized by non-convex unit commitment decisions, this stochastic mixed-integer programming problem entails a large number of scenarios and technical parameters - inducing a high computational burden. Decomposition and approximation techniques increase solution efficiency and convex relaxations enable the derivation of marginal cost of energy and reserve, with each method depicting varied solution quality and convergence.

2 - Hydropower Scheduling By Use Of SDDP - Treatment Of State-dependent Constraints

Arild Helseth, SINTEF Energy Research, Trondheim, Norway

We study a specific and challenging type of state-dependency within the framework of stochastic dual dynamic programming (SDDP) applied to hydropower scheduling. For environmental purposes, the maximum allowed discharge from hydropower stations may be limited depending on the state variables (reservoir level and inflow), reducing the hydropower flexibility. From a mathematical point of view, such state-dependent limits introduce a discontinuity that is not straightforward to embed in the SDDP algorithm. We report on the results from numerically testing a set of possible solution strategies.

3 - Multi-Stage Modeling With Recourse For Solving Stochastic Complementarity Problems With An Application In Energy

Pattanun Chanpiwat, Graduate Student, University of Maryland, College Park, MD, United States, Steven A. Gabriel

The intermittency of the variable renewable energy in power generation could be mitigated using energy storage systems. This project concerns utilizing battery storage for the implementation of renewable energy technologies in the electricity market from multiple perspectives of uncertainty. We have developed multi-stage modeling with recourse decisions for solving stochastic complementarity problems with an application in energy. The model is based on a Nash-Cournot formulation of imperfect competition among power producers. This energy system optimization modeling, based on game theory and energy market equilibria, is expected to provide great insights for energy market planners.

4 - Contextual Merit-order Dispatch Under Uncertain Supply

Miguel Ángel Muñoz Diaz, PhD Student, University of Malaga, Malaga, Spain, Juan Miguel Morales, Salvador Pineda

We consider a forward (e.g., day-ahead) electricity market with uncertain supply, where production quantities are dispatched following a merit order based on marginal production costs. Unlike the traditional practice of using the forecast value of the supply to clear the market, in this talk, we introduce a procedure to find the estimate of the supply (generally different from its expected value) that leads to the most cost-efficient dispatch taking into account the subsequent real-time operation of the power system. This procedure utilizes the forecast supply as the context and exploits a novel bilevel framework for decision-making under uncertainty with contextual information.

■ ME03

CC - Ballroom C / Virtual Theater 3

Hybrid - Matching Markets

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Thayer Morrill, NC, United States

1 - Matching And Money

Ravi Jagadeesan, Stanford University, Stanford, CA, United States, Alexander Teytelboym

We study the implications of budget constraints for matching with contracts. We assume preferences satisfy net substitutability: i.e, if a price of a good increases, then buyers (resp. sellers) who minimize the cost of obtaining a given level of utility will buy (resp. sell) more (resp. less) of other goods. Net substitutability coincides with gross substitutability for quasilinear preferences, but is strictly weaker otherwise. If agents have sufficient incomes for hard budget constraints not to bind, stable outcomes exist and coincide with competitive equilibrium outcomes. Otherwise, competitive equilibria can fail to exist, but stable outcomes exist and coincide with quasiequilibrium outcomes. Stable outcomes are weakly Pareto-efficient, but do not form a lattice or satisfy a Lone Wolf Theorem. Our results suggest a new scope for matching with budget constraints.

2 - Ranking Objects That Rank Back

Thayer Morrill, North Carolina State University, Raleigh, NC, 27695, United States

We consider ranking alternatives that are outcomes of a competitive process. Examples include students ranking colleges, doctors ranking residency programs, and academics ranking journals. We introduce a new approach based on desire. An object is desired if an agent prefers it to her outcome. We characterize the class of desirable rankings and argue that these rankings are superior to rankings based on revealed preference.

3 - Interview Hoarding
Vikram Manjunath, Thayer Morrill

Many centralized matching markets are preceded by interviews between the participants. We study the impact on the final match of an increase in the number of interviews for one side of the market. Our motivation is the match between residents and hospitals where, due to the COVID-19 pandemic, interviews for the 2020-21 season of the National Residency Matching Program were switched to a virtual format. This drastically reduced the cost to applicants of accepting interview invitations. However, the reduction in cost was not symmetric since applicants, not programs, previously bore most of the costs of in-person interviews. We show that, starting from a situation where the final matching is stable, if doctors can accept more interviews, but the hospitals do not increase the number of interviews they offer, then no doctor is better off and many doctors are potentially harmed. This adverse consequence is the result of what we call interview hoarding. We prove this analytically and characterize optimal mitigation strategies for special cases. We use simulations to extend these insights to more general settings.

