**Wednesday, 6:00AM - 7:30AM**

**VWA01**
Virtual Room 01  
Smart Business Strategies Supported by Data-Driven Decisions  
Sponsored: Data Mining  
Sponsored Session  
Chair: Guang Yang, A, AR, United States  
1 - Mozrt - AI Orchestrated Learning  
Yanbin Ye, Principal Data Scientist, Walmart, Bentonville, AR, United States, Wen Xu, Qixin Wang  
Mozrt is a recommender system that focuses on personalizing associates’ learning experiences to ensure they recommend the right content to the right people at the right time. One important success metrics is to save associates time. To achieve this goal, we developed an end-to-end machine learning solution that includes not only NLP-based semi-supervise learning models, but also controls user learning engagements data collections. To increase the personalized recommendation accuracy and reduce cold start problems, we used a hybrid recommendation algorithm that combined traditional collaborative filtering with the deepFM model.  

2 - FraudFox: Adaptable Fraud Detection in the Real World  
Yi Fan, Sr. Applied Scientist, Amazon, Seattle, WA, United States, Matthew Butler, Christos Faloutsos  
How suspicous is ’Smith’, trying to buy $500 shoes, on Monday 3am? How to merge the risk scores from a handful of risk-assessment modules (’oracles’) in an adversarial environment? More importantly, given historical data (orders, prices, and outcomes), and business restrictions, which transactions should we ‘pass’, v.s. investigate? These are the two research problems we focus on in this work. One approach to address the first problem (’oracle-weighting’), is by using Extended Kalman Filters with dynamic importance weights, to automatically and continuously update our weights for each ’oracle’. For the second problem, we show how to derive an optimal decision surface, and how to compute the Pareto optimal set, to allow what-if questions. The resulting system, FraudFox, is scalable, adaptable to changing fraudster behavior, effective, and already in production.

**VWA02**
Virtual Room 02  
Machine Learning for Marketing Applications  
Sponsored: Data Mining  
Sponsored Session  
Chair: Amin Hosseinzadeh, University of Florida, Gainesville, FL, 32611-1942, United States  
1 - Using Generative Model To Identify Breakthrough Innovation  
Zhaopi Cheng, Carnegie Mellon University, Pittsburgh, PA, 15206-3747, United States  
Computational creativity literature has established that an intelligent agent need to first properly identify innovation before creating one. We propose InnoVAE, a customized variational autoencoder (VAE) on a data set of “computing systems” patents to generate and situate patents in an interpretable vector space, consisting of factors of innovation. We argue that three different types of scientific innovation - combinatorial, exploratory, and transformative - can be distinguished by generative algorithms in an unsupervised, data-driven manner, and test the value of this representation by exploring correlations with economic measures of patent impact. We further discuss the potential utility of generative AI methods for business applications.  

2 - Panoramic Market Structure Analysis Leveraging Consumer Location Big Data  
Eunkyung An, New York University, New York, NY, 10012, United States, Natasha Zhang Foutz, Xiao Liu, Baohong Sun  
Consumers’ daily movements and location visitations reveal their 24/7 lifestyle and brand preferences within and across industries. Compared to the traditional, intra-industry, competition-centric market structure, consumer movement data portray a never-before, cross-industry, consumer-centric market structure. We employ the heterogeneous network embedding model to population-scale, granular, behavior-rich, individual-level location data to derive panoramic market structure embedding brand-store-customer networks and lifestyle segments. This analysis offers marketers unprecedented business intelligence for targeting, entry/exit strategy, and cross-industrial promotion and brand alliance.

**VWA03**
Virtual Room 03  
Mining Digital Trace Data of Online Communities  
Sponsored: Data Mining  
Sponsored Session  
Chair: Tianjie Deng, University of Denver, University of Denver  
1 - Are Critics Really Unbiased? The Impact Of Social Ties On Critics’ Rating Behavior  
Tianxi Dong, Assistant Professor, Trinity University, San Antonio, TX, United States, Tianjie Deng, Thomas Peña  
Grounded in the differentiation theory, this study aims to empirically investigate the relationship between social ties and the rating similarities between critics. We collected an extensive data set from Rotten Tomatoes exploring the critics’ social relations in conjunction with their movie-rating behavior. We find that critics (critics who have no connections) give higher ratings than non-loners (critics with at least one connection). What is more, critics tend to give lower ratings when they have more connections. In terms of social tie strengths, critics with strong ties appear to provide similar ratings. These findings raise questions about the reliability of critic ratings as unbiased indicators of quality. Platform stakeholders can adjust their strategies to account for possible review biases resulting from the social interactions among critics.

2 - How Open Source Software Releases Entrain Emergent Routines  
Aron Lindberg, Stevens Institute of Technology, Hoboken, NJ, United States  
While the literature on release cycles in open source software (OSS) has identified numerous different phases, we know little about the mechanisms that allocate different types of work across these phases. Understanding this would be valuable for project managers, core teams, and corporate sponsors wishing to shape the type of work conducted at different points in the evolution of an OSS project. To investigate how the emergent routines of OSS developers become structured across release cycles of OSS we conduct an abductive, computational study of eight OSS projects. We use relational event modeling to analyze 1,169,489 actions covering 93 major software releases. We find that developer activities are structured both by entrainment mechanisms internal to the emergent routines of developer activities: activity, popularity, and inertia, as well as their interactions with external entrainment mechanisms, i.e., the phases of the release cycle. Before a major release development work tends to be entrained by inertia effects whereby developers focus on issues in which they have invested considerable effort in the past. After a major release development work concentrates around the most active developers. Between major releases developers scan for issues which have become popular. Our theorizing suggests that release cycles constitute an important temporal mechanism that shapes how the development work and their types are allocated between OSS developers.

3 -Modeling Lenghthy Behavioral Log Data For Customer Churn Management  
Daehwan Ahn, Post Doc, University of Pennsylvania, Philadelphia, PA, 19130, United States, Dokyun Lee, Kartik Hosanagar  
Churn management has benefited much from advanced feature learning techniques applied to large-scale behavioral log data. Despite its success, the current models can only address sequences of short length ranging from hundreds to thousands. In practice, however, customer log data has a very long sequence that can extend to millions in length that can only be utilized through massive and enormous feature engineering, which requires domain expertise and can be unreliable depending on the data scientist. We propose an automated log-processing approach that extends powerful feature learning approaches to extract valuable signals from lengthy log data. Our proposed framework achieves a significant improvement in customer churn prediction relative to existing manual feature engineering approaches developed by a global game company.

4 - From Client RFPs To Provider Offerings Using NLP  
Paul R. Messinger, University of Alberta, Edmonton, AB, Canada, Aly Megahed, Hamid Reza Motahari Nezhad, Ahmed Nazeem, Juan Cappi, Pravar Mahajan, Robert Engel, Yuva Ong  
We automate two activities that are done at the beginning of the tender bidding process for large service projects. (1) We extract performance requirements from Requests from Proposals (RFPs) for complex service contracts using customized text analytics and natural language processing techniques. (2) We match these requirements to the capabilities of a large service provider. Winning such large B2B service contracts is critical for the business success of service providers. The proposed methods facilitate faster processing of RFPs, consideration of a larger number of RFPs, and cost reductions.
3 - Online Sustainability Reporting and Value Creation for Firms
Ning Xue, University of Colorado, Denver, CO, United States, Dobin Yim, Jiban Khuntia
This study aims to utilize data mining techniques to extract concepts from firms’ digital sustainability reports disclosed on a sustainability reporting platform, and to understand the impacts of two types of practices: employee-orientation (internal) and customer-orientation (external) on firms’ financial performance. Considering the current digital transformation of businesses, this study also explores the differences between digital and non-digital firms to provide implications for the digitization and digitalization process. We test our hypotheses with a matched dataset of 682 firms from 2013 to 2015.

4 - Preserving History: Archiving Search Query Results for Future Research
Joshua Madden
Efforts to preserve web pages have been dramatically increased in the past decade. Cheaper data storage and faster processing have allowed for an increase in the number websites archived and the frequency with which they are archived. However, archiving the results of search queries presents unique challenges not easily addressed by traditional web crawling methods. This research outlines some of the potential challenges and presents some possible solutions for archiving these types of pages.

■ VWA04
Virtual Room 04
Analytics & Data Science Program Academic Excellence
Sponsored: Data Mining
Sponsored Session
Chair: Matthew A. Lanham, Purdue University, Lafayette, IN, 47905-4803, United States
1 - Giving Students a Competitive Edge: Integrating CAP into Curriculum and Aligning to Labor Market Demand
Lynn Letukas, SAS Institute, SAS Campus Dr, Cary, NC, 27513, United States, Jacqueline Johnson
Jobs requesting analytics skills such as data analysis, data science, statistics, or business intelligence have grown by 20 percent annually in the last four years with more than 400K jobs currently posted monthly in the US. Despite this growth, data from Gallup shows a sizable gap between the skills and competencies students learn in college and those most requested by employers. This presentation builds upon others in this session by focusing on how labor market data can be used to assist with course development and in-demand skill integration to improve program and student outcomes. Specifically, this talk examines demand for skills associated with the Certified Analytics Professional (CAP) certification and highlights teaching and learning resources available to faculty and students to learn analytics skills.

2 - Teaching INFORMS CAP Principles To Business Leaders
Joseph A. Cazer, Dean’s Club Professor, Appalachian State University, Appalachian State University, Department of Decision, Boone, NC, 28608, United States
This program shares lessons learned in developing INFORMS based analytics educational programs and materials for mid-level managers and executives. Topics include partnering with private firms, tailoring the program to different audiences, building a curriculum and navigating the university ecosystem.

3 - Integrating INFORMS CAP/aCAP Into Your Academic Program
Matthew A. Lanham, Purdue University, 112 Eastland Dr, Lafayette, IN, 47905-4803, United States
We discuss how we are making a proactive attempt to get every future graduate of Purdue’s M.S. in Business Analytics & Information Management (BAIM) program and many program alumni to become INFORMS Certified Analytics Professionals (CAPs/aCAPs). We discuss why most programs have not achieved this, why we believe we can, how we are going about it, and challenge any academic program to partner with us to create additional incentives to push our graduates and program outcomes to the next level.

4 - A 10-year Business Analytics Journey: Challenges, Successes and Change
Melissa R. Bowers, University of Tennessee-Knoxville, 242 Stokely Management Center, Statistics, Operati, Knoxville, TN, 37996, United States
The University of Tennessee Business Analytics program graduated its first cohort of MS students in 2011. Throughout our decade-long journey, the program has faced many challenges, shared successes, and introduced numerous changes. We will share details of lessons learned that have positively impacted curriculum, recruiting, our partnerships with industry, and our approach to teaching business soft skills.
1 - Competing Streaming Platforms: The Impact Of Exclusive Content
Emily A. Meigs, MIT, Cambridge, MA, 02139-4204, United States
We develop a model to study the joint problem of designing the subscription fee and amount of original content a streaming platform should generate. In our model, the users are heterogeneous in their usage rate and depending on the content on the platforms and their subscription fee decide whether they want to subscribe to a platform or not. The two competing platforms, each choose the subscription fee that they want to offer for (unlimited) access to their content and the investment level they put into their content. The investment in their own content is costly, but higher quality content can potentially be offered at a higher subscription fee to the users. We fully characterize the equilibrium in both the monopolistic and competitive settings. We characterize under what conditions the platforms separate the two types of customers.

2 - Simple Agent, Complex Environment: Efficient Reinforcement Learning With Agent States
Shi Dong, Stanford University, Stanford, CA, United States
We design a simple reinforcement learning agent that, with a specification only of suitable internal state dynamics and a reward function, can operate with some degree of competence in any environment. We establish a regret bound demonstrating convergence to near-optimal per-period performance, where the time taken to achieve near-optimality is polynomial in the number of internal states and actions, as well as the reward averaging time of the best policy within the reference policy class, which is comprised of those that depend on history only through the agent's internal state. Notably, there is no further dependence on the number of environment states or mixing times associated with other policies or statistics of history.

3 - Bootstrapping Fitted Q-Evaluation for Off-Policy Inference
Xiang Ji, Princeton University, Princeton, NJ, United States
Bootstrapping provides a flexible and effective approach for assessing the quality of batch reinforcement learning, yet its theoretical properties are poorly understood. In this paper, we study the use of bootstrapping in off-policy evaluation (OPE), and in particular, we focus on the fitted Q-evaluation (FQE) that is known to be minimax-optimal in the tabular and linear-model cases. We propose a bootstrapping FQE method for inferring the distribution of the policy evaluation error and show that this method is asymptotically efficient and distributionally consistent for off-policy statistical inference. To overcome the computation limit of bootstrapping, we further adapt a subsampling procedure that improves the runtime by an order of magnitude. We numerically evaluate the bootstrapping method in classical RL environments for confidence interval estimation, estimating the variance of off-policy evaluator, and estimating the correlation between multiple off-policy evaluators.

4 - Data-Driven Learning In Nonstationary Newsvendor Problems
Xu Min, Tsinghua University, Beijing, 100084, China, N. Bora Keskin, Jing-Sheng Song
We study a newsvendor problem with unknown demand distribution in a nonstationary environment. The demand in each period consists of a time-varying demand level and an additive random shock. Neither the demand level nor the random shock is separately observable. The amount of change in the demand level over the time horizon is measured by a cumulative variation metric. We design a nonparametric dynamic ordering policy, termed the moving window ordering policy, which computes the order quantity in each period using only the past demand observations. For a finite variation “budget”, we prove that our policy is first-order optimal where the regret grows at the smallest possible rate. Through case studies based on real-life data, we show that our policy can save 20-80% of the cost, relative to policies widely used for perishable inventory replenishment and nurse staffing.

1 - Agent-based Simulation for Emergency Department Throughput
Josh Joseph, Beth Israel Deaconess Medical Center, Boston, MA, United States
Throughput in the emergency department setting reflects a series of dependent queues describing a patient’s full evaluation and treatment. While queueing models may provide substantive insight into bottlenecks in emergency department throughput, modeling approaches which allocate set amounts of variability in service times to human factors may tend to over and under-estimate delays to a significant degree. Use of an agent-based framework, informed by knowledge of emergency physician work habits, may lead to more parsimonious models of throughput for staffing and resource allocation.

2 - Adaptive, Real-Time and Automated Systems for Early Detection of COVID-19 Patient and Survivor Symptoms and Preventing Hospitalization
Jakkia Sairamesh, CapsicHealth, Inc., Palo Alto, CA, United States, Suzanne Hynes, Lauren Hasson, William Stein-III
Recent CMS data has shown that over 20 Billion USD was spent on hospitalizations for COVID-19 patients with an average of $25K USD per hospitalized patient. With changing symptoms, identifying and preventing hospitalizations is a great challenge as COVID-19 cases including survivors have to be monitored at home. Our NLP tools analyzed over 100,000 home and ambulatory visit notes and found that a staggering 10% of the patients were estimated to be at a high-risk based. Our dictionaries were designed to adapt to the changing indicators. Our adaptive AI system was able to identify with 87% recall and 90.7% precision the COVID-19 related symptoms. We compared the automated system with clinician review on 5000+ notes. We present an adaptive system approach where the operational system is being used by clinicians on a daily basis for supporting COVID-19 and other vulnerable patients.

3 - Using Surgical Schedule Bed Board Modeling Results From Pandemic For Planning Future Hospital Occupancy
Franklin Dexter, Professor, University of Iowa, Department of Anesthesiology, Division of Management C, Iowa City, IA, 52242, United States, Richard Epstein, Pengyi Shi
When the hospital census is high, perioperative medical directors or operating room managers may need to postpone some surgical cases scheduled within a few (e.g., <3) workdays. For the COVID-19 pandemic, we used data from state database and detailed data from a large hospital. Monte-Carlo simulations and time series analyses showed that, for purposes of comparing procedures at the same hospital, there is no loss of information by summarizing the probability distributions of hospital length of stay for elective surgical cases using single numbers, the percentages of cases among patients staying longer than overnight. This finding simplifies the mathematics for constructing dashboards or summaries of information system data to help the medical director make decisions.

4 - Early Detection Of Trend Shifts In Emergency Department Surges During The Covid-19 Pandemic
Sara Nourazari, California State University, Long Beach, Long Beach, CA, 90264-0906, United States, Samuel Davis, Rachel Granovsky, Dean J. Straff, Joshua W. Joseph, Leon D. Sanchez
A change detection tool is developed for tracking and early detection of trend shifts to help identify patterns in volume surges and declines in emergency departments during and after the COVID-19 pandemic in the U.S. This will allow studying the impact of different state-level and national guidelines and strategies on COVID-19 related restrictions and their downstream effects. At a macro level, this method can help study the impact of the pandemic on population health and emerging patterns of specific conditions such as mental health.
5 - Decreased Hospital Admissions Through Emergency Departments During The Covid-19 Pandemic
Samuel Davis, Harvard Medical School, Boston, MA, 92648-0901, United States, Sara Nourazar, Rachel Granovsky, Randolph Austin, Dean Straff, Joshua Joseph, Leon Sanchez

Emergency Department (ED) visits decreased significantly during the COVID-19 pandemic. We sought to characterize the impact of COVID-19 on hospital admissions through EDs, with a specific focus on diagnosis group, age, gender, and insurance coverage, via a retrospective, observational study of 501,369 patient visits from twelve EDs in Massachusetts from 1/1/2019-9/9/2019, and 1/1/2020-9/8/2020. We observed a 32% decrease in admissions during weeks 11 to 36 in 2020, with significant decreases in admissions for chronic respiratory conditions and non-orthopedic needs. Decreases were particularly acute among women and children, as well as patients with Medicare or without insurance. Our findings demonstrate decreased hospital admissions through EDs during the pandemic and suggest that several patient populations may have deferred necessary care.

6 - Machine Learning And Clustering-based Approach For County-level Covid-19 Analysis
Charles D. Nicholson, University of Oklahoma, Norman, OK, 73019, United States

COVID-19 is a global pandemic threatening the lives and livelihood of millions of people across the world. Due to its novelty and quick spread, scientists have had difficulty in creating accurate forecasts for this disease. This is especially true for regionally specific predictive models due to either limited case histories or unique factors characterizing the region. This paper employs both supervised and unsupervised methods to identify the critical county-level demographic, mobility, weather, medical capacity, and health-related county-level factors for studying COVID-19 propagation. We use this feature subspace to aggregate counties into meaningful clusters to support more refined disease analysis efforts.

4 - Predicting Review Helpfulness By Analyzing Imbalanced Classifications
Maryam Mahdikhani, College of Charleston, Charleston, SC, United States

This study is motivated by focusing on online fashion retailing. We seek to identify and extract the most frequent terms for helpful reviews on the fashion field and predict the helpfulness of reviews by proposing a novel method that enhances the accuracy of prediction. Our proposed method first extracts three different sets of features from i) topics analysis by using the latent Dirichlet allocation (LDA) model, ii) N-grams by using term frequency-inverse document frequency (TF-IDF) vectorizer, and iii) topics plus n-grams using the TF-IDF vectorizer. The feature sets are then used to train four effective and robust supervised algorithms on imbalanced classifications.

VWA08

5 - Mobile Clinic Deployment Under Uncertainty: The Stochastic Multiperiod Prize Collection Problem
Rosemary Santa Gonzalez, Université du Québec à Montréal, Montreal, QC, Canada, Marilene Cherekely, Marie-Ève Rancourt, Teodor Gabriel Crainic

Mobile clinic deployments are often used to provide healthcare to populations in need of humanitarian relief. Practitioners strive to deploy clinics that can access populations with the highest needs. However, during humanitarian operations uncertainty arises in the travel time, usability of roads, and access. We model mobile clinic deployment as a Two Stage Stochastic Prize Collection Problem in an effort to maximize the benefit offered by mobile clinics while considering the uncertainty. Additionally, we study the effect of multiple recourse policies on the mobile clinic deployment plans.

6 - The Price Of Imposing Vertical Equity Through Asymmetric Outcome Constraints
Thomas Breugem, INSEAD, Fontainebleau, France

Vertical equity is an important aspect in many settings. For example, donors might require a family planning organization to allocate a minimum fraction of the total utility (client volume) to a particular player (e.g., young and poor clients). The price (decrease in client volume) of such requirements is not well-understood and often not accounted for in decision-making. We provide an analytical upper bound on the price (i.e., loss of overall utility) of vertical equity considerations in resource allocation. Our set-up considers a decision maker maximizing total utility over a general convex set, subject to outcome constraints (specifying a minimum percentage of the total utility for each player). We apply our results to practical instances in health delivery.
With the US nearing the end of its inaugural wave of COVID-19 vaccinations, public health authorities are turning their attention to post-pandemic management. The SARS-CoV-2 virus is expected to become endemic. Given that waning immunity to the virus is highly probable, periodic mass vaccination will be necessary for continual outbreak prevention. However, the exact duration of immunity conferred by both vaccines and natural infection is still unknown, making it difficult at present to plan revaccination efforts. We model different periodic vaccination strategies within an SEIR framework based on the COVID-19 Policy Simulator (www.covid19sim.org) to assess their effect on disease burden over the next several years. This study provides qualitative conclusions to aid policymakers in post-pandemic management of COVID-19.

1. Periodic Vaccination Against SARS-CoV-2: Some Projections For The United States

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

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

2. Hospital COVID-19 Demand Redistribution

Felix Parker, Johns Hopkins University, Baltimore, MD, United States, Fardin Ganjkhahloo, Farzin Ahmadi, Kimia Gholbadi

As hospitals cope with the COVID-19 cases, critical resources like ICU beds have become scarce. Better utilization of the currently available capacity can improve access to resources, lower the burden to hospitals and staff, and lead to better patient care. We developed mathematical models that match the demand with available resources in a regional system of hospitals. Our robust mixed-integer linear models minimize the resource shortage while considering operational constraints and desirable allocation properties such as transfer sparsity, consistency, and locality. We validated our models for hospitals in the US and developed an interactive public decision-support website (https://covid-hospital-operations.com/).

3. Data-driven Adaptive Robust Optimization For Resource Sharing During A Pandemic

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

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

4. Informing Opening Of Colleges During Covid-19 Pandemic: An Analysis Of 800 Colleges In The U.S.

Jagpreet Chhatwal, Associate Director, Harvard Medical School, Boston, MA, United States, Turgay Ayer

With the Covid-19 outbreak happening worldwide, clinically vulnerable people should be of concern, as they are more likely to be exposed to the virus. Cancer patients with weak immune systems are a group of aforementioned people that often have to go to hospitals for radiotherapy treatment sessions every day for several weeks. Therefore, special measures are to take place for more protection.

5. Inverse Optimization For Standardizing Cancer Care Guidelines

Kimia Gholbadi, Johns Hopkins University, Baltimore, MD, 21218-2625, United States, Houra Mahmoudzadeh

Radiation therapy treatment is a time-consuming process in cancer care that often involves iterative manual planning by a planner and feedback/approval by an oncologist. There are clinical guidelines on radiation dose thresholds, but these guidelines are not universally agreed upon and differ per institution and oncologist. By considering the historically approved plans as feasible points to an LP, we employ an inverse optimization framework to find the underlying constraints. Finding such constraints enables us to better understand the implicit logic in approving or rejecting treatment plans. In doing so, we help standardize the guidelines and care practices, assess plan feasibility based on past observations, improve the quality of the final plans by preventing low-quality initial plans, and reduce the number of iterations between planners and oncologists.

Our research focuses on scheduling radiotherapy patients, using mixed-integer linear programming, minimizing the total number of potential interactions among patients and between staff members and patients. We use numerical examples to demonstrate the effectiveness of the proposed approach.
Model of intergenerational wealth to analyze the potential impact of policy addressing the harms of slavery and of the de jure segregation and disparity where Black households hold a tenth the wealth of their white peers.

Persistence of existing inequities and systemic racism have resulted in the current American disparity where Black households hold a tenth the wealth of their white peers.

The Diabetes Belt is an area in the rural southeastern US and Appalachia identified by the CDC to have a high diabetes prevalence. Preventive care can reduce the risk of diabetes complications. Since 2011, Medicare beneficiaries can make Annual Wellness Visits (AWVs) to discuss a patient-specific plan for preventive care. We present a Markov decision process model to determine the optimal timing of AWVs to reduce geographic (Diabetes Belt vs surrounding) and racial (non-Hispanic White vs non-Hispanic Black) disparities among Medicare patients and to estimate the impact of AWVs on disparities in preventive care use. This model is part of our work to develop optimal policy recommendations to inform future interventions to reduce disparities in diabetes complications.

In healthcare appointment scheduling, one often seeks to minimize a weighted sum of patient waiting time and physician idle time. It is common to suppose that the relationship between concussion symptoms during the healing process is not well understood. In order to further understand the concussion recovery process, we develop a weighted temporal network to analyze how concussion symptoms are interrelated, mutually reinforcing, and amplifying. In analyzing this network, we look to identify each symptom's evolution through the healing process, and to understand the concussion recovery process.

Pharmacies: A data-driven approach to reduce pharmacy deserts.

Despite the growing number of pharmacies, their distribution and accessibility of services to all US residents may not be equitable. A data-driven and comprehensive study is conducted to understand and optimize efficiency and equity in pharmacy accessibility. A location-allocation optimization model is developed, to maximize equity and accessibility considering demographics, unhealthy days, travel distance, public transit, and vehicle ownership, among others. Considering both geographic and non-geographic factors in Jefferson County KY, we identified the pharmacy desert to help policymakers to improve equitable access to pharmacies.

In order to further understand the concussion recovery process, we develop a weighted temporal network to analyze how concussion symptoms are interrelated, mutually reinforcing, and amplifying.
1 - Entropy As A Driver Of Engagement In Online Discussion Platforms
Joseph Carlstein, University of Pennsylvania, Philadelphia, PA, 19104, United States, Gad Allon, Yonatan Gur

With the rise of remote work and remote learning, it has become increasingly imperative for firms and educators to facilitate discussions in a clear and organized fashion. There are many possible objectives of these discussions, depending on the situation, from identifying a correct answer to a question, to building consensus, to sparking debate. However, in this presentation, we will focus on determining the key drivers of engagement in a group discussion on a closed online platform, and how the platform can leverage comment-level and discussion-level engagement drivers to design effective practical recommendation algorithms for directing traffic to different parts of the discussion, in order to maximize user engagement.

2 - Pricing In A Two-sided Market With Time-sensitive Customers And Suppliers
Mustafa Akan, Carnegie Mellon University, Pittsburgh, PA, 15217, United States, Philipp Afeche

We consider a firm that matches stochastically arriving and time-sensitive customers and suppliers. We characterize the structure and performance of the profit-maximizing and socially optimal pricing policies.

3 - Matching Technology And Competition In Ride-hailing Marketplaces
Katifin M. Daniels, Washington University in St. Louis, Saint Louis, MO, 63112-1207, United States, Danko Turcic

Taxis’ and Uber’s matching technologies differ: taxis random-walk in search of curbside pick-ups while Uber centrally dispatches drivers. We study how taxis can defend against Uber encroachment. We find that taxi market share plummet when mimicking Uber’s centralized dispatch. Taxis benefit from a low-tech alternative: restricting their service area.

4 - Courier Dispatch In On-demand Delivery
Mingliu Chen, Columbia University, New York, NY, 10128, United States

We study a courier dispatching problem in an on-demand delivery system where customers are sensitive to delay. The effect of temporal pooling is evaluated by comparing systems using the dedicated strategy, where only one order is delivered per trip, vs. the pooling strategy, where a batch of sequential orders is delivered on each trip. We capture the courier delivery system’s spatial dimension with a service region analogous to a circular city. We obtain concise but informative results when there is a single courier and customers’ underlying arrival rate is large enough, meaning a crowded market such as rush hour delivery. We also extend our model to incorporate a general arrival rate that does not have to be large, a non-uniform distribution of orders in the service region, and multiple couriers. We find that most observations in our base model still hold in these extensions.

5 - Online Optimization On Asset Selling Platforms
Phil (Pueling) Jiang, Washington University in St. Louis, MO, 63130-4899, United States, Rene A. Caldentey, Lingxiu Dong

Asset selling platforms like used car platforms (e.g., CarMax, Guazi) acquire assets from individual sellers and sell those assets to individual buyers. To keep a high inventory turnover rate, the platforms typically set a salvage deadline for each unit of asset. In this work, we formulate a discounted infinite-horizon problem for asset selling platforms. We characterize the optimal acquisition and pricing strategies and construct an approximation scheme for the problem. Finally, under the scenario of parameter learning, we propose a learning strategy that is adaptive to the on-hand inventory profile.

2 - Product-line Pricing With Dual Objective
Hongmin Li, Arizona State University, WP Carey School of Business, Dept of Supply Chain, Tempe, AZ, 85287, United States, Woonghee Tim Huh

The current literature on pricing and revenue management stresses the profit objective but rarely considers customer utility in the firm’s objective function. In this research, we deviate from this conventional profit objective and study multi-product pricing with a balanced objective of profit and customer utility.

3 - Tight Guarantees For Multi-unit Prophet Inequalities And Online Knapsack
Jiawei Zhang, New York University, New York, NY, 10012-1106, United States, Jiashuo Jiang, Will Ma

Prophet inequalities are a fundamental tool for comparing the performance of online vs. offline algorithms. In the basic setting of k-unit prophet inequalities, the celebrated algorithm of Alaei (2011) with a performance guarantee of 1 - 1/sqrt(k+3) has been applied in online advertising, healthcare scheduling, and revenue management. Despite its wide applicability for rounding an LP solution, the tightness of this guarantee for a given k has remained unknown. In this paper we resolve this question, characterizing the tight bound using differential equations and deriving the best-known guarantee for k-unit prophet inequalities. In the generalization of the online knapsack problem, we also derive an improved and tight guarantee of 1/(3+1/e^2) ~ 0.319, by bypassing the splitting of large vs. small items in our analysis.

4 - Posted Price Versus Auction Mechanisms In Freight Transportation Marketplaces
Sungwoo Kim, Georgia Tech, Atlanta, GA, United States, He Wang, Xuan Wang

We consider a truckload transportation marketplace in which a platform serves an intermediary to match shippers, who make payment to the platform for transportation services, with carriers, who book loads and get compensation from the platform for transporting the loads. The objective of the platform is to design a policy that specifies how to set prices for shippers and payments to carriers, as well as how carriers and loads should be matched, in order to maximize its long-run average profit. This research analyzes theoretical performances of posted price, auction, and hybrid mechanisms which combine posted price and auction mechanisms.

1 - Synthetic Controls For Experimental Design
Jinglong Zhao, Massachusetts Institute of Technology, Cambridge, MA, 2139, United States, Alberto Abadie

This article studies experimental design in settings where the experimental units are large aggregate entities (e.g., markets), and only one or a small number of units can be exposed to the treatment. In such settings, randomization of the treatment may induce large estimation biases under many or all possible treatment assignments. We propose a variety of synthetic control designs as experimental designs to select treated units in non-randomized experiments with large aggregate units, as well as the untreated units to be used as a control group. Average potential outcomes are estimated as weighted averages, of treated units for potential outcomes with treatment, and control units for potential outcomes without treatment. We analyze the properties of such estimators and propose inferential techniques.
2 - Balancing Covariates In Randomized Experiments With The Gram-schmidt Walk Design

Christopher Harshaw, Yale University, New Haven, CT, United States; Fredrik Saye, Daniel Spielman, Peng Zhang

In the design and analysis of Randomized Control Trials, it is widely accepted that balancing pre-treatment covariates between the treatment groups may lead to improved precision of treatment effect estimates when the covariates are correlated with outcomes. However, we argue that there is a fundamental trade-off between efficiency gained by covariate balance and robustness of these estimates. We present the Gram-Schmidt Walk Design, which allows experimenters to optimally navigate this trade-off. The design utilizes recent advances in algorithmic discrepancy theory [Bansal et al 2019]. We provide a tight analysis of the design, including non-asymptotic bounds on the variance and tails of the Horvitz-Thompson estimator. Based on these results, we develop estimators for non-asymptotic confidence intervals.

4 - Interference, Bias, And Variance In Two-sided Marketplace Experimentation: Guidance For Platforms

Geng Zhao, Stanford University, Stanford, CA, United States; Hannah Li, Ramesh Johari, Gabriel Weinraub

Two-sided marketplace platforms often run experiments to test the effect of an intervention before launching it platform-wide. A typical approach is to randomize individuals into the treatment group, which receives the intervention, and the control group, which does not, and compare the performance in the two groups to estimate the effect if the intervention were launched to everyone. We focus on two common experiment types, where the platform randomizes individuals either on the supply side or on the demand side. We develop a simple tractable market model to study bias and variance in these experiments with interference between individuals. We study how the choices of experiment type and treatment allocation proportion affect the bias and variance of the resulting estimators, and propose how a platform can navigate this tradeoff and best choose the treatment proportion.

5 - Near-optimal Experimental Design For Networks: Independent Block Randomization

Chen Chen, Booth School of Business, The University of Chicago, Chicago, IL, 27708-9972, United States; Ozan Candogan, Rad Niazadeh

We consider the problem of designing a randomized experiment for a network of users. A decision-maker uses an unbiased Horvitz-Thompson estimator to estimate the total market effect of the treatment and chooses an optimal joint distribution of randomized assignments to minimize the worst-case variance of this estimator. For networks that can be partitioned into densely connected communities by ignoring only a small number of connections, it is near-optimal to assign all users in the same community to the same variant. We develop a family of independent block randomization (IBR) experiments, and we show these policies are asymptotically optimal when the number of communities grows large and no community size dominates the rest. Beyond the asymptotic regime, the IBR experiment is 7/3-approximation for any problem instance.

3 - Study Of Health Outcomes In A Technology Enabled Virtual Setting.

Maxim Terekhov, University Of Florida, Gainesville, FL, United States

This paper presents an empirical analysis of health insurance claims data to explore telemedicine outcomes. Specifically, I utilize causal forests and a retrospective matched case control study design to demonstrate statistically significant changes in costs, utilization, and medication adherence of telehealth users. These findings provide insight on the value of telemedicine and have important implications for stakeholders in healthcare field.

4 - Spillover Effects Of Doctors’ Knowledge Sharing On Patients-Evidence From An Online Healthcare Platform

Liu Yan, Huazhong Agricultural University, Wuhan, China, Junwei Kuang, Wanxin Qiao

The success of online healthcare platforms (OHPs) depends on the continued participation and contributions of doctors and patients. Little is known about the spillover effects of doctors’ online contributions, especially their knowledge-sharing behavior, on patients in these platforms. Based on the signaling and expectation-confirmation theory, we examine the causal effects of doctors’ knowledge sharing on patients-generated information (PGI). Our results reveal that doctors’ knowledge sharing significantly increases both the volume and quality of PGI. The new findings provide implications for service operation management of OHPs.

VWA18

Virtual Room 18

Information Systems II

Contributed Session

Chair: Qizi Dai, Drexel University, Philadelphia, PA, 19104, United States

1 - Improving Machine Learning Algorithms By Collecting Diverse And Granular Data In Crowdsourcing Platforms

Aida Khosh Raftaar Nouri, Memorial University of Newfoundland, St John’s, NL, Canada; Jeffrey Parsons

Citizen science volunteers have played an essential role in creating training data for the machine learning algorithm. Furthermore, using crowdsourcing maximizes the undiscovered value of the data. This research aims to develop, implement, and evaluate design principles for data collection in crowdsourcing platforms with the ability to collect granular and diverse data. This study also conducts experiments to show that information diversity and granularity are the pertinent dimension of information quality in crowdsourced data improve machine learning algorithms.

2 - Increasing Healthcare Organizations Agility Via Cloud Analytics Platforms

Hossein Kalantar, University of Colorado-Denver, Denver, CO, United States

Healthcare organizations should constantly and swiftly detect and respond to environmental opportunities and threats. The COVID-19 outbreak demands fast and precise actions from healthcare organizations across the globe more than ever before. These organizations can utilize various analytics tools on the cloud-based platform to increase their agility in the operational domain and clinical areas. In this study, we investigate the impact of cloud analytics platform adoption on healthcare organizations’ agility.

VWA19

Virtual Room 19

Topics in Monte Carlo Methods and Rare Event Sampling

Sponsored: Applied Probability Society

Sponsored Session

Chair: Mariana Olvera-Cravioto, University of North Carolina-Chapel Hill, Chapel Hill, NC, 27514-3601, United States

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

1 - Importance Sampling For Maxima On Trees

Michael Conroy, University of Arizona, Tucson, AZ, 27510, United States; Mariana Olvera-Cravioto, Bojan Basrak, Zbigniew Palmowski

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

2 - Approximating Quasi-stationary Distributions with Interacting Reinforced Random Walks

Adam Waterbury, UC-Santa Barbara, Santa Barbara, CA, United States

We propose two numerical schemes for approximating quasi-stationary distributions (QSD) of finite state Markov chains with absorbing states. Both schemes are described in terms of certain interacting chains in which the interaction is given in terms of the total time occupation measure of all particles in the system. The schemes can be viewed as combining the key features of the two basic methods for approximating QSD originating from the works of Fleming and Viot (1979) and Aldous, Flannery, and Palacios (1998), respectively. I will describe the two schemes, discuss their convergence properties, and present some exploratory numerical results comparing them to other QSD approximation methods.
3 - On The Impacts Of Tail Model Uncertainty In Rare-event Estimation
Zhiyuan Huang, Tongji University, Shanghai, China, Henry Lam, Zhenyuan Liu
Rare‐event probabilities and risk measures that quantify the likelihood of catastrophic or failure events can be sensitive to the accuracy of the underlying input models, especially regarding their tail behaviors. We investigate how the lack of tail information of the input can affect the output extremal measures, in relation to the level of data that are needed to inform the input tail. Using the basic setting of estimating the probability of the overshoot of an aggregation of i.i.d. input variables, we argue that heavy-tailed problems are much more vulnerable to input uncertainty than light-tailed problems. We explain this phenomenon via their large deviations behaviors, and substantiate with some numerical experiments.

4 - Exact Derivative Estimation: Unbiased Estimation For Markov Chain Steady-state Expectations
Jeffrey Wang, Northwestern University, Evanston, IL, United States, Chang-Han Rhee
Consider a family of Markov chains whose transition dynamics are affected by model parameters, and suppose that we are interested in the performance measures associated with the steady-state distributions of the Markov chains. The derivatives of such performance measures w.r.t. the parameters play important roles in many contexts including optimization of the performance measures and quantification of the uncertainties in the parameter estimation. In this talk, we propose unbiased estimators with the canonical square root convergence rate for such derivatives. Our estimators build on the probabilistic representation of the derivatives characterized in Rhee and Glynn (2021; arXiv:1707.03870) and the exact estimation technique propose in Glynn and Rhee (2014; Journal of Applied Probability, 51A:377-389).

VWA20
Virtual Room 20
Cutting-Edge Methods for Data-Driven Decision-Making
Sponsored: Applied Probability Society
Sponsored Session
Chair: Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States

1 - Fast Rates For Contextual Linear Optimization
Nathan Kallus, Cornell University, Ithaca, NY, 1044-1501, United States
Incorporating predictive contextual observations in decision making can reduce uncertainty and boost performance. While one may use off-the-shelf ML to learn a predictive model and plug it in, recent work emphasizes integrated approaches that fit models to directly optimize downstream performance. Surprisingly, in the case of contextual linear optimization, we show that the naive plug-in approach actually achieves regret convergence rates that are significantly faster than such integrated methods. Our results are overall positive for practice: predictive models are easy and fast to train using existing tools, simple to interpret and reuse for decision support, and, as we show, lead to decisions that actually perform very well.

2 - Online Learning Via Offline Greedy Algorithms: Applications In Market Design And Optimization
Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, 94305-5008, United States, Negin Golrezaei, Franssica 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.

3 - Calibrating Sales Forecast In A Pandemic Using Online Non-parametric Regression Model
Ruihao Zhu, Massachusetts Institute of Technology, Cambridge, MA, 02139-4230, United States, David Simchi-Levi, Rui Sun, Michelle Wu
Motivated by our collaboration with AB InBev, a consumer packaged goods company, we consider the problem of forecasting sales under the coronavirus disease 2019 (COVID-19) pandemic. Our approach combines online learning and pandemic modeling to develop a data-driven online non-parametric regression method. Specifically, the method takes the future COVID-19 case number estimates, which can be simulated via the SIR epidemic model, as an input, and outputs the level of calibration of the baseline sales forecast generated by AB InBev’s offline learning algorithm. We demonstrate the performances of our algorithm on both synthetic and AB InBev’s datasets of three different geographical regions. The AB InBev’s numerical experiments show that our method is capable of reducing the forecasting error in terms of WMAPE and MSE by more than 50%.

4 - Decision Forest: A Nonparametric Approach to Modeling Irrational Choice
Yi-Chun Chen, UCLA Anderson School of Management, Los Angeles, CA, United States, Velibor Misic
We propose a new nonparametric choice model that can represent any customer choice model, including those that are inconsistent with weak rationality. In the proposed model, each customer type is associated with a binary decision tree, which represents a decision process for making a purchase based on checking for the existence of specific products in the assortment. We theoretically characterize the model complexity and propose two practical estimation methods. Using real-world transaction data, we show that the proposed model outperforms benchmark models in out-of-sample predictive ability. We also demonstrate how the learned model can extract insights about substitution and complementarity effects and identify interesting customer behaviors within a specific product category.

VWA21
Virtual Room 21
Robust Optimization
Contributed Session
Chair: Jing-Rung Yu, PhD, Puli, Nantou, 545, Taiwan

1 - Data-driven Optimization For Transmission And Storage Capacity Expansion Under Seismic Risk
Alfredo Ernesto Oneto, Pontificia Universidad Católica de Chile, Santiago, Chile, Alvaro Hugo Lorca
Seismic events can cause significant damages to electric power networks and induce considerable economic losses. Hence, it is crucial to have a general framework to plan resilient networks against these hazards. This work presents a data-driven stochastic-robust optimization scheme and a practical solution method to find optimal investments for the expansion of transmission and energy storage assets in highly renewable power systems. The model leverages distributional information about seismic sources and effectively models high-dimensional uncertain parameters through a novel data-driven uncertainty set for robust optimization. We test our approach on a 281-bus Chilean power network.

2 - Robust Transmission, Renewable Generation And Storage Capacity Expansion Planning Considering Reserve Provision Of Wind Power Units
Cristina Roldán González, Postdoctoral Researcher, Universidad de Castilla-La Mancha, Ciudad Real, Spain, Raquel García Bertrand
This work presents a robust optimization approach for transmission, renewable generation and storage capacity expansion planning considering the participation of renewable units in reserve markets. The uncertainty in injected generation and load are modeled using a cardinality constrained uncertainty set, while the uncertainty regarding the short-term operation of the system is modeled using a set of representative time periods of the planning horizon. A case study is solved to show the effects of considering the provision reserve capacity of wind power units in expansion decisions.

3 - Stock Price Movement Prediction By Using Robust Classification
Chieh-Hui Wei, National Chi-Nan University, Nantou, Taiwan, Jing-Rung Yu, Wan-Jian Paul Chiou, Chun-Yu Lin
This study applies robust optimization approach to cope with data uncertainty in classification. Our portfolio optimization problem robust mechanism via perturbing the features within a deterministic uncertainty set and considers the worst-case scenario. The comparisons with nominal classification methods in predicting the trends of the composite stock prices in S&P 500 index show the superiority of robust classification.
1 - Understanding Multi-modal Sensor Networks: Combining Uni-modal Sensing And Edge-cloud Computing Analytics
Ankur Verma, Pennsylvania State University, University Park, PA, United States, Soundar Kumara

Sensor networks consist of several multi-modal sensors embedded in industrial and consumer IoT environments. These sensors offer real-time visibility and enhance dynamic decision-making capabilities. Applications range from industrial asset monitoring to smart homes, with benefits like increased efficiency and throughput, reduced downtime, and others per the use case. The edge-connectivity-cloud layer for a single sensor is the basis to understand the engineering and data analytics challenges for a multi-modal sensor network. This presentation will detail some uni-modal sensors for machine health monitoring, and elaborate on the analytics techniques required for high-fidelity multi-modal sensor data, centered around a multi-modal, case study. Hardware-software co-design, signal processing, and data-driven techniques will be presented.

2 - Multi-scale Brain Network Analysis For Connectomics
Steven Winter, Duke University, Durham, NC, United States, David Dunson, Zhengwu Zhang

In brain connectomics, it is common to divide the cortical surface into discrete regions of interest (ROIs) and then to use these regions to induce a graph. The structure of the resulting adjacency matrices depends critically on the chosen regions, leading to dramatically different inference when different regions are chosen. To solve this problem we develop a multi-scale graph model, which links together scale-specific factorizations through common individual-specific latent factors. These scores combine information across from different parcellations to produce a single interpretable summary of an individuals brain structure. We develop a simple, efficient algorithm, and illustrate substantial advantages over comparable single-scale methods in both simulations and analyses of the Human Connectome Project dataset.

3 - Online Monitoring Of Dynamic Spectral Functional xvGraphical Models
Ana M. Estrada Gomez, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Kamran Paynabar

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

4 - Adaptive Partially-observed Sequential Change Point Detection For Covid-19 Hotspots Detection
Jiuyun Hu, Arizona State University, Tempe, AZ, United States, Hao Yan

The authors derive an algorithm to detect the hotspots in Covid-19 case. The challenge is the limited resources and how to distribute next day’s tests based on previous data. The algorithm uses a Bayesian weighted update to get the posterior distribution of test statistics, then use Upper Confidence Bounds (UCB) to get the optimal distribution of next day, and finally use CUSUM statistics to detect the hotspots. The authors also compare the algorithm to the benchmark of evenly distributed tests and distribute all tests once a county. In Washington State example, the hotspot detected is Yakima County.
**Virtual Room 24**

**Challenging Research Problems in the Automotive Industry**

Sponsored: Quality, Statistics and Reliability

**Sponsored Session**

Chair: Arman Sabbagh, Purdue University, West Lafayette, IN, 47907-2067, United States

1 - **Challenging Research Problems in the Automotive Industry**

Arman Sabbagh, Purdue University, West Lafayette, IN, 47907-2067, United States

Novel challenges in the automotive industry have led to fundamentally new research opportunities in quality, statistics, and reliability. The panelists in this session will discuss the new research problems that they are investigating in their work in the automotive industry.