4 - The College Portfolio Problem
Ran Shorrer, Penn State University, State College, PA, 16802, United States, S. Nageeb Ali

A college applicant faces the following risky choice: she applies to a portfolio of colleges while being uncertain about which school would admit her. Admissions decisions are correlated insofar as being rejected by a lower ranked school may imply that she is rejected by a higher ranked school. We show that solutions to this decision problem involve applying to a combination of reach, match, and safety schools. When application costs decrease, a college applicant broadens the range of schools to which she applies by including both those that are more selective and those that are safer options.

■ ME04

CC - Ballroom D / Virtual Theater 4

Hybrid - JFIG Paper Competition

Sponsored: Junior Faculty Interest Group

Sponsored Session

Chair: Alice E Smith, Auburn University, Auburn, AL, 36849, United States

Co-Chair: Dorit Simona Hochbaum, University of California-Berkeley, Berkeley, CA, 94720-1777, United States

Co-Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24061-1019, United States

■ ME05

CC - Ballroom E / Virtual Theater 5

Hybrid - PSOR Best Paper Award

Sponsored: Public Sector OR

Sponsored Session

Chair: Justin J. Boutilier, University of Wisconsin-Madison, Madison, WI, 53706-1603, United States

Co-Chair: Somya Singhvi, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States

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

1 - Off-Grid Lighting Business Models to Serve the Poor: Evidence From a Structural Model and Field Experiments in Rwanda
Serguei Netessine, The Wharton School, Philadelphia, PA, United States, Bhavani Shanker Uppari, Ioana Popescu, Rowan P. Clarke

A significant proportion of the world's population does not have access to grid-based electricity. Rechargeable lamp-based technology is becoming prominent as an alternative off-grid lighting model in developing countries. We explore, in close collaboration with Nuru Energy in Rwanda, the consumer behavior and the operational inefficiencies that result under this model. Specifically, we are interested in measuring the impact of inconvenience along with the impact of liquidity constraints on lamp usage, and evaluating the efficacy of strategies that address these factors. Our undertaking has implications for both firm-level operational decisions and government-level policy decisions.

2 - Deploying a Reinforcement Learning System for COVID-19 Testing at the Greek Border
Kimon Drakopoulos, University of Southern California, Los Angeles, CA, 90305-1028, United States

3 - COVID-19: Prediction, Prevalence and the Operations of Vaccine Allocation
Georgia Perakis, Massachusetts Institute of Technology, Cambridge, MA, 02478-1706, United States

4 - Unmasking Human Trafficking Risk in Commercial Sex Supply Chains with Machine Learning
Pia Ramchandani, University of Pennsylvania, Philadelphia, PA, 19104, United States, Hamsa Bastani, Emily Wyatt

Tuesday, 6:00AM - 6:30AM

■ VT85-5

Virtual Room 85

Technology Showcase: Publishing in Operations Research & Optimization

Technology Showcase

1 - Publishing in Operations Research & Optimization
Elizabeth Loew, Springer, Stoughton, MA, 02072, United States, Matthew Amboy, Razia Amzad, Jialin Yan

Springer Nature's community of book and journal PublihingEditors will showcase their highlights, offering insights to potential authorson where to get published. We will also announce Springer Nature's new Moremedia App and the future edition of the Encyclopedia of Optimization.Spotlights include a new book publishing cooperation in progress betweenSpringer and INFORMS and a new book series LectureNotes in Operations Research. Additionally we will show recentselections from established book series SpringerOptimization and its Applications and InternationalSeries in Operations Research & Management Science, amongothers. Finally we will provide an overview of our journals portfolio, all openfor submissions, featuring premiere journals including the Annalsof Operations Research, MathematicalProgramming, and our newly launched OperationsResearch Forum.For a full list of ourlatest offerings and a 40% discount, visit us at https://www.springer.com/INFORMS.See you next year in Indianapolis!

Tuesday, 6:00AM - 7:30AM

■ VTA01

Virtual Room 01

Complex Systems Modeling and Decision Making

Contributed Session

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

1 - A Regression-optimization Framework for Sequential Decision-making
Long Vu, IBM T. J. Watson Research Center, Yorktown Heights, NY, United States, Pavan Murali, Nianjun Zhou, Dharmashankar Subramanian, Dzung Phan, Lam M. Nguyen

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

2 - Design of Acoustic Metasurfaces with Independent Amplitude and Phase Control
Arvind Krishna, Georgia Institute of Technology, Atlanta, GA, 30318-5599, United States

The design of an acoustic metasurface determines the phase and amplitude of the reflected and transmitted acoustic waves. Since there are many possible designs, it is hard to model the design based on the amplitude and phase. We propose a novel data reduction technique followed by a machine learning methodology to estimate the design for obtaining the desired amplitude/phase.