2 - **Panelist**

Saman Alani-Azar, Ford Motor Company, Canton, MI, 48188, United States

3 - **Panelist**

Frank Sun, Tesla, Silicone Valley, CA, United States

4 - **Panelist**

Weichong Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, 08854, United States

5 - **Panelist**

Shiming Duan, GM, Detroit, MI, United States

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**Virtual Room 25**

**Probabilistic Forecasting**

Sponsored: Manufacturing and Service Operations Management

**Sponsored Session**

Chair: Ville Satopaa, INSEAD, Paris, 75012, France

1 - **Joint Bottom-up Method For Forecasting Grouped Time-series: Application To Australian Domestic Tourism**

Nicolò Bertani, INSEAD, Boulevard De Constance, Fontainebleau, 77300, France, Ville Satopaa, Shane T. Jensen

We introduce a new method to model and forecast a large number of time-series and their aggregates (grouped forecasting). Relying on Bayesian learning, the method models these series jointly, takes into account their contemporaneous covariance, and performs automatic selection of lag terms both within and across series using Spike-and-Slab mixture priors. This enables the model to faithfully learn the hidden and complex data generating process. Testing the method on benchmark grouped Australian tourism data, the method achieves higher forecast accuracy compared to the state-of-the-art alternatives. Moreover, it reveals complementarity and substitution effects across geographies and tourism types.

2 - **New Results On The Connection Between Multi-Agent Scoring Rules And Strategy-Proof Allocation Mechanisms Without Money**

Jens Witkowski, Frankfurt School of Finance & Management, Adickesallee 32-34, Frankfurt, 60322, Germany, Rupert Freeman

We build upon a recently discovered equivalence between the class of weakly budget-balanced wagering mechanisms (multi-agent scoring rules) designed for eliciting probabilities and the class of allocation mechanisms for divisible goods as studied in fair division. This equivalence leads to theoretical advances and new practical approaches for both probability elicitation and fair division. In this talk, I will focus on the implications of interpreting strategy-proof allocation mechanisms without money as wagering mechanisms based on proper scoring rules. In particular, I will show how the equivalence can be used to strengthen previous characterizations of the fair division mechanism design space.

3 - **Using L2 Scores to Optimise Combinations of Density Forecasts**

Xiaochun Meng, University of Sussex Business School, Brighton, United Kingdom, James W. Taylor

Combining density forecasts has become common practice for various applications. The optimal weights are often obtained by minimizing a chosen proper scoring rule, where the log score is most commonly used in the literature. Unfortunately, with the log score, closed-form solutions generally do not exist for the combining weights. In this paper, we optimise the weights by minimising L2 scores. We establish the closed-form representations for the optimal weights, and then use them to incorporate time-varying structure to provide further improvement in forecast accuracy. We use simulated and real data to illustrate our results.

4 - **Stable RELIABILITY Diagrams For Probabilistic Classifiers**

Timo Dimitriadis, Heidelberg University, Heidelberg, Germany, t

A probability forecast or probabilistic classifier is reliable or calibrated if the predicted probabilities are matched by ex post observed frequencies, as examined visually in reliability diagrams. The classical binning and counting approach to plotting reliability diagrams has been hampered by a lack of stability under unavoidable, ad hoc implementation decisions. Here, we introduce the CORP approach, which generates statistically consistent, optimally binned, and reproducible reliability diagrams in an automated way. CORP is based on nonparametric isotonic regression and implemented via the post-adjacent-violators (PAV) algorithm. The CORP approach furnishes a numerical measure of miscalibration, and provides a CORP-based Brier-score decomposition that generalizes to any proper scoring rule.

5 - **Human Forest Vs. Random Forest In Time-sensitive Covid-19 Clinical Trial Prediction**

Pavel Atanasov, Pytho LLC, Brooklyn, NY, United States, Regina Joseph, Felipe A. Feijoo, Max Marshall, Sauleh Ahmad Siddiqui

What methods generate the most accurate forecasts about clinical trial phase success? We describe the first multi-method clinical trial forecasting tournament, comparing machine learning models and crowdsourcing methods that estimate the time-dependent probability of phase transition for COVID-19 vaccines and treatments. The crowdsourcing approach uses the Human Forest process and software, which enables forecasters to define custom reference classes, query a historical database and review resulting base rates, and use-adjusted probabilistic estimates, are aggregated. Accuracy was compared against a random survival forest machine model, across 28 questions. Results show that Human Forest significantly outperformed the RF model, registering 32%-48% better Brier scores. Human Forest’s advantage was due to better calibration.

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**Virtual Room 27**

**Sustainability II**

**Contributed Session**

Chair: Shimaa Al-Quradaghi, Qatar University, United States

1 - **An Integrative Multiplier Framework With Sustainable Investment Under Externality Cost**

Michelle Li, Babson College, Babson Park, MA, United States, Jose Cruz

We analyze the multiperiod effects of sustainability investments on a multistage supply chain network’s economic, social, and environmental decision making. The network consists of suppliers, manufacturers, and retailers who decide on production, distribution, inventory, and prices, as well as the level of sustainability investment to maximize net return. Also, the decision makers are constrained by externalities costs and consumers’ preference and willingness to pay for sustainable products. The model allows us to investigate the interplay of different decision-makers and to compute the resultant network equilibrium pattern of transactions, inventory, prices, and sustainability levels.

2 - **Does Leader Disability Status Improve Productivity Performance For Workers With A Disability? An Empirical Analysis In The Apparel Industry.**

Dustin Cole, Michigan State University, East Lansing, MI, United States, Sriram Narayanan, Shawnee Vickery

This research examines impact of leader disability status on the productivity of workers with disabilities using a unique set of data collected at a social enterprise. Our results show that a leader who does have personal experience with a disability is able to improve the productivity of workers with a disability by mitigating the potential productivity decline as the number and ratio of workers with a disability increases. The quantitative finding is built upon using a case study approach at two different, but similar organizations.

3 - **Quantification Of Potential Emission Reduction In Order Fulfillment Optimization.**

Reginald Bryant, Research Scientist, IBM Research, Nairobi, Kenya, Kedar Kulkarni, Isaac Waweru

Most competitive retailers are using omni-channel networks to fulfill home-delivery orders while simultaneously driving reductions in their carbon footprint. We analyzed the carbon emissions associated with the last-mile delivery of retail packages under two scenarios: one based on order-fulfillment heuristics, the other using an optimization approach. Afterwards, a series of experiments were conducted to assess the potential further reductions with relaxed customer-side service-level-agreements. Experiments suggest that emissions and cost reductions can be achieved without drastic operation changes.
4 - Eco Industrial Park For End Of Life Vehicles
Shimaa Al-Quradghi, Qatar University, Doha, Qatar, jQipeng Phil Zheng, Alberto Betancourt, Ali Elkamel
The aim of this paper is to provide a mathematical model to optimize the exchange of material flows in the network of Eco-Industrial Park for End-of-Life Vehicles. The model finds the optimal processing routes while maximizing the yield of the component of interest, maximizing profit, minimizing cost, or minimizing waste, depending on which weights are chosen. Finally, the model is illustrated on a case study of ELVs recovery network in Qatar and the optimal network infrastructure is obtained. The results are analyzed to provide insights about the network and to prepare for capacity planning.

VWA28
Virtual Room 28
Healthcare Operations Management
Sponsored: MSOM/Healthcare
Sponsored Session
Chair: Alex Mills, Baruch College, City University of New York, New York, NY, 10010-5585, United States
Co-Chair: Masoud Kamalhadi, University of Miami, Bloomington, IN, 47405-1701, United States
1 - Cross-functional Team Co-location
Temidayo Adepoju, Boston University, Boston, MA, United States, Anita I. Tucker, Cherisse Carlo, Chris Manasseh
We investigate the impact of team co-location in improving the efficiency of a dedicated observation unit (DOU). The DOU is a unit in the hospital designed to treat observation patients (low risk). In July 2018, the unit expanded to treat patients with higher medical complexity which increased the demand and variability in the unit. Using a difference-in-difference approach and instrumental variables approach we examine the operational cost and the efficiency gain respectively, of this expansion. We find that the observation LOS increases in the unit after the unit expanded. However, through team co-location which enhances the coordination, the DOU gains efficiency that results in a reduction in LOS for the observation patients cared for in the unit compared to observation patients cared for off-service in the inpatient unit.

2 - Multichannel Delivery In Healthcare: The Impact Of Telemedicine In Southern India
Kraig Delana, University of Oregon, Eugene, OR, 97403, United States, Sarang Deo, Kamalini Ramdas, Ganesh Babu, Thulasiraj Ravilla
We empirically study the impact of telemedicine centers on patients’ access, outcomes, and costs at the Aravind Eye Care System in Southern India. We find that telemedicine centers increase visit rates, particularly for new patients, as well as glasses prescription rates while decreasing indirect costs of travel for patients.

3 - Optimization Of Pediatric Vaccines Distribution Network Configuration Under Uncertainty
Zahra Azadi, University of Miami Herbert Business School, Coral Gables, FL, 33158, United States, Sandra D. Eksioglu, Harry Neil Geismar
Millions of young people are not immunized in low- and middle-income countries because of low vaccine availability resulting from inefficiencies in cold supply chains. We create supply chain network design and distribution models to address the unique characteristics and challenges facing vaccine supply chains in these countries. The models capture the uncertainties of demand and the resulting impacts on immunization, the unique challenges of vaccine administration, the interactions between technological improvements of vaccines and immunizations, and the trade-offs between immunization coverage rates and available resources. The objective is to maximize the percentage of fully immunized children and the vaccine availability in clinics. We tested the model using Niger’s Expanded Program on Immunization, which is sponsored by the World Health Organization.

4 - Telehealth Expansion And Patient Demand In Acute Care
Oxden Engin Cakici, American University, Washington, DC, 20016, United States, Alex Mills
Many healthcare providers have recently expanded telehealth services where patients can see a doctor online. In theory, increasing capacity of telehealth services should expand the provider’s panel size because telehealth is more convenient, but the drawback of telehealth is that it may require a follow up visit for a physical exam. We model the patient’s strategic choice for acute care among walking, telehealth, and walk-in office visit using a game theoretic model, as a function of the provider’s capacity allocation to telehealth. We find that too much expansion of telehealth can decrease the provider’s panel size, and we discuss policy implications that emerge from this result.
2 - Admission Pricing In Public Emergency Departments: Theory And Evidences From A Natural Experiment
Man Yu, Hong Kong University of Science and Technology, ISOM Department, HUST, Clear Water Bay, Hong Kong, Hong Kong, Ji Chen, Tian Li
We study the pricing decisions of a medical service provider who operates both an emergency department and a non-emergency department with different priority schemes and admission fees. Effects of adjusting the admission fees are examined both in an analytical model and with empirical data from public hospitals in Hong Kong.

3 - Dynamic Service System Design With Flexible Servers And Priority Customers
Rui David Chen, The Chinese University of Hong Kong, Shenzhen, Shenzhen, 518172, China
We study non-preemptive queueing systems consisting multiple classes of customers with different waiting cost rates and multiple servers with heterogeneous service rates. We compare two common-in-practice systems (dedicated system and work-conserving flexible priority system) and characterize conditions for each one to be more favorable. Under the objective of minimizing discounted total waiting cost, we develop a Markov decision process formulation and analytically characterize the structure of the optimal dynamic server assignment policy. We prove that, the optimal policy is of a threshold type with intentional idleness. We also invent an approach to compute the optimal threshold values. Through numerical experiments, we quantify the advantage of the optimal policy.

4 - Effects Of Firm’s Structural Position In Its Value Network On Competitiveness And Complexity
Yang Yang, Assistant Professor, University of Texas at El Paso, El Paso, TX, United States
Competition is fluid and dynamic, so firms must constantly create temporary advantages by frequently launching various competitive actions to sustain their competitive advantage. While research has shown that firms become increasingly dependent on their suppliers and customers to gain competitive advantage and has examined the impact of value network on firm performance (i.e., a result of a firm’s competitive actions), no study has investigated how value networks could directly affect a firm’s strategic competitive behavior. This study examines how firms’ structural characteristics in value networks influence their competitive behavior in respect of competitive aggressiveness.

5 - Investigation Of Information Usage In A Retail Supply Chain
Abdurrezzak Sencer, Assistant Professor, Penn State University, Beaver, PA, United States, Mutlu Y. Avcilar, Mehmet Barut
In this empirical study, we focus on how member relationships impact information sharing as well as the moderating impact of information quality on the relationship between acquiring information and processing information in a retail supply chain network.

6 - The Role Of Peer Experience And Learning In Operational Decisions
Neslihan Ozlu, Neslihan Ozlu, Stockholm University-Företagsekonomi, Stockholm, Sweden
Drawing on purchasing data from a European manufacturer, we investigate the purchasers-ordering behaviour under variable lead times. In particular, we examine the learning of the purchasers through their experiences with the suppliers from their peers. We also incorporate the specific versus all other purchasers as well as suppliers into the analysis. We mainly observe varying behaviours of purchasers depending on the relationships with the suppliers. Our results have both managerial and practical implications.

VWA31
Virtual Room 31
Supply Chain Competition
Contributed Session
Chair: Neslihan Ozlu, Stockholm University, Stockholm, 18254, Sweden
1 - Chief Intellectual Officers: An Exploratory Analysis Of Their Emergence And Effects
Yoichiro Nishimura, Associate Professor, Chuo University, Tokyo, Japan, regesion@hotmail.com, Masayo Kani
While many studies examine CPO, COO and CEO, little is known about CIPO. In this study, we examine the emergence of CIPO inside the firm and its effect on corporate IP strategy. We primarily relied on two perspectives to examine CIPO: contingency perspective and institutional perspective. We find that firm size and R&D size which represent the general & IP-related CEO’s workload respectively are positively associated with the emergence of CIPO. Furthermore, we also show that the emergence of CIPO is affected by the institutionalization of the CIPO position in the industry. We also reveal that top executive who is appointed as CIPO is likely to adopt industry norm in terms of corporate IP strategy.

2 - Customer Segmentation, Pricing, And Lead Time Decisions: A Stochastic-user-equilibrium Perspective
Jun Ma, University of Calgary, Calgary, AB, Canada, Barrrie R. Nault, Ding Zhang, Yiliu (Paul) Tu
We study a two-echelon supply chain network consisting of manufacturers and retailers facing customers that differ in their price- and time-sensitivity. We adopt a stochastic-user-equilibrium approach in a supply chain network by incorporating discrete choice theory and using a multinomial logit-based variational inequality to express equilibrium conditions. We find that price/lead time options provided by individual firms depends on multiple factors, including the mean and variance of customers’ sensitivity coefficient distributions, time-cost relationship of firms, and supply chain management approaches.

3 - Competition Or Cooperation? Equilibrium Analysis In The Presence Of Process Improvement
Xuan Zhao, Professor, Wilfrid Laurier University, Waterloo, ON, Canada, Wei Li
Competition is a business phenomenon that dominates many supply chains. We aim to understand why and how cooperation occurs in supply chains with the presence of process improvement in upstream component production. An original equipment manufacturer (OEM) can purchase the component from either a non-competing supplier (NS) or a competing supplier (CS) that also sells substitutable products in the end consumer market. We demonstrate that without process improvement, cooperation does not exist. Two cases are considered in which process improvement is present: supplier-initiated investment and OEM-initiated investment.

4 - Effects Of Firm’s Structural Position In Its Value Network On Competitiveness And Complexity
Yang Yang, Assistant Professor, University of Texas at El Paso, El Paso, TX, United States
Competition is fluid and dynamic, so firms must constantly create temporary advantages by frequently launching various competitive actions to sustain their competitive advantage. While research has shown that firms become increasingly dependent on their suppliers and customers to gain competitive advantage and has examined the impact of value network on firm performance (i.e., a result of a firm’s competitive actions), no study has investigated how value networks could directly affect a firm’s strategic competitive behavior. This study examines how firms’ structural characteristics in value networks influence their competitive behavior in respect of competitive aggressiveness.

VWA32
Virtual Room 32
Emerging Topics on Supply Chains and Platforms
Sponsored: MSOM/Supply Chain
Sponsored Session
Chair: Fang Xin, Singapore Management University
1 - Information, Inspection And Contract: A n Analysis O f C 2C E-commerce Platforms
Linqiu LI, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, China, Xin FANG, Yunfong LIM
We consider a customer-to-customer platform that serves as a marketplace and provides an inspection service. An individual, who may not be a professional seller and is uncertain about the quality of his product, sells the product through the platform to a buyer. The inspection service of the platform can detect whether the product is of low quality with a probability. We find that with the inspection, the equilibrium of the signaling game between the seller and the buyer is completely different from that without the inspection. The platform’s revenue is also larger with the inspection than that without the inspection.

2 - Mitigating Supply Disruption Risk With Endogenous Capacity Allocation Priority
Wenbin Wang, Shanghai University of Finance and Economics, Shanghai, 200433, China, Zhongzhong Jiang, Jiahua Zhang
This paper considers a supply chain where two manufacturers buys from a capacitated supplier. We design and compare different capacity allocation rules in mitigating the supplier’s disruption risk.

3 - Time-based Pricing at Grocery Stores? Transitioning Strategies under Retail Competition and Congestion Externalities
Xiaoyan Shao, University College London, School Of Man.
Gower Street, London, WC1E 6BT, United Kingdom, Christopher S. Tang, Onesun Steve You
We examine whether (and, if so, how) retailers selling essential items (e.g., groceries) should transition to time-based pricing, or charging higher prices during peak hours in order to smooth demand and reduce the store congestion experienced by consumers. We incorporate consumers’ congestion disinutility in a two-stage dynamic game between two retailers. We find that, when the retailers are myopic, both choose an “immediate transition”; this choice does not affect consumer welfare. Otherwise, depending on the extent of retailer myopia and of consumers’ aversion to congestion, there can be an equilibrium where both retailers choose a “cautious transition”, or when one chooses an “immediate transition” while the other chooses a “cautious transition”; each of these equilibria may be detrimental to consumer welfare.
4 - Incentivizing Farmer Adoption Of Agri-technology Products
Xiao Tan, Washington University in St. Louis, St. Louis, MO, 63130, United States

With the development of agriculture technology, new agri-technology products like UAV help farmers with seeding and fertilizing. However, it is of highrisk and uncertainty to use these products. We characterize farmers’ behaviors in equilibrium when they engage in Cournot competition. Also, we study the firm’s optimal effort and price regarding farmers’ behaviors. The government may able to subsidize farmers or the firm. Our analysis will show which player should be subsidized under certain conditions.

■ VWA33
Virtual Room 33
Supply Chain Management IV
Contributed Session
Chair: Babiche Aerts, Antwerpen, 2060, Belgium

1 - Contingency Planning For Combined Adaptation Of Healthcare And Commercial Supply Chains For A Pandemic Response
Oleg Gusikhin, Ford Motor Company, Dearborn, MI, United States, Xingyu Li, Dmitry Ivanov, Kathryn E. Stecke

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

2 - The Choice Of Agricultural Cooperation Model In The Poverty Alleviation Supply Chain:contract Farming Vs Live Commerce
Zigonc Cai, South China University of Technology, Guangzhou, China, Fei Ye

This article studies two agricultural models for cooperation between the farmer and e-commerce: contract farming (CF) and live commerce (LC). Under CF, e-commerce determines the contract price of crops, and the farmer produce according to the contract price. Under LC, the farmer directly sells crops online through the e-commerce platform to the market, and the e-commerce collects a certain platform commission from the farmer. In the model, the e-commerce actively assumes the corporate social responsibility of poverty alleviation and receives government subsidies.

3 - Coordination Strategy For An Eco-friendly Three-level Textile Supply Chain
Arnab Bisi, Associate Professor, Johns Hopkins Carey Business School, Baltimore, MD, United States, Arnab Adhikari

The design of a multi-level eco-friendly textile supply chain remains an interest for scholars. Existing scholarly works mostly incorporate a two-level apparel manufacturer-retailer setting. It motivates us to depict a multi-level eco-friendly textile supply chain using a three-level setting that comprises a textile firm, an apparel manufacturer, and an apparel retailer. We demonstrate the collaboration of textile supply chain members using greening cost-sharing, profit-sharing, and two-part tariff contracts. We propose a contract selection framework for greening quality, pricing, and supply chain member’s profitability. Also, we devise the coordination mechanism.

4 - Multi-echelon, Multicommodity Supply Chain Design With Uncertain Demand From A Climate Change Mitigation Perspective
Reza Alizadeh, University of Oklahoma, Norman, OK, United States, Janet K. Allen, Farrokh Mistree

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

5 - Modeling And Solving The Replenishments Of The Forward Area For A B2C Warehouse In Order To Minimize Stock Outs
Babiche Aerts, University of Antwerp, Antwerp, Belgium, Trijntje Cornelissen,
Kenneth Sorensen

In a B2C e-commerce warehouse where inventory is split over a reserve and forward area, replenishments to the forward area are crucial to avoid stock outs. Replenishments keep warehouse operations up and running, but despite their critical role, the planning of replenishments orders is studied to a minor extent. We present and solve a mathematical model for this replenishment problem, that allows to include different inventory policies, and takes into account limited replenishers and restricted replenishment time. For larger instances, we propose a heuristic approach. Preliminary results are discussed for different target stocks, replenishment levels and resource availability.

■ VWA34
Virtual Room 34
Economic and/or Environmental Implications of Innovative Business Models

Sponsored: MSOM/Sustainable Operations

Sponsored Session
Chair: Safak Yucel, Georgetown University, Washington, DC, 20057, United States

1 - Reducing Food Waste In The Food Service Industry
Feng Tian, Ross School of Business, University of Michigan, Ann Arbor, MI, 77305, United States, Ekaterina Asialikhina

Food waste is a global environmental problem that spans many industries including food service. We build a stylized model of a firm that serves consumers who decide on the amounts of food to buy in the presence of demand uncertainty. We identify key determinants of food waste and suggest potential solutions that lead to lower waste.

2 - Wastewater Recycling Capacity Investment In Urban Water Management
Qian Luo, Singapore Management University, Singapore, Singapore, Onur Boyabatli, Buket Avci

Wastewater plays a pivotal role in water sustainability by closing the urban water cycle and serving as another water source. This paper investigates a wastewater recycling capacity optimization problem considering rainfall and recycling cost uncertainty. We formulate the water utility’s decisions as a two-stage stochastic problem and characterize the optimal water allocation schemes and the optimal recycling capacity. We also conduct sensitivity analysis to investigate the impacts of rainfall and recycling cost variabilities their correlation on the optimal expected cost and recycling capacity. In this paper, we also conduct a case study using publicly available data to calibrate the model and conduct extensive numerical analysis to complement the analytical results.

3 - Design Of Electricity Demand-response Programs
Vishal Agrawal, Georgetown University, Washington, DC, 20057, United States, Safak Yucel

Demand-response programs incentivize customers to reduce their electricity demand as compared to a baseline when utility firms face unusually high electricity demand and procurement cost. We investigate how the existence of the baseline affects demand-reduction decisions by customers, and in turn, the design of demand-response programs by utility firms.

4 - A Dynamic Structural Model Of Renewable Energy Investment
Seyed Amin Seyed Haei, Clemson University, Clemson, SC, United States, Ahmet Colak, Safak Yucel

In this study we look at investments in renewable energies from the dynamic structural modeling lens. We focus on one of the California’s electricity market clean energy program (i.e., Renewable Portfolio Standard), that is the most ambitious program across the United States. We evaluate how this program may influences firms’ strategic decisions such as market entry/exit, and capacity adjustments.
1 - Estimating The Value Of Concentrating Solar Power Under New Costs Paradigm

Kehinde Abiodun, Colorado School of Mines, Golden, CO, 80401, United States

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

2 - Experience Curves And The Relatedness Of Technologies: Offshore And Onshore Wind Energy

Christian Hernandez-Negron, University of Massachusetts-Amherst, Amherst, MA, United States, Erin Baker, Anna Goldstein

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

3 - Multistage Adaptive Robust Optimization For The Management Of Hydroelectric Resources

Marcel Favreau, Pontificia Universidad Catolica de Chile, Santiago, Chile, Alvaro Lorca

The problem of hydrothermal scheduling seeks to use the water stored in reservoirs throughout time efficiently. This problem has been typically approached through multistage stochastic programming models that minimize the total expected operational cost over the planning horizon. We propose a multistage adaptive robust optimization model that minimizes the hydrological worst-case cost. To solve this model, we propose an efficient formulation based on full affine policies and vector autoregressive models to represent the hydro inflows uncertainty. Our experiments show the proposed model’s efficiency for large-scale systems and the reliability that robust optimization models deliver.

2 - Hierarchical Parametric And Semi-parametric Bayesian Modeling Of Electric Outages

Luis J Novoa, Assistant Professor, James Madison University, Harrisonburg, VA, United States, Atilla Ay, Refik Soyer, Goran Vojvodic, Babak Zafarli

When an electric outage occurs, it is important for utility companies to identify which device(s) failed and estimate repair times. This impacts the development of prevention policies and crew scheduling. We develop hierarchical parametric and semi-parametric bayesian models to assess the reliability of different devices in a power system and provide probabilistic statements about the reliability of each device as well as the overall power system, while considering different weather scenarios.

3 - Assessing Wildfire Hazards Around Electric Grids

Fernando Marianno, IBM, Yorktown Heights, NY, United States, Wang Zhou, Levente Klein, Ildar Khabibrakhmanov, Rui Zhang, Johannes Schmid

Sparks generated by power lines touching vegetation often cause wildfires, and thus a continuous wildfire hazard assessment around electric grids is needed. Infrared signatures from satellites can identify fire events in near real time. We present a data and physical-model driven framework to assess dynamic wildfire hazards around electric grids. The framework, which accounts for terrain, available fuel, vegetation, and weather, continuously processes massive amounts of data that drive the physical and hazard models. The framework enables continuous calculation of the minimum distance between the wildfire location and power lines and proposes operational actions under extreme conditions.

4 - Predictive Analysis Of Green-ness Of U.S. Congress Members Using Machine Learning Techniques

Jiayu Fan, Clark University, Worcester, MA, United States, Jie Bian, Yue Gao

The League of Conservation Voters (LCV) tracks the voting records of Congress members on environmental issues in its National Environmental Scorecard. It is a nationally accepted index used to rate the ‘green-ness’ of U.S. congress members. In this study, we use a longitudinal sample over a 44-year period and employ machine learning methods to predict senators’ LCV Scores, including nonlinear models, random forest, and XGBoost. The results demonstrate that Party affiliation, presidential election voting, the percentage of college-educated, and unionization rate have the most significant effects on the LCV scores. We discuss implications for policymakers, firms, and residents as well.

5 - Power-to-X: Evaluating Commodities For Long-duration Storage

Rebecca Ciez, Purdue University, West Lafayette, IN, United States, rceiez@purdue.edu

Further incorporating the industrial sector into a net-zero emissions electricity system may also present opportunities to use commodities as an energy storage resource: by adjusting production based on seasonal electricity patterns and by consuming commodities themselves to produce energy. Here, we combine historical trends in commodities manufacturing capacity utilization and electricity demand in a two-stage optimization framework to construct and dispatch electricity and commodity production for a zinc processing facility.

1 - Predictive Multi-microgrid Generation Maintenance, Formulation And Impact On Operations & Resilience

Farnaz Fahlahri, GRA, Wayne State University, Detroit, MI, United States, Murat Yildirim, Jeremy Lin, Caisheng Wang

This work proposes a framework that builds a seamless integration between sensor data and operational & maintenance (O&M) drivers in a multi-microgrid setting and demonstrates the value of this integration for improving multiple aspects of microgrids operations. The framework offers an integrated stochastic optimization model that jointly optimizes O&M. Operational uncertainty from renewables, demand, and market prices are modeled through scenarios. We use the model structure to develop a decomposition-based solution algorithm to ensure computational scalability. The model provides significant improvements in terms of reliability, costs, generation availability, & resilience.

1 - Sources Of Uncertainty In Long-term Global Scenarios Of Solar Photovoltaic Technology

Evelina Trutnev, University of Geneva, Renewable Energy Systems, Geneva, Switzerland, Marc Jaxa-Rozen

The deployment of solar photovoltaic (PV) technology has consistently outpaced expectations over the past decade. However, long-term prospects for PV remain deeply uncertain, as recent global scenarios span two orders of magnitude in installed PV capacity by 2050. Here we systematically compile an ensemble of 1,550 scenarios from peer-reviewed and influential grey literature, including IPCC and non-IPCC scenarios, and apply a statistical learning framework to link scenario characteristics with foreseen PV outcomes. We show that a large portion of the uncertainty in the global scenarios is associated with general features such as the type of organization, energy model and policy assumptions, without referring to specific techno-economic assumptions. IPCC scenarios consistently project lower PV adoption pathways and higher capital costs than non-IPCC scenarios.

VWA36

Virtual Room 36

Environment, Energy, and Natural Resources I

Contributed Session

Chair: Rebecca Ciez, Murrysville

1 - Predictive Multi-microgrid Generation Maintenance, Formulation And Impact On Operations & Resilience

Farnaz Fahlahri, GRA, Wayne State University, Detroit, MI, United States, Murat Yildirim, Jeremy Lin, Caisheng Wang

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2 - Determinants Of Uncertain Regional Technological Transitions In Global Decarbonisation Scenarios

Pei-Hao Li, University College London, Energy Institute, London, United Kingdom, Dave Pye, IPCC

IPCc collated numerous global decarbonisation pathways to gain insights into how to reach the Paris Agreement targets. However, only simple descriptive statistics are applied to show the uncertain energy transitions at the global level in their reports. Influences of key determinants on regional technological transitions have not been systematically investigated to date. Thus, this study intends to fill the research gap by identifying key determinants of uncertain regional transitions in the global transition scenarios with machine learning techniques. Spectral Clustering will determine technological transition archetypes at the regional level. The Random Forest algorithm will then identify the key determinants of the regional transitions. Finally, policy implications for regional energy transitions will be drawn from the identified determinants.

3 - Net Zero-emission Pathways Reduce The Physical And Economic Risks Of Climate Change

Laurent Drouet, RFF-CMCC European Institute on Economics and the Environment (EEE)

Mitigation pathways exploring end-of-century temperature targets entail varying degrees of temperature overshoot. The intertemporal consequences of overshoot have been typically evaluated from the point of view of mitigation. Here, we provide an assessment of the benefits of limiting overshoot via an ensemble of integrated assessment models. We compute physical and macroeconomic probabilistic indicators of temperature overshoot pathways. Temperature overshooting affects the full distribution of many critical physical impacts, such as those associated with heat extremes. We show that limiting overshoot reduces risk in the right tail of the distribution, in particular for low-temperature targets such as 1.5°C.

4 - Clustering Performance and Feasibility Metrics of 2°C Scenarios

Giacomo Marangoni, Politecnico di Milano, Milano, 20156, Italy, Massimo Tavoni

What are climate mitigation strategies that perform well across a multitude of performance metrics and against a wide range of plausible alternative futures? Here, we take a large ensemble of available 2°C-consistent climate-energy-economy scenarios and derive from the underlying data a representative set of prototypical pathways towards climate stabilization. We extract and select the most informative features from the variables describing the scenarios and cluster them following multiple approaches to reach a parsimonious, yet exhaustive and most informative features from the variables describing the scenarios and cluster them following multiple approaches to reach a parsimonious, yet exhaustive and robust, representation of the several ways to decarbonize our economy. We focus on a variety of metrics which cover technological, environmental, economic, land-use and energy demand dimensions, and identify solutions that balance all the metrics of interest well under multiple socio-technical assumptions.

2 - Fitted Q-iteration For Network-Safe Demand Response

Antoine Lesage-Landry, Polytechnique Montréal, Montréal, QC, Canada

We use the fitted Q-iteration (FQI) algorithm and historical grid measurements to compute a network-safe control policy. We compare our method to a greedy, grid-agnostic approach in a case study using real load profiles. The average cumulative loss reduction and tracking root mean square error are 48% and 0.093 for FQI, compared to the grid-agnostic approach.

5 - Interdiction Of Wildlife Trafficking Supply Chains: An Analytical Approach

Bürç B. Keskin, University of Alabama, AL, 35406-4062, United States, Bistra Dilkina, Aaron Ferber, Emily Barbee, Oakley Prell

Illicit Wildlife Trafficking (IWT) has a negative impact on the environment and communities, enabling the spread of diseases, land degradation, and biodiversity loss. IWT is a global issue, with almost 6,000 different species seized since the 90s and expanding to more than 150 countries. Traffickers operate complex and dynamic networks that require detailed strategies to disrupt. We model disrupting these networks as a network interdiction problem where authorities seek to interdict along specific routes to reduce the trafficker’s profitability and force any resulting geographical displacement to be as costly as possible. We characterize the observed and available data in IWT, modeling assumptions, and network interdiction formulations that apply to this complex setting, and we evaluate the proposed methods in the context of global air travel networks.
3 - Learning To Control In Power Systems: Design And Analysis Guidelines For Concrete Safety Problems

Patricia Hidalgo-Gonzalez, University of California, San Diego

Rapid progress in machine learning and artificial intelligence has brought attention to its applicability in power systems for new forms of control that help integrate higher levels of renewable generation and address increasing levels of uncertainty and variability. In this work we discuss these new applications and shine light on the most relevant new safety risks and considerations that emerge when relying on learning for control purposes in electric grid operations. We build on recent taxonomical work in AI safety and focus on four safety problems. We draw on two case studies, one in frequency regulation and one in distribution system operations, to exemplify these problems and show mitigating measures. We then provide general guidelines to help people working on integrating learning capabilities for control purposes to make safety risks a central tenet of design.

4 - A Model-Based Reinforcement Learning Approach For Controlling Smart Buildings Integrating Renewable Energy Resources

Ehsan Rezaei, PhD Student, Polytechnique Montréal, Montréal, QC, Canada; Vincent Tahiti, PhD Student, Concordia University, Montreal, QC

Due to the limitations of classical identification and control approaches, the optimization of thermal behavior of buildings is one of the main challenges towards the implementation of smart buildings. In recent years, reinforcement learning (RL) has gained great popularity to solve some of these issues. In this work, we present a model-based RL method to minimize the power consumption of a building integrating PV system and battery while preserving thermal comforts of its occupants. In this approach, a nonlinear model can be efficiently learned from observations. This approach makes the planning more efficient than model-free RL methods. The model-based RL agent is then used to control building’s systems in a simulated environment to assess the efficiency of control. Due to its last training process, the proposed model-based RL can be used for real-time applications.

5 - Deep Statistical Solvers

Balhazar Donon, RTE

We introduce Deep Statistical Solvers (DSS), a new class of trainable solvers for optimization problems. The idea is to learn a solver that generalizes to a given distribution of problem instances. This is achieved by directly using as loss the objective function of the problem, as opposed to most previous Machine Learning based approaches, which mimic the solutions attained by an existing solver. Though both types of approaches outperform classical solvers with respect to speed for a given accuracy, a distinctive advantage of DSS is that they can be trained without a training set of sample solutions. Focusing on use cases of systems of interacting entities (e.g. power systems, discretized PDEs), the proposed approach is instantiated within a class of Graph Neural Networks. We experimentally validate the approach on linear problems and non-linear AC grid power simulations.

■ VWA40

Virtual Room 40

Data-Driven Analytics for Future Electricity Systems

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Ali Darapour, Princeton University, NJ, United States

1 - Machine Learning for Determining Optimal Load-following Reserve Requirements in Systems With High Shares of Variable Renewable Electricity

Mauricio Hernandez, PhD Student, Duke University, Durham, NC, 27708, United States; Ali Darapour, Elnaz Daraji Pour, Dalia Patino-Echeverri, Xiaoqiong Zhang

Cost-effective integration of large shares of VRE requires grid assets to meet the necessary load-following capability (LFC) requirements. Multiple studies propose using stochastic unit commitment models to identify time-varying load-following needs dynamically. Although this approach effectively determines optimal targets, its computational complexity prevents it from being used in large-scale grids. This study proposes a machine learning approach that maps the system’s operating conditions and the required LFCs to ensure cost-effective integration of VRE. It uses the Electricity Market Simulation Tool to identify necessary LFC for a scaled version of PJM under different conditions.

2 - Lyapunov-regularized Reinforcement Learning For Power System Transient Stability

Wenqi Cui, University of Washington, Seattle, WA, United States; wynqicui@uw.edu, Baowen Zhang

Transient stability of power systems is becoming increasingly important with the growing integration of renewable resources. Their power electronic interfaces can implement almost arbitrary control laws, which provide increased flexibility in frequency responses. To design optimal non-linear policy for these controllers, reinforcement learning (RL) has emerged as a powerful method. A key challenge is to enforce that a learned controller must be stabilizing. This paper proposes a Lyapunov regularized RL approach for optimal frequency control for transient stability in lossy networks. Because the lack of an analytical Lyapunov function, we learn a Lyapunov function parameterized by a neural network. The learned Lyapunov function is then utilized as a regularization to train the neural network controller by penalizing actions that violate the Lyapunov conditions.

3 - Grid-aware Learning For Distribution System Modeling And Monitoring

Shanny Lin, University of Texas at Austin, Austin, TX, United States, Hao Zhu

Feeder modeling aims to estimate the network line parameters from fast nodal samples based on a linearized model, while the goal of monitoring is to enhance the observability of grid-edge resources by utilizing heterogeneous types of data. To address the limitation of data availability, both learning problems have leveraged unique spatio-temporal characteristics of residential loads and resources to improve the solution effectiveness.

4 - Enforcing Policy Feasibility Constraints Through Differentiable Projection For Energy Optimization

Bingqiong Chen, Carnegie Mellon University, Pittsburgh, PA, United States; Priya Doni, Kyri Baker, J. Zico Kolter, Mario Berges

Real-world applications of reinforcement learning (RL) are limited due to the fact that the actions from such learned policies may not be feasible or safe. In this work, we propose a method, PROF, to integrate convex operational constraints into RL frameworks. Specifically, we incorporate a differentiable projection layer within a neural network-based policy to enforce that all learned actions are feasible. We then update the policy end-to-end by propagating gradients through this differentiable projection layer, making the policy cognizant of the operational constraints. We demonstrate our method on two applications: energy-efficient building operation and inverter control.

5 - Machine Learning Approaches To The Unit Commitment Problem

Yafei Yang, Stevens Institute of Technology, Hoboken, NJ, United States, Lei Wu

With the growing scale and complexity of modern power grids, it becomes more complicated to accurately formulate the physical power system and more difficult to efficiently solve the corresponding UC problems. As a matter of fact, plenty of historical power system operation records, as well as real-time data, could provide useful information and insights into the underlying power grid. To this end, machine learning methods could be valuable to help understand the relationship of UC performance to power system parameters, reveal the rationality behind such relationship, and finally address UC problems in a more efficient and accurate way. This talk discusses the current practices, challenges, and promising strategies of adopting machine learning approaches to effectively solve the mixed-integer linear programming-based UC problems.

■ VWA41

Virtual Room 41

mpi-sppy: Asynchronous Optimization under Uncertainty

Sponsored: Computing Society

Sponsored Session

Chair: David Woodruff, University of California Davis, CA, United States

1 - Asynchronous Projective Hedging: Introduction, Implementation, And Large-scale Computational Experiments Using mpi-sppy

Jean-Paul Watson, Senior Research Scientist, Lawrence Livermore National Laboratory, Livermore, CA, United States; David L Woodruff, Jonathan Eckstein, Bernard Knueven

We describe a scenario-based decomposition algorithm - Asynchronous Projective Hedging, or APH - for multistage stochastic programming that resembles the progressive hedging method of Rockafeller and Wets, but is capable of asynchronous parallel operation without sacrificing theoretical convergence in the convex case. Perhaps more importantly, each iteration of the decomposition method may process only a subset of the possible scenarios. We discuss the implementation of APH in the mpi-sppy parallel library for stochastic programming, and detail large-scale computational experiments highlighting both the effectiveness of APH and the scalability (to tens of thousands of ranks) of mpi-sppy.

17
developm ent practice in O R, reveal the relationship of the O R scholars w ith arithmetic and exact iterative m ethods. 

showing that they outperform  the alternate exact approaches of rational-

sppy softw are and solved in parallel using progressive hedging on the National 

modifications. O ur m ulti-stage stochastic m odel is im plem ented using the mpi-

fully exact solutions. T his talk presents a fram ew ork to exactly solve sparse linear 

overview  design and perform ance considerations related to bounds and 

other optim ization problem s. Exactly solving linear program s and system s is 

operate exclusively in double precision; applications w here m ore precision is 

m obility betw een the airport and the surrounding city of D allas. U sing scalable 

the critical infrastructure at Dallas Fort Worth (DFW) Airport which influences 

m obility at the critical infrastructure at Dallas Fort Worth (DFW) Airport which influences 

m obility between the airport and the surrounding city of D allas. Using scalable 

method that can leverage HPC resources we have developed a multi-stage stochastic infrastructure expansion m odel for determining parking and curb 

modifications to the DFW Airport over a 20-year horizon. Additionally, we have 

explored the impacts of congestion pricing in conjunction with infrastructure modifications. Our multi-stage stochastic model is implemented using the mpi-

software and solved in parallel using progressive hedging on the National Renewable Energy Laboratory’s HPC system Eagle. In this talk we present results from solving this model at scale.

3 - Bounds And Confidence Intervals In Mpi-sppy
David L. Woodruff, University of California-Davis, Davis, CA, 95616, United States, dl Xiaoqiu Chen, Bernard Knueven, Jean-paul Watson

mpi-sppy (https://github.com/Pyomo/mpi-sppy) is a softw are package to allow 

for optimization of Pyomo optimization models uncertainty. In this talk we will 

overview design and performance considerations related to bounds and confidence intervals. Particular attention will be paid to issuesassociated with 

problems that have more than two stages and scenarios that do not exhibit stage-

wise independence.

■ VWA42
Virtual Room 42
Computer Science - Applications to OR

Contributed Session
Chair: Arjun Balasangim, Massachusetts Institute of Technology, Cambridge, MA

1 - Exactly Solving Linear Systems via The Sparse Exact (SPEX) Framework: History and Theoretical Foundation
Erick Moreno-Centeno, Texas A&M University, College Station, TX, United States, Christopher Lourenco

Solving sparse linear systems has a central role in solving linear programs and other optimization problems. Exactly solving linear programs and systems is 

necessary for some applications (e.g., theoretical results, feasibility problems, military applications, applications with hefty costs, ill-conditioned problems, etc.). To address this, we are developing the Sparse Exact (SPEX) Factorization Framework: a high-performance, well-documented, and extremely robust softw are package. This talk will focus on the history and the theoretical 

foundations of the package, and a companion talk by Christopher Lourenco will focus on the recent developments and computational results.

2 - Exactly Solving Linear Systems via the Sparse Exact (SPEX) Framework: Moving Towards Exact Optimization
Christopher Lourenco, Assistant Professor, US Naval Academy, Annapolis, MD, United States, Erick Moreno-Centeno

Solving sparse linear systems, via LU, Cholesky, and other factorizations, is a 

fundamental subroutine in mathematical programming. Though most solvers 

operate exclusively in double precision; applications where more precision is 

needed are increasingly forcing solvers to move towards quad precision or even 

fully exact solutions. This talk presents a framework to exactly solve sparse linear 

systems like those in mathematical programming. Our presented algorithms 

operate exclusively in integer-arithmetic and we provide computational results 

showing that they outperform the alternate exact approaches of rational-

arithmetic and exact iterative methods.

3 - A Study of Software Development Practice in Operations Research
Mestur Yavuz, University of Alabama, Tuscaloosa, AL, United States, Huseyin Ergin

Software is a crucial part of operations research (OR). In this talk, we present the 

results of two studies. The first explores all papers published in INFORMS Journal 

on Computing in the 5-year window (2016-2020) and the second one is a survey of 

389 OR scholars. The results shed light on the current state of software 

devlopment practice in OR, reveal the relationship of the OR scholars with 

research software, and present the expectations and concerns of them regarding 

code and data sharing practices.

4 - Throughput-fairness Tradeoffs in Mobility Platforms
Arjun Balasangim, Massachusetts Institute of Technology, Cambridge, MA, United States, Karthik Gopalakrishnan, Radhika Mittal, United States, Mohammad Alizadeh, Hamsa Balakrishnan, Hari Balakrishnan

We study the problem of scheduling, routing, and allocating tasks from different 
customers to vehicles in shared mobility platforms (e.g., food and package delivery, ridesharing, and mobile sensing). We introduce Mobius, a system that uses 
guided optimization to navigate the inherent tradeoffs between fairness and 
throughput caused by shared mobility. Mobius supports spatiotemporally diverse 
dynamic customer demands. Our evaluation demonstrates these properties, 

along with the versatility and scalability of Mobius, using traces gathered from 
ridesharing and aerial sensing applications.

■ VWA43
Virtual Room 43
Learning and Equilibria
Sponsored: Auctions and Market Design
Sponsored Session
Chair: John Dickerson, University of Maryland, College Park, MD, United States

1 - Using Inverse Optimization To Learn Cost Functions In Generalized Nash Games
Stepphanie Allen, University of Maryland-College Park, College Park, MD, 20782-1159, United States

As demonstrated by Ratliff et al. (2014), inverse optimization can be used to 

recover the objective function param eters of players in multi-player Nash games. These games involve the optimization problems of multiple players in which the players can affect each other in their objective functions. In generalized Nash equilibrium problems (GNEPs), a player’s set of feasible actions is also impacted by the actions taken by other players in the game. One example of such an impact comes in the form of “coupled constraints” as referenced by Rosen (1965), Harker (1991), and Facchinei et al. (2007) which involve the other players’ variables in some of the constraints of a player’s feasible region. We extend the framework of 

Ratliff et al. (2014) to find inverse optimization solutions for this class of GNEPs. We validate our formulation on a simulated multi-player transportation problem.

2 - Tâtonnement beyond Constant Elasticity of Substitution
Denizalp Goktas, Brown University, Providence, RI, United States, Amy Greenwald, Enrique Areyn

We propose a new convex program that generalizes the dual of the Eisenberg- 

Gale program from the special case of utilities that satisfy constant elasticity of 
substitution (CES) to arbitrary continuous, concave, homogeneous utility functions. The main tools that enable this extension are the dual concepts of 

expenditure minimization and indirect utility maximization functions, which 

provide an intuitive interpretation of the dual of the Eisenberg-Gale program, 

which to our knowledge was not yet well understood. Additionally, we show that 

solving any quasilinear Fisher market can be reduced to solving a linear Fisher 

market, allowing known results for linear Fisher markets to be applied to 

quasilinear Fisher markets. We further show that solving our convex program 

with centralized gradients is equivalent to computing the equilibrium 

prices of a Fisher market via tâtonnement. This result allows us to establish the 

existence of the discrete tâtonnement process at a rate of O(1/t) for Fisher 

markets with continuous, strictly concave, homogeneous (CSCH) utility functions representing locally non-satiated preferences—a class of utility functions beyond the class of CES utility functions, the largest class for which convergence results 

were previously known. CSCH Fisher markets include nested and mixed CES Fisher markets, thus providing a meaningful expansion of the relevant space of Fisher markets that is solvable via tâtonnement.

3 - The Survival Of The Strictest In An Uncertain World: Stable And Unstable Equilibria Under Regularized Learning With Partial Information
Emmanouil Vasilios Vlatakis Gkaragkounis, PhD Candidate, Columbia University, New York, NY, United States

Understanding the Nash equilibrium convergence properties of no-regret learning 
general N-player games is a fundamental question in online learning and game 
theory. In this talk, we focus on the archetypal “follow the regularized leader” (FTRL) family of algorithms, and we consider a wide spectrum of uncertainty that 

the players may encounter - from noisy, oracle-based feedback to bandit, payoff-

based information. We present a succinct equivalence between the stability of a 

Nash equilibrium and its support: A Nash equilibrium is stable if and only if 

with arbitrarily high probability if and only if it is strictly pure (i.e., each equilibrium strategy has a unique best response). This talk is based on joint works with P. Mertikopoulos (InRIA), A. Giammou (Univ.Wisconsin) and L. Flokas (Columbia Univ.), T. Lianes (NTUA), G. Pilouras (SU TD)
2 - Visualizing The Intellectual Structure Of The Impact Of COVID-19 On E-learning
Hyae jung Lim, Kyungpook National University, Daegu, Korea, Republic of, Chang-Kyo Suh
E-learning platforms developed enormously over time since the appearance of the Internet. However, COVID-19 pandemic made the ways of e-learning change on another level. This study intended to explore the visualization of the intellectual structure of the e-learning field concentrated on the appearance of the COVID-19 pandemic using CiteSpace (Chen, 2017). In this research, we collected the articles through the Web of Science on e-learning field related to the COVID-19 crisis. We analyze the references of the papers through author-co-citation analysis. Then, we classify the major research domains and characteristics. The results and interpretation will be further discussed in the conference.

3 - A Study On Online Platform Customer Journey And Channel Management With Data Analytics And Deep Learning
Tzu-Chien Wang, National Taiwan University, Taipei, Taiwan, Chialin Chen, Ruey-Shan Guo
In the IoT era, customer journey analysis enables better understanding of customers’ behaviors and interactions with an online platform. In this study, we utilize data analytics and deep learning to analyze customer journey on an online financial platform with a three-stage procedure. In the first stage, we perform cluster analysis to construct a user characteristic behavior model. In the second stage, we apply convolutional neural network and long short-term memory methods to predict customers’ subsequent behaviors and the target conversion value. In the third stage, binary differential evolution is used to solve channel planning and revenue optimization problems under budget constraints.

4 - Enhancing Object Detection Using Wisdom Of The Crowd
Joshua Grassel, Arizona State University, Tempe, AZ, United States, Romana Yasmin, Adolfo Raphael Escobedo
Aggregating multiple human judgments to reach an informed decision that is superior to any individual’s judgment is known as the wisdom of the crowd. An area of study where this concept has received little attention is object detection. In this research, we define an approach to classify images by crowdsourcing object detection judgments. Participants evaluate an image through multiple methods of elicitation, whose responses are then aggregated using computational social choice and machine learning methods. The aggregation algorithms are customized to increase accuracy or reduce false negative (or false positive) rates.

5 - Extensions On Antminer Algorithms For Rule-based Classification
Sayed Kaes Maruf Hossain, PhD Candidate, New Mexico State University, Las Cruces, NM, United States, Sajia Afrin Ema, Hansuk Sohn
In this research, we have suggested multiple extensions on the AntMiner algorithms for rule-based classification. Firstly, we incorporated a strategy to dynamically balance the weight of exploration and exploitation during the rule discovery process. Secondly, we have suggested a probabilistic approach to improve the existing exhaustive rule pruning procedures. Thirdly, we performed a modular analysis to explore how the algorithm behaves for a range of probability functions. The early experimental results show competitive results for the proposed strategies as compared to others.

INFORMS Anaheim 2021
2 - Equilibrium Existence in a Limited Participation Economy
Kim Weston, Rutgers University, Piscataway, NJ, United States
A limited participation economy models the real-world phenomenon that some investors have access to more of the market than others. Basak and Cocco (1998) introduced a continuous-time, running consumption model of limited participation with two (classes of) investors: an unconstrained investor with access to a complete market, and a constrained investor who cannot trade in the stock market and faces incompleteness. Equilibrium existence results have so far been limited to considering logarithmic constrained investors, in part due to the complications that arise with an endogenously-determined stochastic interest rate. In this talk, I will discuss an extension of Basak and Cocco's model to the case of exponential investors. Equilibrium is described by a coupled system of semilinear PDEs, where the ratio of the presence of a traded annuity that is accessible to both the constrained and unconstrained investors. The equilibrium existence proof is based on Banach's fixed point theorem in Holder spaces.

3 - Disagreement And Control Rights: Implications For Debt Policy And Aggregate Dynamics
Steven D. Baker, University of Virginia, Charlottesville, VA, United States, Zhaohe Chen, Timothy C Johnson
We examine firm capital structure when heterogeneous agents optimally hold different claims, and control of the firm may change hands. When agents cannot commit to firm value maximization, controlling agents have the incentive to alter firm policy to maximize their preferred portfolio at the expense of other claim-holders. We consider settings that can include partial control rights to minority share-holders and/or debt-holders. In general equilibrium, the distortions relative to complete contracting are large even with small disagreement. However, it need not be the case that the distortions amplify the business cycle nor that stronger protection of debt holders mitigates the problem.

4 - Rogue Traders
Huayuan Dong, Dublin City University, Dublin, Ireland, Paolo Guasoni, Eberhard Mayerhofer
Investing on behalf of a firm, a trader can feign personal skill by committing fraud that with high probability remains undetected and generates small gains, but that with low probability bankrupts the firm, offsetting ostensible gains. Honesty requires enough skin in the game: if two traders with isoelastic preferences operate in continuous-time and one of them is honest, the other is honest as long as the respective fraction of capital is above an endogenous fraud threshold that depends on the trader's preferences and skill. If both traders can cheat, they reach a Nash equilibrium in which the fraud threshold of each of them is lower than if the other one were honest. More skill, higher risk aversion, longer horizons, and greater volatility all lead to honesty on a wider range of capital allocations between the traders.

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3 - Efficiency and Competitiveness Evaluation of Medium-lift Launch Vehicle (MLV) Using Integrated DEA - TOPSIS Model
Rustam Ismatov, Master, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China, Xhen Wan, Huiyan Xu

Owing to the increasing launch demand and lack of satellite launch vehicles for commercial customers, the commercial launch market for transporting satellites into orbit by medium-lift launch vehicles (MLVs) is getting extremely popular and competitive. Understanding the efficiency and competitiveness of each MLV is particularly significant for countries who are planning to launch their own satellites. This paper presents a hybrid model that combines the data envelopment analysis (DEA) model, and technique for order performance by similarity to ideal solution (TOPSIS) to evaluate and then rank the efficiency and competitiveness of 19 MLVs that are currently operational in the world market.

4 - Best Possible Choice of Covid-19 Vaccines for Economically Weak Countries: Using AHP, TOPSIS and DEA Models
Binoy Barua, Master, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China, Muhammad Ayaz

As of March 2021, there are 308 candidate vaccines at various stages of development. As no single vaccine has yet been found to be the most efficient so a need for decision making exists especially for economically weak countries. In this work, we identified a total of 10 criteria and we chose seven alternatives (vaccines). We used three mathematical tools that belong to MCDM (Multi-criteria decision-making methods). The tools were - AHP, TOPSIS and DEA. Among the 10 criteria, 8 criteria were chosen for AHP and TOPSIS. The weights of the criteria were calculated using AHP. Then, we ranked the COVID-19 alternatives using the TOPSIS method. The DEA model was used to evaluate the performance of each vaccine basing on 7 criteria. The aim of combining TOPSIS and DEA was to determine the vaccines that perform well in both TOPSIS and DEA.

5 - Sequential Price Negotiations For Big-ticket Items: Empirical Discovery And Estimation Of Predetermined Strategies
Abdullah Gökçinar, PhD Candidate, The University of Texas at Dallas, Richardson, TX, United States, Metin Cakanyıldırım, Suleyman Karabük

We empirically analyze negotiations between the seller and buyer over the price of a big-ticket item. In a negotiation, the seller and buyer take turns to accept the other’s offer, make a concession from the previous offer, or exit. Empirical results suggest that a player makes concessions following a predetermined negotiation strategy towards a price, and he/she may accept or exit based on the other player’s offers. Following these, we analytically model negotiations to estimate negotiation strategies along with acceptance and exit probabilities. These estimations can help us in revealing latent negotiation characteristics in different player subpopulations.

3 - Management Of A Distribution System Subject To zSupply Disruptions
Kangyi Li, Lehigh University, Bethlehem, PA, 18015, United States, Lawrence V. Snyder

We study a periodic-review inventory system with a distribution system topology that is subject to supply disruptions. We assume that demand follows a Poisson process, each stage follows a base-stock policy and the allocation policy is first-come, first-served (FCFS). We propose two heuristics for this problem. Our heuristics combine a heuristic for serial systems subject to supply disruptions with the decomposition-aggregation (DA) heuristic for distribution systems without disruptions. We also consider the special case of a two-echelon distribution system and provide an explicit cost function using a “top-down” approach.

4 - Fairness Aware Dynamic Ridesharing
Xingyu Liu, Tsinghua University, Shenzhen, China, Minghua Chen, Wai Kin (Victor) Chan

In this work, the utility of each rider is computed by a nonlinear function of multiple factors. We formulate the problem into a mixed nonlinear integer programming, then we reformulate the proposed model with column generation. The pricing problem is solved by a polynomial-time algorithm. For the master problem, we develop a polynomial-time approximation method. The numerical experiments are conducted based on the NYC trip record. Results reveal that the proposed approach improves fairness significantly.

5 - AM Challenges in the Industry 4.0 Era
Yoher J Arteaga Irene, Tsinghua University, Shenzhen, China, Wai Kin (Victor) Chan

Additive Manufacturing (AM) technology could revolutionize the way industry makes products. However, there are still challenges that must be overcome since these are slowing down AM adoption by industry. Therefore, this research aims to uncover these limitations based on a systematic literature review. The findings show that there are five global challenges that AM is currently dealing with, technical aspects, supporting technologies, management of operations, supply chain configuration, and legal innovation.
4 - Limiting Average Variance Of A Markov Decision Process With Randomized Rewards
Andrew Benton, Rutgers University, New Brunswick, NJ, United States

We study the variance of the sum of rewards of a Markov decision process over an infinite horizon, focusing on problems with randomized rewards. Since this value is generally divergent, we focus on the limiting average variance. Closed forms are provided for the limiting average variance of finite unichain Markov chains with randomized rewards. Sufficient conditions for the convergence of the multichain problem are also discussed. These results are then applied in an inventory control setting. Finally, we formulate a linear programming solution to select the policy with minimal variance among expectation-optimal policies.

5 - Strengthening The Resilience Of Seaport Terminals For Disruption Management
Weimar Ardila, University of South Florida, Tampa, FL, United States, Alex Savachkin, Devashish Das, Daniel Romero

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

■ VWA52
Virtual Room 52
Business Analytics for Disaster Management
Sponsored: Social Media Analytics
Sponsored Session
Chair: Alfonso Pedraza-Martinez, Indiana University
1 - Business Analytics For Disaster Management: Research Opportunities And Challenges
Alfonso J Pedraza-Martinez, Indiana University, Kelley School Of Bus. Bloomington, IN, 47405-5308, United States, Lu (Lucy) Yan, Yu Kan

We discuss the state of the art of academic and practitioner business-analytics applications for disaster management. In doing so, we identify opportunities for future research in this area. Moreover, we present an empirical application that exemplifies our proposed agenda.

2 - The Role Of Volunteer Experience On Performance On Online Volunteering Platforms
Gloria Urrea, University of Colorado Boulder, Boulder, CO, 80303-1154, United States, Eunae Yoo

Online volunteering platforms allow humanitarian organizations (HOs) to recruit volunteers to work remotely on projects. We investigate the relationship between volunteers' experience levels and two performance metrics on these platforms: project completion and volunteer retention. To test these relationships, we collected a novel panel dataset from the Humanitarian OpenStreetMap Team Tasking Manager, on which volunteers contribute to mapping projects. Our dataset includes 5,162 online volunteering projects with 2,169,683 contributions by 96,450 volunteers. The results of our econometric analyses shed light on online volunteer management and offer operational insights for HOs as well as for online volunteering platforms.

3 - Does Gender Shape Organizers’ Charitable Crowdfunding Success?
Kristin Kelley, Research Fellow, WZB Berlin Social Science Center, Berlin, Germany, Jorge Mejia, Alfonso J. Pedraza-Martinez

Men raise more money for entrepreneurship on crowdfunding platforms due to their higher status. The perception that women are better at promoting the welfare of others should offset men's advantages in communal, female-dominated contexts like charitable crowdfunding. We analyze data from 120,677 charitable crowdfunding campaigns to examine this possibility.

4 - Inventory Pre-positioning Decision Support For Humanitarian Relief In Nepal
Jason Acimovic, Penn State University, University Park, PA, United States

Humanitarian organizations typically work independently to pre-position stock in countries in preparation for a disaster. This lack of coordination leads to gaps and overlaps. Working with the Emergency Supply Prepositioning Strategy Group (ESUPS), we utilize inventory data they collected from various NGOs working in Nepal to formulate and solve an optimization problem suggesting where inventory should go. From this, we and ESUPS developed a decision support tool to help guide local NGOs working in Nepal. We will talk about the experience of implementing optimization problem solutions in actual humanitarian organizations, and the status of the project.

■ VWA53
Virtual Room 53
Crowdfunding and Platform Economics in Social Media
Sponsored: Social Media Analytics
Sponsored Session
Chair: Zhen Fang, University of Washington, Seattle, WA, 98105, United States
1 - Bargaining-based Subsidy Payment Negotiations In Sponsored Data Programs
Jialin Song, Microsoft, Redmond, WA, 61801, United States, Qing Wang

Major Mobile Service Providers (MSPs) in U.S. have all introduced sponsored data programs that allow Content Providers (CPs) such as Facebook and Youtube to subsidize the data usage by consumers. The MSP and CP may need to negotiate the subsidy payment based on specific negotiation mechanism. We develop a model-based study to analyze different negotiation schemes. Specifically, we apply Nash bargaining theory to model the negotiation between a monopoly MSP and a set of CPs under the one-to-many bargaining framework. We analyze and compare two bargaining protocols: we build a multi-stage optimization model to solve the sequential bargaining problem, and apply Nash-in-Nash solution to solve the simultaneous bargaining problem. Our results show that the bargaining outcome leads to different welfare consequences under different bargaining protocols.

2 - Business Practice Of Social Media - Platform And Customer Service Adoption
Yang Gao, University of Rochester, Rochester, NY, 14611, United States, Shujing Sun, Huaxia Rui

Based on the full trajectory of 274 international airlines on Twitter, we propose a two-stage model to estimate the key drivers in the adoption of the platform and customer service on social media. Regarding peer influence, we show that firms pay close attention to their peers’ moves and act correspondingly, as a firm is more likely to adopt the technology when the extent of peers’ adoption increases. We also find evidence of knowledge spillover across firms, where firms are attracted by positive consumer voices but discouraged by negative voices following peers’ adoptions. Regarding consumer pressure, we find that higher volume and sentiment directed at the firm itself positively contribute to both adoption, only positive voices significantly contribute to customer service adoption.

3 - More Than Double Your Impact: An Empirical Study Of Match Offers On Charitable Crowdfunding Platforms
Zhen Fang, University of Washington, Seattle, WA, 98105, United States, Xue Tan, Shengsheng Xiao, Yong Tan

To promote charitable giving, charitable crowdfunding platforms adopted match offers, whereby leadership donors match the others' donations at a given rate. Our study seeks to understand how the suppliers (donors) evaluate projects with and without match offers differently, especially varying with their donation experience, and how the demanders (fundraisers) react to match offers. At an individual level, we find that, on average, donors derive a higher utility toward matched projects. Warm-list donors are three times more likely to contribute to matched projects, while cold-list donors are twice more likely to do so. New donors prefer unmatched projects. The market-level analysis shows that increasing the matched project ratio benefits both sides of the market. Our work connects micro-level and macro-level to disentangle the impact of match offers systematically.
1 - Designing Policies For Allocating Housing To Persons Experiencing Homelessness
Bill Tang, University of Southern California, Los Angeles, CA, United States, Phebe Vayanos, Cagil Kocyigit
We study the problem of allocating scarce housing resources of different types to individuals experiencing homelessness based on their observed covariates. Our goal is to leverage administrative data collected in deployment to design an online policy that maximizes mean outcomes while satisfying budget requirements. We propose a policy in which an individual receives the resource maximizing the difference between their mean treatment outcomes and the resource bid price, or roughly the opportunity cost of using a resource. Our approach has nice asymptotic guarantees and is easily interpretable. We evaluate it on synthetic and real-world Homeless Management Information System data to illustrate practical usage of our methodology.

2 - Analytics To Improve The United States Immigration System
Geri Louise Dimas, PhD Candidate, Worcester Polytechnic Institute, Worcester, MA, 01602-1915, United States, Andrew C. Trapp, Renata Alexandra Konrad, Adam Ferrarotti
The United States immigration court system is extremely backlogged with 1.3 million cases waiting to be heard. Due to large influxes of immigrants together with limited design and resources, the court system struggles to manage this growing backlog, resulting in delays that unnecessarily tax governmental and community resources. We explore the intricacies of the court system, deconstructing different elements and their respective complexity through discrete event simulation. We study possible improvements to the simulated system by adjusting its properties, such as the assignment of cases to judges, queueing discipline, hearing medium (in person, or remote), and priority queues.

3 - Reducing Vulnerability To Human Trafficking By Improving Access To Housing And Support Services
Yaren Bilge Kaya, PhD Candidate, Northeastern University, Boston, MA, 02130-0000, United States, Kayse Maass, Renata Alexandra Konrad, Andrew C Trapp, Geri Dimas
Exposure to trauma, violence, and substance use, coupled with a lack of community support services, puts runaway and homeless youth at high risk of being trafficked. Access to safe housing and supportive services such as healthcare and education is known to be an effective answer to youth’s vulnerability towards exploitation. However, in most communities in the U.S. the number of youths experiencing homelessness exceeds the capacity of the housing resources available. This study involves primary data collection and an integer linear optimization model to project the collective capacity required by service providers to adequately meet the needs of these vulnerable youth in NYC.

2 - Decision Support On Road Resurfacing Under Maintenance Cost Uncertainty
Zhuoyi Zhao, Iowa State University, Ames, IA, United States, yyzhao@iastate.edu, John Jackman, K. Jo Min
The maintenance cost of an asphalt road has been increasing on average and fluctuating over time. The decision-maker has an option to resurface the road after which the road condition is left unchanged. In this paper, assuming the maintenance cost follows a geometric Brownian motion process and is reset to the initial value upon resurfacing, we model and analyze resurfacing decisions from a real options perspective leading to optimal threshold maintenance costs and expected duration until resurfacing. We also investigate how key factors such as volatility impact the resurfacing decision through numerical examples. Finally, managerial insights and economic implications are provided.

3 - Inmate Overcrowding And Prison Operations: A Review
Ben Lewis, Research Fellow, University of Michigan, Ann Arbor, MI, United States
Overcrowding has been an ongoing issue in federal and state prisons for decades, and many US prisons are still operating over capacity despite efforts to reduce prison populations in the wake of COVID-19. This systematic literature review aims to 1) highlight the individual, group, and societal impacts of inmate overcrowding, 2) illustrate the current landscape of prison operations literature, and 3) identify optimization approaches that could reduce overcrowding in prisons. Co-citation analysis suggests that overcrowding generally has negative impacts on prisoners and prison operations and that assignment and queuing approaches are best suited for minimizing prison populations.
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2 - Leveraging The Potential Of Outsourcing And Offshoring In Complex Product Development

Ole Frauen, Volkswagen AG, Okerstr. 15, Wolfsburg, 38100, Germany, Arnd H. Huchzermeier, Jurgen Milim

Leveraging the potential of outsourcing and offshoring remains a major challenge in complex product development. It is a question about effectively decomposing and distributing work across geographical and organizational boundaries while providing high quality products. The decisions must clearly depend on the product's characteristics and the emerging collaborative network. The conducted study is based on an extensive data set involving all development projects of one of the largest car manufacturers worldwide. We demonstrate that a precise distinction between outsourcing and offshoring, as well as the introduction of a network perspective, are crucial to evaluate the effects in more detail.

2 - An Entrepreneur's Innovation Dilemma: Learning-financing Tradeoff At Lean Startups

Onesun Steve Yoo, University College London, London, United Kingdom, onesun.yoo@ucl.ac.uk, K Sudhir

Using a Bayesian learning model of lean startup and a Nash bargaining game between the investor and entrepreneur, this paper examines entrepreneur’s trade-off between optimizing learning for the startup’s success relative to the need to convey market potential by producing observable success signal for early-stage investors. We find that depending on the entrepreneur’s relative bargaining position, the entrepreneur may distort product development downwards or upwards to sacrifice learning relative to the one prescribed in the Lean startup method. The two types of distortions differently impact the innovation efficiency and innovation output. We examine how they could be mitigated and collectively improve the innovation economy.

3 - Optimal Presentation Of Alternatives

Zeya Wang, Georgia Institute of Technology, Atlanta, GA, United States, Movaraid Rahmani, Karthik Ramachandran

In many contexts such as healthcare, knowledge outsourcing, or product design and development, a provider may have multiple alternatives that could potentially solve the client’s problem. A key decision for the provider is: how to present these alternatives to a client? In this paper, we develop a game-theoretic model where the provider chooses which alternative to present and in what sequence, and the client chooses which alternative to implement. We characterize the optimal strategies for the provider in equilibrium to determine which alternative the provider should offer and when to offer it. We study the effects of implementation ability, asymmetric implementation cost and correlation between options on these strategies.

4 - The Value Of Analytics Partnerships For Biopharmaceuticals

Niyazi Taneri, Cambridge, Judge Business School, University of Cambridge Judge Business School, Tru, Cambridge, CB2 1AG, United Kingdom, Jiatao Ding, Michael Freeman

Through partnerships for analytics, biopharmaceutical firms aim to gain complementary capabilities and streamline their operations—e.g. improve the selection of drug candidates and speed up the drug development cycle. In an industry with notoriously low success rates and a patent cliff, improvements on these fronts translate to more products with longer periods of on-patent sales. We study the shareholder value implications of such partnerships and provide insights on when those partnerships add the most value.

1 - Optimization In Medium-term Planning For Military Aircraft Maintenance

Sergio Rebouças, Brazilian Air Force, Sao Jose dos Campos, Brazil, Denny Wallace Imbassahy, Fernando Teixeira Abrahão

The assignment of military aircraft must be closely linked to the fleet maintenance plan. Optimization of maintenance activities and resources is crucial to maximize fleet availability and minimize the costs of air operations. Current optimization models generalize critical constraints that make their application in real-life difficult. This work proposes a new approach to medium-term optimization planning for military aircraft maintenance. Innovative constraints are defined and implemented through the Biased Random-Key Genetic Algorithm for optimization of the fleet maintenance plan, improving the model's adherence to the operational context.
2 - The Multiphase Course Timetabling Problem
Vicky H. Mak-Hau, Deakin University, Melbourne, Australia, Rasul Esmaeilebigi, John Yearwood, Vivian Nguyen
We present a new MILP formulation and solution method for solving a highly complex military training scheduling problem. A lesson may require simultaneously a student from two or more different syllabi, along with an available instructor with minimum lesson specific qualifications. The constraints are imposed on students, instructors and resources. Lessons are broken down into four phases each potentially requiring different physical and human resourceing. In addition, a subset of lessons, when scheduled to occur consecutively, can achieve efficiencies in instructor utilization by having combined preparation, briefing and debriefing times for the respective lessons and students.

- Trajectory Planning For Mission Survivability Of Autonomous Vehicles In Moderately To Extremely Uncertain Environments
Fanruiqi Zeng, Georgia Institute of Technology, Atlanta, GA, United States, Husein R. Idris, John-Paul Clarke
In this work, we propose a receding horizon control strategy with novel trajectory planning policies that enable dynamic updating of the planned trajectories of autonomous vehicles operating in environments where potential conflicts are, from a statistical perspective, either partially known or completely unknown. The proposed policies utilize two metrics: (1) the number of feasible trajectories; and (2) the robustness of the feasible trajectories. We measure the effectiveness of the suggested policies in terms of mission survivability. Our findings have significant implications for achieving safe aviation autonomy.

2 - Miles-in-Trail Restrictions and Aviation System Performance: Chicago O’Hare Case Study
Ke Liu, PhD Candidate, UC Berkeley, Berkeley, CA, United States, Rasul Esmaeilbeigi, John Yearwood, Vivian Nguyen
This paper focuses on the improvement opportunities from the reduction of Miles-in-Trail (MIT). We design a model including estimation of planned arrival time and deterministic queueing diagram to assess the impacts of an MIT or a set of MITs. Our model is applied to ORD of 2018 as a case study. As results show, if all ORD-sourced MITs were eliminated, the overall queueing delay would increase by 3.3 hr per day on average while arrival delay would decrease by 14.7 hr per day. We found ORD during 8-9, 11-12 and 17:30-18:30 tends to experience more throughput loss when implementing MITs and those delayed flights are allocated into 9-10, 12-13 and 18:30-19:30 respectively. Our results strongly suggest that ORD-sourced MITs, while relieving some build-up of flights in the ORD terminal area, do so at a substantial penalty in the form of increased arrival delay and throughput shortfalls.

3 - Optimization Models For Flights Arrival Scheduling Incorporating Carrier Preferences
Yeming Hao, University of Maryland-College Park, 4326 Rowalt Dr Apt 201, College Park, MD, 20740-3161, United States, David J Lovell, Michael O. Ball, Sergio Torres
This study presents results of a simulation of strategies to incorporate business-driven airline preferences in Time-based Flow Management metering operations. Traffic flow systems that balance demand versus capacity at airports assign Controlled Times of Arrival (CTAs) to incoming flights. We evaluate optimization models and heuristics to assign these CTAs based on user-provided information and priority preferences in a way that minimizes the total CTA delay cost. We quantify potential savings by comparing the results with the default first-come-first-served (FCFS) scheme. Simulations under a variety of realistic scenarios show that our proposed heuristic could reduce CTA delay costs between 20% and 30% relative to the FCFS baseline scheme.

4 - Capacity-aware Traffic Flow Management For Urban Air Mobility Operation
Jungwoo Cho, Postdoctoral fellow, Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of, Yoonjin Yoon
In urban areas where UAM demand is expected to be concentrated, the risk of contact between aircraft can frequently be at the highest level. To minimize such risk, there needs strategic planning to redirect traffic to lower-density or less-congested airspace. This study proposes a new approach that keeps traffic levels in urban airspace below the desired threshold while minimizing the total distance traveled by all aircraft. We first assume airspace is composed of hexagonal spatial units and then allocate a sequence of spatial units that each aircraft can reserve and use to avoid regions with expected traffic above specified thresholds. In doing so, we generate initial paths for all participating aircraft, calculate the estimated occupancy of spatial units, and redirect traffic via delayed departure or rerouting.

5 - Using Flight Shifting to Mitigate Delay in Multiple Airport Regions
Ang Li, University of California-Berkeley, Berkeley, CA, 94720-2392, United States, Mark M. Hansen, Bo Zou
This study aims to improve operational performance of a multiple airport region (MAR) by analyzing interdependent capacity scenarios of that MAR airports and redistributing airport traffic to make more efficient use of the available capacity. We identify MARs based on temporal distance between airports. Capacity interdependence in MAR is demonstrated by conducting clustering analysis on daily capacity profiles. Flight shift models are proposed in both tactical and strategic levels to reduce flight delays of all flights serving airports in the same MAR. Results show that by rescheduling flight landing airport and landing time, the total flight delay in the New York MAR could be significantly reduced in both models.
Distributed Algorithms for Power System Operations I
Sponsored: OPT/Computational Optimization and Software
Sponsored Session
Chair: Kibaek Kim, Argonne National Laboratory, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

1 - Leveraging GPU Batching For Scalable Nonlinear Programming Through Massive Lagrangian Decomposition
Youngdae Kim, Argonne National Laboratory, Lemont, IL, 60657-5499, United States, Francois Pacaud, Kibaek Kim, Mihai Anitescu
We present the implementation of a trust-region Newton algorithm ExaTron.jl for bound-constrained nonlinear programming problems, fully running on multiple GPUs. ExaTron solves a batch of the problems by employing a vast number of thread blocks on GPUs. Without data transfers between CPU and GPU, our implementation has achieved the elimination of a major performance bottleneck under a memory-bound situation, particularly when solving many small problems in batch. We discuss the design principles and implementation details for our kernel function and core operations. By using the application of distributed control of alternating current optimal power flow, we show that parallel computational performance of ExaTron scales linearly with respect to the batch size and the number of GPUs and outperforms performance on a single-core CPU by up to two orders of magnitude.

2 - On The Tightness And Scalability Of The Lagrangian Dual Bound For The Alternating Current Optimal Power Flow Problem
WeiQi Zhang, University of Wisconsin-Madison, Madison, WI, United States, Kibaek Kim, Victor Zavala
We study tightness and scalability properties of a Lagrangian dual (LD) bound for the nonconvex alternating current optimal power flow (ACOPF) problem. We show that the LD bound is as tight as that provided by the powerful and popular semidefinite programming relaxation. However, a key advantage of the proposed bound is that it can be computed in a parallel, decentralized manner. Specifically, in the proposed approach we partition the network into a set of subnetworks, we dualize the coupling constraints (giving the LD function), and we maximize the LD function with respect to the dual variables of the coupling constraints (giving the desired LD bound). The dual variables that maximize the LD are obtained by using a bundle method and we provide a proof of convergence for such method. We demonstrate our developments using PGLib test instances.

3 - A Privacy-preserving Distributed Control Of Optimal Power Flow
Minseok Ryu, Argonne National Laboratory, 1205 Beal Avenue, Lemont, IL, 60439-2117, United States, mryu@anl.gov
We consider a distributed optimal power flow formulated as an optimization problem that maximizes a non-differentiable concave function. Solving such a problem by the existing distributed algorithms can lead to data privacy issues because the solution information exchanged within the algorithms can be utilized by an adversary to infer data. To preserve data privacy, in this paper we propose a differentially private projected subgradient (DP-PS) algorithm that includes a solution encryption step. We show that a sequence generated by DP-PS converges in expectation, and with probability 1. Moreover, we show that the rate of convergence in expectation is affected by a target privacy level of DP-PS chosen by the user. We conduct numerical experiments that demonstrate the convergence and data privacy preservation of DP-PS.

4 - Machine Learning For Distributed Power Systems
Mathieu Tanneau, ISyE Georgia Tech, Atlanta, GA, United States, Pascal Van Hentenryck, Terrence W. K. Mak, Minas Chatzos
This presentation considers distributed algorithms for optimal power systems, one of the fundamental problems in energy systems. It presents a machine-learning approach that has the potential to speed-up distributed (ADMM) algorithms significantly. Results on large test cases with thousands of buses will be presented and highlight how the potential benefits of machine-learning to improve the convergence speed of ADMM algorithms. Limitations of the approach and future research directions will also be discussed.

5 - Evaluating The Performance Of Distributed Optimization Algorithms With Nonideal Data Sharing
Mohammad Alkhraijah, Georgia Institute of Technology, Atlanta, GA, United States,
Distributed optimization allows independent power systems with local controllers to cooperatively solve an optimization problem by sharing the computation results through an iterative process. Data quality plays a major role in the performance of distributed algorithms as the independent systems continuously share the results of their computations. We investigate the impacts of different data quality issues due to communication errors and malicious attacks on the performance of distributed optimization algorithms in the context of DC Optimal Power Flow. We compare and characterize the performance of three distributed optimization algorithms in terms of their convergence rates and solution quality with different communication noise models. We also investigate the impact of targeted attacks on the shared data and propose a detection method.

Advances in Discrete Optimization and Machine Learning
Sponsored: Opt/Machine Learning
Sponsored Session
Chair: Husscin Hazimeh, Massachusetts Institute of Technology, Cambridge, MA, 02139-4850, United States

1 - Tightened Single-neuron Relaxations For Neural Network Verification
Juan Pablo Vielma, Google, Cambridge, MA, 02142-1508, United States, Ross Anderson, Christian Tjandraatmadja, Will Ma, Knrul Patel, Joey Hurley
We improve the effectiveness of propagation- and linear-optimization-based neural network verification algorithms with a new tightened convex relaxation for ReLU neurons. While our description of the relaxation may require an exponential number of inequities, we show that they can be separated in linear time and hence can be efficiently incorporated into optimization algorithms on an as-needed basis. Based on this relaxation, we design two polynomial-time algorithms for neural network verification: a linear-programming-based algorithm that leverages the full power of our relaxation, and a fast propagation algorithm that generalizes existing approaches. In both cases, we show that for a modest increase in computational effort, our strengthened relaxation enables us to verify a significantly larger number of instances compared to similar algorithms.

2 - Duality And Meaning In Computation
Ted K Ralphs, Lehigh University, Industrial And Systems Engineering, Bethlehem, PA, 18015-1518, United States
In this talk, we discuss notions of duality arising in algorithms for discrete optimization and machine learning problems and explore how such notions are related. We then describe how these notions can be exploited to better interpret the results of computations. The specific application we have in mind is explainability in machine learning, but the concepts apply more broadly.

3 - Binary Matrix Factorisation Via Column Generation
Reka Agnes Kovacs, University of Oxford, Oxford, United Kingdom, Oksay Gunluk, Raphael Hauser
Identifying discrete patterns in binary data is an important dimensionality reduction tool in machine learning and data mining. In this talk, we consider the problem of rank-k binary matrix factorisation (BMF) under Boolean arithmetic: given a binary matrix X of dimension n x m and a fixed positive integer k, find two binary matrices A and B of dimension n x k and k x m such that the discrepancy between X and the Boolean product of A and B is minimum. We describe a novel mixed integer linear programming formulation with exponentially many variables and use column generation technique to solve its LP relaxation. The dual bound provided by our formulation is stronger than the bound given by previously available models for BMF. Experimental results on real world datasets demonstrate that our proposed method is effective at producing highly accurate factorisations.

4 - Ecole: A Library For Learning Inside Milp Solvers
Antoine Prouvost, Polytechnique Montréal, Montréal, QC, H3C 3A7, Canada, Justin Dumouchelle, Maxime Gasse, Didier Chételat, Andrea Lodi
We describe Ecole (Extensible Combinatorial Optimization Learning Environments), a library to facilitate integration of machine learning in combinatorial optimization solvers. It exposes sequential decision making that must be performed in the process of solving a Markov decision process. This means that, rather than trying to predict solutions to combinatorial optimization problems directly. Ecole allows machine learning to work in cooperation with a state-of-the-art a mixed-integer linear programming solver that acts as a controllable algorithm. Ecole provides a collection of computationally efficient, ready to use learning environments, which are also easy to extend to define novel training tasks.
5 - Subset Selection: From Linear Models To Neural Networks
Hussein Hazimeh, Massachusetts Institute of Technology, Cambridge, MA, 02139-4850, United States

Subset selection is a fundamental concept in machine learning, which is commonly used to improve model interpretability. We present two scalable methods for subset selection in linear models and neural networks. Our first method solves the L0-regularized regression problem to global optimality through a tailored branch-and-bound (BnB) algorithm. Our BnB can scale to problems with \~10^7 features, more than 1000x larger than what is possible using Gurobi and MOSEK. Our second method is aimed at training neural networks under a cardinality constraint. We propose a new reformulation that converts the cardinality constrained problem to an equivalent unconstrained problem based on binary variables. By smoothing the binary variables, we demonstrate how the neural network can be efficiently trained using first-order methods while enforcing the cardinality constraint.

3 - Improving Decision Diagram Relaxations For Sequencing Problems
Isaac Rudich, Polytechnique Montréal, Montréal, QC, H3G 1A3, Canada

Relaxations of multivalued decision diagrams (MDDs) are effective for improving methods of solving sequencing problems. To strengthen the bounds generated by MDD relaxations, we used multiple metrics to improve merge rules and encoded a restricted MDD into the relaxed MDD. We evaluated our approach by comparing its performance to previous work done by Cire and van Hoeve on variations of the traveling salesman problem (TSP), such as the asymmetric TSP, TSP with time windows, TSP with precedence constraints, and the sequence ordering problem.

VWA65
Virtual Room 65
Decision Diagram Methods
Sponsored: OPT/Integer and Discrete Optimization
Sponsored Session
Chair: Andre Augusto Cire, University of Toronto Scarborough, Rotman School, Toronto, ON, M1C 1A4, Canada

1 - "ddo" A Fast and Efficient Framework for Solving Combinatorial Optimization Problems with MDD
Virtual Room 85
Technology Showcase: Radical Simplification for the Creation of Optimization Models
Technology Showcase
1 - Radical Simplification for the Creation of Optimization Models
Segye Wasserkrug, IBM Research 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.

Branch-and-bound MDD
Xavier Gillard, Grad. Student, UC Louvain, Louvain-la-Neuve, Belgium

In this talk I will present you ‘ddo’ a free fast and efficient framework for solving combinatorial optimization problems with branch-and-bound MDDs. To that end, we will start modelling well known problems (Knapsack, Travelling Salesman with Time Window a.k.a. TSP-TW). Once the basic are in place, we will discuss some performance strategies. In particular, we will see how to easily exploit the available hardware on your platform. We will also see how to boost the performance of the solvers though the introduction of problem specific knowledge in the form of a rough upper bound. Finally, I will present some numerical results comparing the performance of ‘ddo’ and Gurobi on the resolution of MISP (Maximum Independent Set Problem), MCP (Maximum Cut Problem) and MAX2SAT (Maximum 2 Satisfiability). These results show the relevance of using ddo as it may significantly outperform MIP.

2 - DD-based Reformulation For A Class Of Combinatorial Bilevel Problems
Leonardo Lozano, University of Cincinnati, Carl H. Lindner Hall, Cincinnati, OH, 45246-2310, United States, David Bergman, Andre Augusto Cire

We study a class of challenging discrete bilevel problems and propose a reformulation based on decision diagrams that results in a single-level mixed integer program (MIP). The decision diagrams are to provide a convex representation of the discrete follower problem which is then appended to the leader problem via KKT conditions. In contrast to previous approaches from the literature that reformulate bilevel problems as nonlinear single-level MIPs and often transform the resulting problem into a linear MIP usually via big-M formulations, our approach exploits the structure given by the decision diagrams to provide a linear reformulation, thus avoiding any linearization or big-M constraints.

4 - Greedy Algorithms To Maximize Anti-coordination In Network Games
Soham Das, Texas A&M University, College Station, TX, United States, Ceyhun Eksin

In an anti-coordination network game, players are encouraged to differentiate their actions from their neighbors. Since, despite incentives, selfish agents may fail to do so, our goal is to eliminate all active coordination links by controlling a minimum set of players. We motivate the problem by an epidemic game where people (healthy and sick) decide to take the costly action, e.g. taking protective measures vs. free riding. The player selection problem is combinatorial with a submodular objective. Hence, we consider greedy algorithms that exploit behavior cascades on the network. Numerical experiments show that the greedy algorithms are near optimal and outperform centrality based heuristics.
5 - A Bilevel Programming Framework for Joint Edge Sertive Placement and Pricing
Tarannum Nisha, University of British Columbia, Vancouver, BC, Canada, Duong T. Nguyen, Vijay K. Bhargava
Due to the heterogeneity and limited capacities of edge resources, it is important to address the joint pricing and service placement problem in edge computing. To this end, we propose a bilevel optimization model where the edge infrastructure provider is the leader while each service is a follower. Given the resource pricing and provisioning decisions computed by the leader, the followers optimize their resource procurement and workload allocation strategies. We customize the column-and-constraint generation from robust optimization literature to solve the proposed integer bi-level model. Our model not only maximizes the profit of the provider but also minimizes the cost for every service.

VWA67 Virtual Room 67
Nonlinear Optimization in Cybersecurity
Sponsored: OPT/Nonlinear Optimization
Sponsored Session
Chair: Abdullah Al Omair, Ohio State Univ., Athens, OH, 45701-9291, United States
Co-Chair: Theodore T. Allen, Ohio State University, Columbus, OH, 43210-1271, United States

VWA68 Virtual Room 68
Advances in Derivative-Free Optimization II
Sponsored: OPT/Nonlinear Optimization
Sponsored Session
Chair: Lindon Roberts, The Australian National University
1 - A Progressive Barrier for Constrained Derivative-Free Multiobjective Optimization
Ludovic Salomon, Polytechnique Montreal, Montréal, QC, Canada, Sebastien Le Digabel, Jean Bigeon
The last decade has seen the development of new efficient convergent-based derivative-free and blackbox optimization algorithms for multiobjective optimization, most of them extensions of reliable single-objective methods. However, very few have been designed to take into account inequality blackbox constraints. This work presents an extension of the single-objective blackbox Mesh Adaptive Direct Search (MADS) algorithm with the progressive barrier to multiobjective blackbox optimization. It integrates the knowledge of inequality constraints. Numerical experiments on synthetic benchmarks and engineering applications show that this new method is competitive according to other state-of-the-art algorithms.

2 - Derivative Free Optimizers For Noisy Intermediate Scale Quantum Devices
Juliane Mueller, Lawrence Berkeley National Lab, Berkeley, CA, United State, Wim Lavrijsen
We present a performance comparison of derivative-free optimization algorithms applied to noisy intermediate scale quantum (NISQ) devices. The optimization objective function is black-box, computationally expensive to evaluate, and contains noise. Although a wide variety of derivative-free optimizers exist, few of them can properly deal with noise and get stuck in noise-induced local optima. In this talk, we examine when these optimizers break down and how to potentially alleviate their drawbacks by coupling them with a first optimization phase that uses non-interpolating surrogate models to guide the search for promising regions in the parameter space from which well-established local search methods can be started. We present the results of numerical experiments conducted on two simulation applications.

3 - Convergence Analysis of a Trust-Region Method under Noisy Settings
Liuyuan Cao, Lehigh University, Bethlehem, PA, 18015-3704, United States
The convergence of a trust-region method is analyzed under the assumption that the local approximation models and function evaluations are only accurate with a sufficiently high probability. The objective function is assumed to have Lipschitz continuous gradients but non-convex. Two different definitions of approximation models being accurate are studied, and under both definitions the number of iterations needed for the algorithm to find a solution with $\epsilon$ accuracy is shown to be bounded by $O(1/(\epsilon^{2.5}))$ with high probability.

VWA69 Virtual Room 69
Theory and Applications on Stochastic Optimization
Sponsored: OPT/Optimization Under Uncertainty
Sponsored Session
Chair: Haoming Shen, University of Michigan, Ann Arbor, MI, 48105-2404, United States
Co-Chair: Ruwei Jiang, University of Michigan, Ann Arbor, MI, 48109-2117, United States
1 - Adjustable Distributionally Robust Optimization With Infinitely Constrained Ambiguity Sets
Zhi Chen, College of Business, City University of Hong Kong, Rm 7-270 Centre For Academic Exchange 81 Tat Chee, Kowloon, Hong Kong, Chin Pang Ho, Haolin Ruan
We study adjustable distributionally robust optimization problems over a class of ambiguity sets that involve infinitely many expectation constraints. We adopt the extended linear decision rule approach to progressively improve the approximation to these problems and thus we can iteratively obtain a better here-and-now decision. Numerical examples are presented to showcase possible applications.

2 - Tight Conic Approximations For Two-Sided Chance-Constrained Optimization
Abolhassan Fathabadi, University of Arizona, Tucson, AZ, United States, Jianqiang Cheng, Kai Pan, Boshi Yang
In this talk, we focus on developing tight conic approximations for two-sided chance constrained (TCC) programs with an application to AC optimal power flow problem. We present an efficient second-order cone programming (SOCP) approximation of the TCC programs under Gaussian Mixture (GM) distribution. As compared to the conventional normality assumption for forecast errors, the GM distribution adds an extra level of accuracy representing the uncertainties. Moreover, we show that our SOCP formulation has adjustable rates of accuracy and its optimal value enjoys asymptotic convergence properties. Finally, we demonstrate the effectiveness of our proposed approaches with both real historical data and synthetic data on the IEEE 118-bus system.

3 - A Study On Distributionally Robust Chance Constraints
Ruwei Jiang, University of Michigan, Ann Arbor, MI, 48109-2117, United States, Haoming Shen
In this talk, we present a study on distributionally robust chance constraints (DRCC). We consider models and solution algorithms for DRCC and demonstrate them in examples and numerical case studies.

4 - Chance-Constrained Set Covering With Wasserstein Ambiguity
Haoming Shen, University of Michigan - Ann Arbor, Ann Arbor, MI, 48105-2404, United States, Ruwei Jiang
We consider a distributionally robust chance-constrained set covering problem with a Wasserstein ambiguity set. This model involves binary-valued uncertainty and binary decision variables, leading to an inherently different reformulation from most existing models. We provide an exact two-stage reformulation and derive two families of valid inequalities. Numerical studies based on randomly generated test instances and real-life applications show the effectiveness of our reformulation and valid inequalities.

VWA70 Virtual Room 70
Distributionally Robust Optimization
Sponsored: OPT/Optimization Under Uncertainty
Sponsored Session
Chair: Grani Adiwena Hansausanto, The University of Texas at Austin, Austin, TX, 78712, United States
1 - Wasserstein Robust Support Vector Machines With Fairness Constraints
Vije Wang, University of Texas at Austin, Austin, TX, United States, Viet Anh Nguyen, Grani Adiwena Hansausanto
We propose a distributionally robust support vector machine with a fairness constraint that encourages the classifier to be fair in view of the equality of opportunity criterion. We use a type-3 inf-$\epsilon$ Wasserstein ambiguity set centered at the empirical distribution to model distributional uncertainty and derive an exact reformulation for the worst-case unfairness measure. We establish that the model is equivalent to a mixed-binary optimization problem, which can be solved by standard off-the-shelf solvers. We further prove that the expectation of the hinge loss objective function constitutes an upper bound on the misclassification probability. Finally, we numerically demonstrate that our proposed approach improves fairness with negligible loss of predictive accuracy.
2 - Two-stage Data-driven Distributionally Robust Optimization With Random Recourse
Xiangyi Fan, UT Austin, Austin, TX, United States
We study two-stage data-driven stochastic optimization problems with random recourse where the adaptive decisions are multiplied with the uncertain parameters in both the objective and the constraints. We propose a scalable approximation scheme via piecewise linear and piecewise quadratic decision rules. The emerging decision rule problems can be reformulated as exact copositive programs, which admit tractable approximations in semidefinite programming. To address the inefficiency of solving large-scale semidefinite programs, we design a decomposition algorithm where smaller-size subproblems can be solved in parallel. We further establish the performance guarantees of the proposed scheme and demonstrate its effectiveness through numerical examples.

3 - First-order Methods For Distributionally-Robust MDPs
Christian Kroer, Columbia University, Mudd Hall 500 W 120th St, New York, NY, 10027-6623, United States, Julien Grand-Clement
Markov decision processes (MDPs) are known to be sensitive to parameter specification. Distributionally robust MDPs alleviate this issue by allowing for ambiguity sets which give a set of possible distributions over parameter sets. The goal is to find an optimal policy with respect to the worst-case parameter distribution. We propose a framework for solving Distributionally robust MDPs via first-order methods and instantiate it for several types of Wasserstein ambiguity sets. By developing efficient proximal updates, our algorithms achieve convergence rates that are significantly better than existing value iteration methods. Numerical experiments show that our algorithm is significantly more scalable than state-of-the-art approaches across several domains.

4 - Optimal Transport Based Distributionally Robust Optimization
Soroosh Shafieezadeh-Abadeh, ETH Zurich, Zurich, Switzerland, Lőrinc Aolaritei, Daniel Kuhn, John Lygeros, Florian Dorfler
We show that the ordinary use of the Wasserstein type-p distance in DRO problems is not suitable even for simple loss functions. We then propose an optimal transport based DRO approach with a general transportation cost. In this general setting, the new DRO problem can be viewed as a zero-sum game. We prove that this zero-sum game admits a Nash equilibrium. We then proceed and explore the relationship between the distributional robustness and its regularization effect. In particular, we establish a link between the DRO setting and the use of high-order stationary regularization, and then, we propose a simple dual formulation of the DRO problem for the class of generalized linear models using techniques in nonconvex optimization. This formulation enables us to both analyze the equivalency between the distributional robustness and its implicit/explicit regularization effect.

5 - On Data-driven Prescriptive Analytics With Side Information: A Regularized Nadaraya-watson Approach
Grani A. Hansususanto, The University of Texas at Austin, ETC 5.120, 204, Austin, TX, 78712, United States, Prateek Raj Srivastava, Chin Pang Ho
We consider the stochastic optimization problem with side information, which aims to minimize the conditional expected loss in the presence of observable exogenous covariates. In general, the joint distribution of the side information and the loss function is unknown. Instead, only historical data is available. We propose an approximation based on the Nadaraya Watson estimator and derive out-of-sample performance guarantees based on moderate deviations theory. Our analysis leads to a variance-based regularization scheme, which is generally nonconvex. We adopt ideas from distributionally robust optimization to obtain equivalent tractable formulations. We present numerical experiments for portfolio optimization and newsvendor problems.

2 - Robust, Anomaly Detection of Melt-Pool Monitoring using Convolutional LSTM Network for Laser Power Bed Additive Manufacturing Process
JaeHyuk Kim, PhD Student/Pohang University of Science and Technology, Pohang, Korea, Republic of,
Laser Powder bed fusion (LPBF) is a widely used method in additive manufacturing. Despite the advanced development of LPBF, stability of the LPBF and the quality of the built part have been continually issued. To evaluate the status of LPBF, anomaly detection using melt pool from melt-pool monitoring has been studied. However, in previous studies, a definition of the anomaly melt-pool is unclear, and there is a limitation that only the melt pools generated in specific process parameters can be detected. Therefore, we propose a robust method for anomaly detection of melt-pool monitoring using convolutional LSTM Network.

3 - Design Of A Make-to-order (MTO) Multiproduct Batch Plant With Non-dedicated Storage Tanks, Under The Restriction Of A Targeted Delivery Lead Time
Amy Van Meir, University of Antwerp, Antwerp, Belgium, Trijntje Cornelissens, Johan Springael
Most design models of multiproduct batch plants are based on costs, while also responsiveness is a strategic key performance indicator. A metric for responsiveness is the lead time between ordering and delivery of a customer order. We integrated the targeted delivery lead time in the design of a make-to-order batch plant. Since orders are stored until transported, both number and capacity of production and storage tanks are determined, while minimizing total cost. By using the targeted delivery lead time as a constraint, the influence on cost and plant design is analyzed. The mathematical model is solved by mixed integer linear programming techniques and metaheuristics for larger instances.

4 - Manufacturing Localization And Its Performance Implications: An Empirical Study In The Automotive Industry
Zhenzhen Yan, PhD Candidate, Michigan State University, East Lansing, MI, United States, Sriram Narayanan, Tobias Schoenherr, Sourish Sarkar
Literature on manufacturing relocation focuses on the decision drivers while the decision consequences are understood due to the difficulty of data collection. This study contributes to this stream of literature by investigating the performance implications of manufacturing localization, firms’ decision of relocating manufacturing activities closer to the target market. Specifically, we use the automotive industry as an empirical context and apply a causal estimation to a uniquely assembled dataset across recalls, inventory, and other industry-specific proprietary data compiled over a 20-year period. Our findings provide practical insights to firms that consider relocation.
We present a kinematic waves-based Deep Convolutional Neural Network (Deep CNN) for estimating high-resolution traffic speed fields using sparse probe vehicle trajectories. Two key notions incorporate traffic physical constraints into the learning framework. Firstly, the use of anisotropic traffic kernels in the Deep CNN model - an architecture modification aimed to explicitly capture the space-time correlations in free-flow and congested traffic. These correlations are guided by the Kinematic Wave Theory of traffic flow. Secondly, simulation-based training - the use of simulated data as a surrogate to real-world data for training. This implicitly honors traffic physical constraints underlying the simulated data, and hence the simulation model. Speed field estimations for two real-world datasets show promising results.

2 - Physics Regularized Gaussian Process For Traffic State Estimation
Xianfeng (Terry) Yang, University of Utah, Salt Lake City, UT, 84112, United States, Yun Yuan

This study presents a new modeling framework, named physics regularized machine learning (PRML), to encode classical traffic flow models into the ML architecture and to regularize the ML training process. More specifically, leveraging the Gaussian process (GP) as the base model, a stochastic physics regularized Gaussian process (PRGP) model is developed and a Bayesian inference algorithm is used to estimate the mean and kernel of the PRGP. A physics regularizer, based on macroscopic traffic flow models, is also developed to augment the estimation via a shadow GP, and an enhanced latent force model is used to encode physical knowledge into the stochastic process. Based on the posterior regularization inference framework, an efficient stochastic optimization algorithm is then developed to maximize the evidence lower-bound of the system likelihood.

3 - Physics-Informed Deep Learning for Traffic State Estimation: A Hybrid Paradigm
Sharon Di, Columbia University, New York, NY, 10027, United States

This paper introduces a physics-informed deep learning (PIDL) framework to the Traffic state estimation (TSE) problem. PIDL contains both model-driven and data-driven components, making possible the integration of both approaches. This paper focuses on highway TSE with observed data from loop detectors and probe vehicles, using both density and average velocity as the traffic variables. With numerical examples, we show the use of PIDL to solve a popular second-order traffic flow model, i.e., a Greenshields-based Aw-Rascle-Zhang (ARZ) model, and discover the model parameters. We then evaluate the PIDL-based TSE method using the Next Generation Simulation (NGSIM) dataset. Experimental results demonstrate the proposed PIDL-based approach to outperform advanced baseline methods in terms of estimation accuracy and data efficiency.

Wednesday, 7:45AM - 9:15AM

W VB01
Virtual Room 01
Participatory Specification of Trustworthy Machine Learning
Sponsored: Data Mining
Sponsored Session
Chair: Kush R Varshney, IBM Research, IBM Research, Yorktown Heights, NY, 10598, United States

1 - Paving An Intentional Path Towards Inclusive Practices In AI Development
Tina M. Park, Research Fellow (Methods for Inclusion), Partnership on AI, San Francisco, CA, United States
Partnership on AI believes that working with communities affected by the deployment of AI/ML technologies is integral to their responsible development and mitigation of harm. To deepen our understanding of how inclusive public engagement approaches can help developers and researchers, PAI launched the Methods for Inclusion project. Multidisciplinary in nature, Methods for Inclusion draws from fields outside of computer science and technology, such as public planning & policy, education, public health, sociology, and community organizing which have grappled with questions of participation and inclusion for many decades. Drawing on semi-structured interviews with developers, data scientists, and researchers, as well as community advocates, the project explores the challenges present in conducting participatory design processes inclusively and equitably.
What is a fair performance metric? We consider the choice of fairness metrics through the lens of metric elicitation -- a principled framework for selecting performance metrics that best reflect implicit preferences. The use of metric elicitation enables a practitioner to tune the performance and fairness metrics to the task, context, and population at hand. Specifically, we propose a novel strategy to elicit group-fair performance metrics for multiclass classification problems with multiple sensitive groups that also includes selecting the trade-off between predictive performance and fairness violation. The proposed elicitation strategy requires only relative preference feedback and is robust to both finite sample and feedback noise.

3 - Addressing The Design Needs Of Implementing Fairness In AI Via Influence Functions

Brianna Richardson, University of Florida, Gainesville, FL, United States, Kush R. Varshney

The steady rise in machine learning applications is commensurate with the rise in efforts towards responsible and trustworthy AI. Despite the plethora of tools that exist to encourage interpretable, explainable, and fair AI, recent research depicts a lack of implementation by the practitioners who are meant to employ them. Utilizing findings and practices from participatory design research, this work introduces a novel explainable fairness methodology: influential fairness. Influential fairness employs state-of-the-art methods from robust statistics and fairness research to provide local, sample-specific explanations for group fairness metrics. Through task-based user studies, this work demonstrates the gaps in current fairness research and utilizes participatory design to maximize the insight and usability of influential fairness implementation.

4 - Empowering People To Design AI Systems For Their Own Contexts

Min Kyung Lee, UT Austin, Austin, TX, United States

I present two participatory methods for AI design and their case studies in on-demand food rescue and algorithmic work scheduling: i. WeBuildAI is a participatory framework for stakeholders to build algorithmic community policies, such as determining efficiency and equity trade-offs; and ii. Well-being elicitation methods enable workers to build computational well-being models for the optimization and evaluation of algorithmic work.

2 - Fair Performance Metric Elicitation

Gaurush Hiranandani, Student, UIUC, Urbana, IL, United States, Narasimhan Harikrishna, Oluwasanmi Koyejo

2 - Human Vs. Ai: Will Ai Allow Humans To Do Tasks That Are Best Suited To Them?

Donghyuk Shin, Arizona State University, W. P. Carey School of Business, Dept. of Informatics, Tempe, AZ, 85287, United States

The explosion of AI technologies is fundamentally reshaping how we work, transforming numerous occupations and industries. We investigate whether AI technology reinstates labor with new tasks, and how AI technology frees people up, allowing them to concentrate on what they can do best. To empirically test these questions, we use individual-level data from QANDA, a leading math problem-solver application, which provides both an AI-driven search engine and human tutor services. We find that, as the search engine quality improves, the search engine serves more common and basic questions, leaving only those that are more challenging to the human tutor. This study adds to the emerging economics of AI literature by calling further attention to future researchers to explore the substitutable vs. complementary role between human and AI.

4 - A Reinforcement Learning Algorithm for Online Personalized Tutor Recommendation

Mohamad Kazem Shirani Faradonbeh, University of Georgia, Athens, GA, United States

Intelligent computerized education reduces costs of tutoring by learning from the trajectories of the students. We present a data-driven algorithm implemented on an online platform for recommending personalized tutoring to students. To do so, multiple important challenges are addressed. First, the experiments for collecting data need to be diverse for exploring student responses, while at the same time they must focus on the immediate weakness of each student. Moreover, there are many tutoring items, but each student provides an extremely small data. Further challenges as well as employed methods that utilize student backgrounds for combining the data will be discussed.

VWB03

Virtual Room 03

Statistical Learning for Systems Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Xiaolei Fang, North Carolina state university, North Carolina State University, Raleigh, NC, 27607, United States

1 - Domain Knowledge-oriented Deep Learning For The Remaining Useful Lifetime Prediction Of System With Multiple Failure Modes

Yuqi Su, North Carolina State University, Raleigh, NC, United States, Xiaolei Fang

Remaining useful lifetime (RUL) prediction is an important aspect of system prognostics and health management (PHM). Over the past decade, deep learning has been thriving and produced many outstanding results in various fields including PHM. In real-world applications, complex system always operates under multiple failure modes, while most previous studies rely heavily on prior knowledge of the system. To fill this gap, we propose a domain knowledge-oriented deep learning framework that is distributional accessible to depict the degradation process and to adapt RUL prediction when multi-sensors and multiple failure modes exist. The experimental results show the proposed method improves RUL prediction performance comparing with other benchmark architectures especially under the consideration of asymmetric preference that penalties more on late prediction.

2 - Fast And Reliable Metamodelling Of Large-scale Nonlinear Time-dependent Problems

Xinchao Liu, University of Arkansas, Fayetteville, AR, United States

This research proposes a reduced-order surrogate learning framework for nonlinear structural dynamics governed by unequivocal physics principles. Motivated by the nonlinear spatio-temporal surface displacement process due to aircraft-UAV collisions, this paper shows (i) how the reduced-order physics models (including physics of motion, fundamental material laws and finite element framework) can be obtained from the Proper Orthogonal Decomposition; (ii) how the reduced-order physics models can be accelerated by gradient boosted ensemble trees; (iii) how the input (force) uncertainty in nature is incorporated into deterministic finite element results; and (iv) how the error is controlled and modelled for governing-equation-based reduced-order models.
3 - Human-machine Interaction System Reliability Model With Multiple Dependent Degradation Processes
Yuhao Hu, NC State University, Raleigh, NC, United States, Rui Wang, Mengmeng Zhu

Human factors greatly affect the performance of the machine. However, most system reliability models neglect the impacts of human factors. We thus propose a new human-machine interaction (HMI) system reliability model, in which the health state of the machine is not only affected by internal and external factors but also human behaviors. The human behaviors in this paper are illustrated by human situation awareness (HSA). Time and automation levels are chosen to model HSA. Also, the proposed model considers random shocks and multiple dependent degradation processes of the machine. This dependency is solved by the copula method. The impacts of HSA and random shocks will be reflected on the system as incremental change and sudden jump on degradation rate. The proposed model is firstly demonstrated by a simulated case, then by a battery management system in electric vehicles.

4 - Property Listing Popularity: The Case Of Airbnb In Canada
Bronte J Smith, Lakehead University, Thunder Bay, ON, Canada, Kem Z Zhang, ShiKui Wu

Airbnb is one of the most transformative developments in the tourism sector. Most literature tends to focus on consumers instead of the hosts that bridge the company to its consumers. Using a sample of multiple Canadian cities, this research will adopt a data-driven approach to explore the key determinants of host success in recent years. This research will increase insights into variables affecting host performance and thus guiding their practice, especially demonstrating how it is impacted by the Covid-19 pandemic
2 - UAVs For Search And Rescue: A Reinforcement Learning Approach
Leren Qian, Northeastern University, Boston, MA, United States, Peijl Wang, Dinghao Ma, Mohammad Dehghaninomohammadabadi, Mehdi Behroozi, Emanuel Melachrinoudis

Reinforcement Learning (RL) is becoming an emerging field of research and a powerful tool to solve complex problems. This study applies RL to solve a team orienteering problem (TOP) of UAVs with charging stations. In this problem, a fleet of UAVs need to visit a set of service nodes with the objective of maximizing the total collected service rewards. To increase UAVs reliability and reachability, UAVs can access charging stations along their routes. The problem is solved with a two-phase solution approach where the nodes are decomposed into clusters before using RL to find the best policy. A non-decreasing tree search updating strategy is designed to deal with the natural complexity of the combinatorial optimization problem during the state-action value update. Experiments show the approach outperformed the state-of-the-art commercial solver dealing with this task.

3 - Integrating Reinforcement Learning with a Discrete Event Simulation Environment for Queueing Networks
Sahil Belsare, Northeastern University, Boston, MA, 02120-2175, United States, Mohammad Dehghaninomohammadabadi

In this project, RL is applied to solve a M/M/C queueing system in a simulated environment. To conduct this, Simply, a discrete event simulation (DES) library in Python, is integrated with RL algorithms. This integration provides a unique platform to link a DES environment with RL techniques and enable a new approach to solve traditional simulation-optimization problems.

VWB07

Virtual Room 07

Reaching Global Optimum in Non-Convex Optimization Problems

Sponsored: Data Mining
Sponsored Session

Chair: Igor Molybog, University of California-Berkeley, University of California-Berkeley, Berkeley, CA, 94709, United States

1 - Nonconvex-nonconcave Minimax Optimization With Moderate Accuracy
Mehran Razaviyayn, University of Southern California, Los Angeles, CA, 90089-1057, United States

We studied the problem of solving general smooth nonconvex min-max optimization problems to moderate accuracy levels.

2 - On The Absence Of Spurious Local Trajectories In Time-varying Nonconvex Optimization
Cedric Josz, Columbia University, New York, NY, 94270, United States

We study the landscape of a time-varying nonconvex optimization problem, for which the input data vary over time and the solution is a trajectory rather than a single point. A motivating example will be the alternating current optimal power flow problem where the demand varies throughout the day. To understand the complexity of finding a global solution of such a problem, we introduce the notion of spurious (i.e., non-global) local trajectory as a generalization to the notion of spurious local solution in nonconvex (time-invariant) optimization. We provide sufficient conditions for local trajectories to escape spurious local minima due to time variations. This joint work with Fattahi, Ding, Mohammadi, Lavaei and Sojoudi: https://arxiv.org/abs/1905.09937

3 - When Does MAML Objective Have Benign Landscape?
Igor Molybog, University of California-Berkeley, Berkeley, CA, 94709, United States, Javad Lavaei

The paper studies the landscape of the optimization problem behind the Model-Agnostic Meta-Learning (MAML) algorithm. The goal of the study is to determine the global convergence of MAML on sequential decision-making tasks possessing a common structure. We investigate in what scenarios the benign optimization landscape of the underlying tasks results in a benign landscape of the corresponding MAML objective. For illustration, we analyze the landscape of the MAML objective on LQR tasks to determine what types of similarities in their structure allow the algorithm to converge to the globally optimal solution.

VWB08

Virtual Room 08

Innovation/ Entrepreneurship I

Contributed Session

Chair: Marc Eulierich, University Duisburg-Essen, Hagen, 58099, Germany

1 - Black-owned Small Businesses In Englewood, Chicago: Documenting The Effects Of COVID-19 And The Black Lives Matter Movement In 2020
Sophie Boorstein, Northwestern University, Evanston, IL, United States

The present study assesses impacts of 2020 crises on Black-owned small businesses in Englewood, Chicago. The research examined SafeGraph foot traffic data to identify customer visitation patterns relative to COVID-19 stay-at-home orders and BLM protests. Through semi-structured interviews with Black-identifying entrepreneurs (n=8) in Englewood, the research further elucidated mechanisms by which the pandemic, protests, and looting disproportionately influenced minority-owned businesses. Amid unique foot traffic trends in Englewood and other majority-Black neighborhoods, business owners managed their retail enterprises with complex mechanisms, staffing, and health decisions.

2 - The Ultimate, Most Revolutionary Paper Ever! How Bragging Affects New Product Success
Daniel Blaseg, Assistant Professor of Entrepreneurship, ESADE Business School, Sant Cugat, Spain, Christian Schulze

When new firms introduce a new product to the market, they face an important decision: Should they be modest, or should they brag? We investigate bragging (the use of superlatives) by studying 360,412 new products launched on Kickstarter. We find that the relationship between bragging and new product success follows an inverse U-shape. Ideally, about one in thirteen words should be a superlative. The right amount of bragging can help new firms increase product success by up to 66%. Competitive intensity moderates the results. The greater the competition and their bragging density, the higher the optimal bragging density. Contrary to conventional wisdom, it is not optimal to “stand out”.

3 - How To Sell Videogames? Analyzing The Drivers Of Successful Video Game Sales
Marc Eulierich, Professor for Internal Auditing, University Duisburg-Essen, Duisburg, Germany, Anna K. Eulierich

The video game industry has an enormous economic, cultural, and social influence on today’s society. Oddly enough, this field of research is far from exhausted. It is for this reason, that our study contributes to our existing literature by addressing a quite fundamental question, namely which factors drive video game sales. Using an unique data set, we perform a comprehensive analysis of different influencing factors in order to develop an in-depth understanding of the video game industry’s success when it comes to sales figures. By combining information from different data sources, we are able to examine the impact of various market- and game-specific factors as well as cultural effects.
With growing concerns on drug safety issues, FDA has implemented major moves to allocate more inspections to high-risk manufacturers. The actions of FDA implicitly assume that the frequent inspections at low-quality facilities could reduce the drug safety concerns. However, whether more monitoring guarantees better quality remains unclear. In this study, we directly examine the validity of this assumption in the generic drug industry and test the impact of inspection frequency on the manufacturing quality. Overall, we do not find evidence that supports the link between more frequent inspections and fewer recall events, suggesting that the current risk-based inspection model alone might not help bring down the quality failures in drug products. We propose two explanations for the results - the organizational culture and the inherent quality levels.

2 - The Impact Of Uncertainty Avoidance Culture On Patient Engagement During The Covid-19 Pandemic
Kellas Cameron, Assistant Professor, University of South Florida, Tampa, FL, 33602, United States, Lu Kong

National Cultures have played an undeniable role in how different countries have been able to effectively tackle the Covid-19 pandemic. We posit the countries that exhibit a higher uncertainty avoidance index had better responses due to their population’s willingness to adapt to new social and health directives, as this risk-averse nature has been associated with higher patient engagement. Our model demonstrates how these dimensions of national culture - as opposed to individual preferences - directly impacted the implementation of novel mitigation processes to lower infections rates. We outline ways in which those in health operations can leverage these cultural norms to maximize positive patient health outcomes.

3 - Impact Of Environmental And Safety Violations On Quality
Gopesh Anand, University of Illinois-Urbana Champaign, Champaign, IL, 61820-6913, United States, Christian Blanco, John Gray, In Joon Noh

In this research, we study how violations in environmental and safety regulations, revealed through adverse facility inspection outcomes by the EPA and OSHA, impact process and product quality in pharmaceutical manufacturing, assessed using inspection outcomes by the FDA. We use the attention-based view to address the question of whether, in general, there is a comprehensive attention to compliance with regulations, or whether the attention to compliance gets divided among multiple regulations.

4 - Healthcare Reimbursement Policy Impact On Multiple-provider Readmission Reduction Programs
Jon M. Stauffer, Texas A&M University, College Station, TX, 77843, United States, Jonathan Eugene Helm, Kurt M. Brethauer

We examine the transition from Fee-for-Service to alternative reimbursement plans, such as bundled payments and the Hospital Readmission Reduction Program, and how this impacts the motivation for providers to reduce readmissions. Results show that bundled payment plans do motivate cost-effective readmission reduction effort from hospitals, but if post-discharge providers are included in the gain-sharing contracts they may perform insufficient or excessive effort. We discuss two redesigned structures (single-controlling provider and risk-adjusted) for bundled payment plans to address these readmission reduction effort misalignment issues.

Anqi Wu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Yixin Iris Wang

Understanding the interactions between multiple chronic conditions (MCC) and their evolution with time is an important and challenging problem. Graphical Models like Bayesian networks are often deployed to model their interactions and predict their future pathways toward developing new conditions. However, these interactions are often dynamic in nature and time-varying (non-linear). As a result, the underlying structure of the network also varies with time. To meet these challenges, this work utilizes a functional continuous-time Bayesian network to model the time-varying nature of MCC. In addition, we also adopted Model Predictive Control, an online, recursive inference procedure to examine the impact of various behavioral changes on the emerging trajectories of MCC and control the progression of chronic conditions in a patient with MCC.
3 - The Impact of Transparency on Drug Innovation

Hanu Tyagi, University of Minnesota, Minneapolis, MN, United States, Rachna Shah

Operational transparency in supply chains has shown benefits to firms in varied contexts and settings. However, there is little research on the impact of transparency on a firm’s propensity for product innovation. Using a uniquely curated dataset of pharmaceutical drug launches over a long period of time, we show how transparency in clinical trials leads to between- and across-firm knowledge spillovers thereby impacting drug innovation.

4 - Effects Of Telehealth And Ehr

Seung Jun Lee, Chung-Ang University, Seoul, Korea, Republic of, sjlee1@cau.ac.kr, Yerin Heo, Injoonhwan, Yongwon Seo

Due to the pandemic situation, the modern healthcare system is widely adopting various treatment services to improve care quality. One of the approaches relates to the telehealth, which refers to the use of electronic services to support a wide range of remote services, such as patient care, education, and monitoring service. Although such telehealth service may provide improved operational performance, few empirical literature explores the marginal impact of the telehealth service. Thus, this study discovers the impact of telehealth service on hospital performance.

5 - Path Dependency In Physician Decisions

Lawrence Jin, National University of Singapore, Singapore, Singapore, lawrencejin@gmail.com, Rui Tang, Han Ye, Junjian Yi, Songfa Zhong

We examine path dependency in physician decisions. In both emergency department visits and childbirth deliveries settings where the ordering of patients is conditionally random, we find that physicians’ treatment decision for the current patient is positively correlated with their decision for the previous patient. The estimated path dependency is stronger when consecutive patients share greater similarity, and when the current patient is associated with larger medical uncertainty. Our findings are consistent with memory and attention-based anchoring and adjustment mechanism, whereby treatment decision for the previous patient is used as a shortcut by physicians to make future treatment decisions.

6 - Learning In Drug Shortages

Hyun Seok (Huck) Lee, Korea University Business School, 3643 SE Shoreline Drive, Seoul, 97333-3235, Korea, Republic of, Junghae Lee, In Joon Noh

In this study, we investigate whether pharmaceutical manufacturing plants learn from their own drug shortage instances. Specifically, we examine if more drug shortages recovery at a plant lead to quicker recovery from its subsequent shortages. We also investigate factors that might affect this learning. Our findings will have policy implications for the FDA and will also contribute to the academic literature on learning.
This rate of regret matches the optimal one of the classic MAB problem $O(\sqrt{2n})$. In stage two, the policy explores the periodic mean rewards of arms using the Fourier analysis with a UCB-based learning procedure. In stage one, the model in which the mean rewards vary over time in a periodic manner. The consum Taylors have random attention spans and view the products sequentially before purchasing a "satisficing" product or leaving the platform empty-handed when the attention span gets exhausted. We show a nested structure of the optimal product ranking as a function of the attention span when the attention span is fixed and design a $1/\sqrt{\alpha}$-approximation algorithm accordingly for the random attention spans. When the conditional purchase probabilities are nonparametric estimators that use the control function approach, and versatile: can capture a wide class of regularization constraints on the mixing distribution. One method relies on reformulating the estimation problem as a constrained convex program and leverages the conditional gradient algorithm to generate the support of the underlying mixing distribution. Numerical experiments on synthetic data show that our method recovers a better approximation of the true mixing distribution compared to both the BLP and control function approaches.

3 - A Simulation-optimization Staffing Model To Improve Patient Flow And Patient Safety In The Emergency Department.
Vishnunarayan Girishan Prabhu, Clemson University, Clemson, SC, United States
Ronald G. Pirrillo, William Jackson, Michael Ramsay

Approximately 145 million patient visits are made to Emergency Departments (EDs) in the US annually. The diverse nature and overwhelming volume of patient visits to EDs make it predisposed to crowding, leading to reduced quality of care. This research focused on developing a simulation-optimization model to identify optimal physician staffing levels to minimize the combined cost of patient wait times, handoffs and physician shifts in the ED. By generating shift schedules using the optimization model and testing them in the validated simulation model, we observed that patient time in the ED and handoffs can be reduced by as much as 27% and 26% compared to the current practices.

4 - An Inventory-Routing Problem For Cooperative Hospital Supply Chain Operations
Silia Mertens, Hasselt University, Hasselt, Belgium, Lotte Verdonck, Lien Vanbrabant

A high amount of capital is tied up in hospital inventories because of the unpredictable demand and the severe consequences of a stock-out in critical materials. A way to reduce the amount of inventory while maintaining a high service level is inventory pooling. It requires re-engineering the traditional hospital SC into a cooperative SC consisting of a central warehouse that operates for multiple hospitals and replaces the central warehouse of each individual hospital. The aim of this research is to provide hospitals with new insights on how to improve the efficiency of their logistics processes, and on the optimal shaping and operational implementation of a cooperative hospital SC.

WVB14
Virtual Room 14
Data-driven Frameworks, Methods, and Applications in OM
Sponsored: Revenue Management and Pricing
Sponsored Session
Chair: Yingyu Chen, University of Toronto, Mississauga, ON, L5L 1C6, Canada

1 - Data Aggregation And Demand Prediction
Renzhu Zhang, New York University Shanghai, Shanghai, China, Maxine Cohen, Kevin Jiao

We study how retailers could use clustering techniques to improve demand prediction accuracy. A typical retail setting involves predicting demand for hundreds of products simultaneously. In this paper, we propose a practical method—referred to as the Data Aggregation with Clustering (DAC) algorithm—that balances the tradeoff between data aggregation and model flexibility. The DAC allows us to predict demand while optimally identifying the features that should be estimated at different aggregation levels. We analytically show that the DAC yields a consistent estimate along with improved asymptotic properties relative to the standard approaches. Using both simulated and real data, we demonstrate the improvement in prediction accuracy obtained by the DAC relative to several common benchmarks. Our results also yield useful managerial insights.

2 - Learning And Optimization With Seasonal Patterns
Longlin Wang, Tsinghua University, Beijing, China, Ningyu Chen, Chun Wang

The stationarity assumption of Multi-armed Bandits (MAB) can be restrictive in the business world as decision makers often face an evolving environment with time-varying mean rewards. In this paper, we consider a non-stationary MAB model in which the mean rewards vary over time in a periodic manner. The unknown periods of the arms can be different and scale with the length of the decision horizon T polynomially. For this setting, we propose a two-stage policy that combines the Fourier analysis with a UCB-based learning procedure. In stage one, the policy correctly estimates the periods of all arms with high probability. In stage two, the policy explores the periodic mean rewards of arms using the periods estimated in stage one and exploits the optimal arm in the long run. We show that our policy achieves the rate of regret $O(\sqrt{\log T})$, where $K$ is the number of arms and $T$ is the length of period of the $k$-th arm. This rate of regret matches the optimal one of the classic MAB problem $O(\sqrt{T})$ if we regard each phase of an arm in the period as a separate arm.

3 - Nonparametric Estimation Of Mixing Distributions In The Presence Of Endogeneity
Ashwin Venkataraman, University of Texas at Dallas, Jindal School of Management, Richardson, TX, 75080, United States
Srikanth Jagabathula, Sandeep Chitla

We propose a novel methodology for dealing with endogeneity in discrete choice models, that is nonparametric: does not make any assumption on the mixing distribution (addressing the classical BLP estimator’s limitation) but still allows for coefficients that are fixed across customers (addressing the limitations in prior

4 - Revenue Maximization And Learning In Products Ranking
Shuoguang Yang, Hong Kong University of Science and Technology, Hong Kong, China, Ningyuan Chen, Anran Li

We consider the revenue maximization problem for an online retailer who plans to display a set of products differing in their prices and qualities and rank them in order. The consumers have random attention spans and view the products sequentially before purchasing a "satisficing" product or leaving the platform empty-handed when the attention span gets exhausted. We show a nested structure of the optimal product ranking as a function of the attention span when the attention span is fixed and design a $1/\sqrt{\alpha}$-approximation algorithm accordingly for the random attention spans. When the conditional purchase probabilities are not known and may depend on consumer and product features, we devise an online learning algorithm that achieves $O(\sqrt{\alpha})$ regret relative to the approximation algorithm.

WVB15
Virtual Room 15
Choice, Data and Optimization for Assortment and Pricing
Sponsored: Revenue Management and Pricing
Sponsored Session
Chair: Ruxian Wang, Johns Hopkins University, Carey Business School, Kensington, MD, 20895, United States
Co-Chair: Chenxu Ke, Nanjing University, Nanjing University

1 - Product Price, Quality and Service Decisions under Consumer Choice Models
Chenxu Ke, Nanjing University, Nanjing, China, chenxu.ke@nju.edu.cn, Ruxian Wang, Shiliang Cui

In this paper, we develop an integrated framework to study a firm’s joint decision on product price, quality and service duration in a variety of monopolistic and competitive scenarios. We find that with multiple substitutable products being offered, it is sufficient for a firm to provide only two maximally differentiated service durations at optimality. The quality of each product should be set at a level such that the marginal utility to consumers equals the marginal cost to the firm, independent of the decisions on other products, whereas pricing decision should take into account all products.

2 - Assortment And Price Optimization Under The Threshold Utility Model
Zhuodong Tang, Hong Kong University of Science and Technology, New Clear Water Bay Road Kowloon Bay Kwun Tong, Hong Kong, NO, China, Guillermo Gallego, Ruxian Wang

We consider pricing and assortment optimization problems arising from the threshold utility model (TUM) under which consumers purchase all products whose net utility exceeds non-negative product-specific thresholds selected to maximize the total expected consumer surplus subject to a bound on the number of products purchased in expectation. For the monopolistic problem, we identify the conditions under which the multi-product price optimization can be efficiently solved. In the oligopolistic setting, we establish the existence of a Nash equilibrium under price competition and market share competition. We also investigate sequential games under which the threshold is updated periodically. The assortment optimization problem is NP-hard in general. We characterize polynomial-time solvable cases and develop efficient approximation schemes for general TUM.

3 - A Multi-choice Model With Context Effects
Xin Chen, UIUC, Transportation Bldg 104, Urbana, IL, 61801-2925, United States, Reza Yousefi Maragheh

Most of the existing papers in operations management assume a single-choice outcome when modeling choice selection behavior. In this paper, we develop a utility-based extension of the logistic regression, the Contextual Logit (CL) to model the choice selection of customers while allowing for multi-choice. Using the CL model, one can capture various complex contextual interactions among both complementary and substitute products. The predictive performance of this model is validated by comparing it with recent benchmark multi-choice models on 70 real data sets selected from diverse categories of products. We prove the NP-hardness of the Assortment Optimization Problem (AOP) under the CL model, and show that when some types of contextual interactions are dominant in data, the AOP is tractable. Efficient heuristics are proposed to solve the AOP under the general CL model.
A challenging aspect of the bandit problem is that a stochastic reward is observed only for the chosen arm and the rewards of other arms remain missing. Since the arm choice depends on the past context and reward pairs, the contexts of chosen arms suffer from correlation and render the analysis difficult. We propose a novel multi-armed linear contextual bandit algorithm called Doubly Robust (DR) Thompson Sampling that applies the DR technique used in missing data literature to Thompson Sampling with contexts (LinTS). The proposed algorithm improves the bound of LinTS by a factor of $\frac{1}{\sqrt{d}}$, where $d$ is the dimension of the context, under some regularity assumptions. A benefit of the proposed method is that it uses all the context data, chosen or not chosen, thus allowing to circumvent the technical definition of unsaturated arms used in theoretical analysis of LinTS.

2 - Contextual Pareto Bandit Under Covariate Shift
Apurv Shukla, Columbia University, New York, NY, 10025-1868, United States

We consider the contextual bandit problem under covariate shift and vectorial rewards. We propose a tree-based policy that maintains separately discretizes action and covariate spaces. For vectorial feedback, we use Contextual Pareto regret as the performance metric of the proposed policy. We establish an upper bound on the performance of the proposed policy for multiple-models of covariate shift including single, multiple and smoothly varying context distributions. Finally, the efficacy of the proposed policy is described on a suite of Atari-57 games.

3 - Taylor Expansion Policy Optimization For Scalable Off-policy Reinforcement Learning
Yunhao Tang, Columbia University, United States

In this talk, I will focus on a model-free off-policy reinforcement learning (RL) framework called Taylor Expansion Policy Optimization (TayPO). TayPO is a principled framework with important theoretical insights: it generalizes prior work on trust region policy search and draws close connections to operator-based off-policy evaluation. TayPO also entails empirical performance gains on large-scale distributed RL agents, such as R2D2 and IMPALA, when evaluated on Atari-57 games.

4 - Sparsity-Agnostic Lasso Bandit
Min-hwan Oh, Seoul National University, Seoul, 08826, Korea, Republic of, Garud N. Iyengar, Assaf Zeevi

We consider a stochastic contextual bandit problem where the dimension of the feature vectors is potentially large, however, only a sparse subset of features of cardinality $d$ affect the reward function. Essentially all existing algorithms for sparse bandits require a priori knowledge of the value of the sparsity index $s$. This knowledge is almost never available in practice, and mis specification of this parameter can lead to severe deterioration in the performance of existing methods. The main contribution of this paper is to propose an algorithm that does not require prior knowledge of the sparsity index $s$ and establish tight regret bounds on its performance under suitable regularity conditions. We also numerically show that it consistently outperforms existing methods, even when the correct sparsity index is revealed to them but is kept hidden from our algorithm.
2 - Understanding Differential Effects Of Social Network Capital
On The Crowdsourced Answering Process In Stack Overflow
Orçun Temizkan, Ozyegin University, Istanbul, Turkey, Ram Kumar
Virtual Question and Answer (VQA) communities are becoming increasingly important in today’s knowledge intensive environment. They represent a crowdsourced knowledge creation process that involves volunteer participants, and thus these are large repositories of online knowledge. A knowledge creation process may require different types and degree of social network capital of participants based on the complexity of the VQA process. We develop and empirically test models of the differential effects of social network capital on the VQA process. Empirical results based on data from Stack Overflow will be presented. Research and managerial implications will also be discussed.

3 - Team Alliance Strategies In Crowdsourcing Platforms
Sina Zare, Arkansas State University, Jonesboro, AR, United States
Various factors play crucial roles in team alliance that may originate from the tendency to work with those who have similar technical backgrounds. On the contrary, the lack of specific expertise may initiate alliance and collaboration across teams. This study investigates alliance strategies and motivations in crowdsourcing platforms.

VWB19
Virtual Room 19
Learning and Optimization in Decision Making
Sponsored: Revenue Management and Pricing
Sponsored Session
Chair: David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States
Co-Chair: Xiaoyue Gong, MIT, Cambridge, MA, 02139-4301, United States

1 - On Adaptivity and Confounding in Contextual Bandit Experiments
Chao Qin, Columbia University, Daniel Russo
Multi-armed bandit algorithms minimize experimentation costs required to converge on optimal behavior. They do so by rapidly adapting experimentation effort away from poorly performing alternatives as feedback is observed. But this desirable feature makes them sensitive to confounding. We highlight, for instance, that popular bandit algorithms can’t address the problem of identifying the best action when day-of-week effects may confound inferences. In response, this paper proposes simple, but critical, modifications to the Thompson sampling algorithm. Theoretical guarantees suggest the new algorithm strikes a delicate balance between adaptivity and robustness to confounding. It attains asymptotic lower bounds on the number of samples required to confidently identify the best action --- suggesting optimal adaptivity --- but also satisfies strong performance guarantees in the presence of day-of-week effects and delayed observations --- suggesting unusual robustness. These issues arise in a very general model of contextual bandit experiments. The paper includes several new results that advance previous theory of Thompson sampling in such problems, which may be of independent interest.

2 - Chasing Convex Bodies Optimally
Mark Sellke, Stanford University
I will explain our recent understanding of the chasing convex bodies problem posed by Friedman and Linial in 1993. In this problem, a player receives a request sequence $K_1, K_2, \ldots, K_T$ of convex sets in $\mathbb{R}^d$ and moves online into each requested set. The player’s movement cost is the length of the resulting path. Chasing convex bodies asks to find an online algorithm with cost competitive against the offline (in hindsight) optimal path. This is equivalent to a competitive analysis view on online convex optimization. Obtaining any finite competitive ratio for this problem was open until 2018. We give an optimal algorithm based on an object from classical convex geometry known as the Steiner point.

3 - Simultaneous Learning Of Consumer Preference Over Different Markets.
Fabrizio Previglano, University of Chicago, Chicago, Illinois, United States
We study the ranking and selection problem faced by a company that wants to identify the most preferred product among a finite set of alternatives when consumer preferences are unknown over different markets that may have similar characteristics. The company is able to sequentially display a subset of products to different customers on each market and ask them to report their top preference over the displayed set. The objective of the firm is to design a display policy that minimizes the expected number of samples needed to identify a top product on each market with a fixed high probability.

4 - Dynamic Planning And Learning Under Recovering Rewards
Feng Zhu, MIT IDSS, Boston, MA, United States, David Simchi-Levi, Zeyu Zheng
Motivated by emerging applications in promotions and recommendations, we introduce a general class of multi-armed bandit problems that satisfies: (i) at most K out of N different arms are allowed to be pulled in each time period; (ii) the expected reward of an arm immediately drops after it is pulled, and then non-parametrically recovers as the idle time increases. To maximize expected cumulative rewards over T time periods, we propose and prove performance guarantees for a class of “Purely Periodic Policies”. For the offline problem when all model parameters are known, our proposed policy obtains an asymptotically tight approximation ratio that is at the order of $1-O(1/K^1/2)$. For the online problem when the model parameters are unknown and need to be learned, we design an Upper Confidence Bound (UCB) based policy that has $O(NT/2)$ regret against the offline benchmark.

VWB20
Virtual Room 20
Markets and Service Systems
Sponsored: Applied Probability Society
Sponsored Session
Chair: Krishnamurthy Iyer, University of Minnesota, Saint Paul, MN, 55114-1380, United States

1 - Spatiotemporal Disease Transmission In Queueing System.
Shervin Doroudi, University of Minnesota, Minneapolis, MN, 55455-0150, United States, Kang Kang, Mohammad Delaey, Alexander Wickham
Motivated by the ongoing COVID-19 pandemic, we draw upon existing models of disease transmission to introduce a new framework for assessing the risk of infections in service facilities (e.g., grocery stores) that can be modeled as queueing systems. In our framework, the probability of disease transmission from one customer to another depends on both (i) the physical distance between these customers over time and (ii) the amount of time they spend together in the system. We leverage our framework to assess the impact of the choice of physical queuing layout design on transmission risks.

2 - SRPT In Multi-server Queues With Abandonment
Rouba Ibrahim, University College London, 1 Canada Square, School of Management, Level 38, C, London, E14 5AB, United Kingdom, rouba.ibrahim@ucl.ac.uk, Jing Dong
The shortest-resting-processing-time (SRPT) scheduling policy has been extensively studied, for more than 50 years, in single-server queues with introductory service. Yet, much less is known about its performance in multi-server queues. In this paper, we present the first theoretical analysis of SRPT in multi-server queues with abandonment.

3 - Behavior-Aware Queueing
Raga Gopalakrishnan, Assistant Professor of Operations Management, Smith School of Business at Queen’s University, Kingston, ON, Canada, Yueyang Zhong, Amy R. Ward
Service system design is often informed by queueing theory. Traditional queueing theory assumes that servers work at constant speeds. That is reasonable in computer science and manufacturing contexts. However, servers in service systems are people, and, in contrast to machines, both systemic and monetary incentives created by design decisions influence their work speeds. We study how server work speed is affected by decisions concerning (i) how many servers to staff, (ii) payment per service completion to servers, and (ii) whether and when to turn away customers, in the context of a finite-buffer many-server queue in which the work speeds emerge as the solution to a noncooperative game. This talk is complementary to Amy Ward’s talk in Session ID 912.
Different from recent studies that impose some priors on the latent image, this study is to jointly extract spatiotemporal (belonging to both space and time) variations to evaluate quality of the liver. To achieve this objective, we use techniques from time-vertex signal processing. In particular, we use joint Fourier transform (JFT) to extract features that contain information from both time and space domains. Then, we use a high-dimensional control chart to monitor the features and estimate the change point.

4 - Active Learning For Image Classification Of 2d Mos2 With Deep-reinforcement-learning-based Query Strategy
Zebin Li, University at Buffalo, SUNY, Buffalo, NY, United States, Fei Yao, Hongyue Sun
Molybdenum disulfide (MoS2) is one of the promising 2D materials that has nice properties and broad applications, especially in semiconductor devices. The commonly fabricating technique for 2D MoS2 is through chemical vapor deposition (CVD). However, the evaluation of the CVD-synthesized 2D MoS2 via optical images is time-consuming and heavy for researchers. In this work, we proposed an active learning image classifier with a deep-reinforcement-learning (DRL)-based query strategy. The classifier can reach a high accuracy with fewer labels required from researchers, which is able to reduce the workload of researchers. Compared with the uncertainty-based query strategy, the DRL-based query strategy improves the acquisition of effective information. This work shows the effectiveness of applying DRL in active learning and demonstrates a good integration of them.

5 - Inkjet Printing Droplet Evolution Prediction via Tensor Time Series
Luis Javier Segura, University at Buffalo, Buffalo, NY, United States, Zebin Li, Luis Javier Segura, Hongyur Sun
Droplet behaviors substantially determine the quality of the produced products in the Inkjet Printing (IP). The droplet formation mechanism (i.e., droplet evolution) understanding is fundamental for the process performance. This work investigates droplet evolution prediction via Tensor Time Series analysis. The method learns the spatial-temporal relationships by joining the force of Tensor Graph Convolutional Network (TGCN) and Tensor Recurrent Neural Network (TRNN). The method is tested in experimental and simulated droplet evolution data in the IP process.

6 - Suspicious Machine Selection In A Serial-parallel Multistage Manufacturing Process: Production Log Data-based Approach
Seung-Hyun Choi, Postech, Pohang, Korea, Republic of, cshyun102@postech.ac.kr, Dong-Hee Lee, Eun-Su Kim, Young-Mok Bae, Young-Chan Oh, Kwang-Jae Kim
Serial-Parallel multistage manufacturing process consists of multiple process stages, each of which has several alternative machines. Performance of machines in a process stage is not identical and faulty machine tends to produce more defective products. In order to reduce efforts for diagnosing faulty machines, it is desirable to first find machines that are suspected of being faulty, called suspicious machines. This study proposes a method to select suspicious machines using production log data, which record a sequence of operating machines for each product. The proposed method is illustrated using a case study on a ring-shaped pattern of defectives in semiconductor manufacturing process.
2 - Smart Sensor Fusion of Infrared and Ultrasonic Characterization for Additive Manufacturing Quality Control

Christiani Zamiela, Mississippi State University, MS, United States, ccc998@mstate.edu, Tianheng Guo, Christian Bian

The objective is to develop a deep fusion methodology for porosity detection using in-situ infrared and ex-situ ultrasonic images. A core problem with Laser-based additive manufacturing (LBAM) is that lack of fusion between successive layers of printed metal can lead to porosity and abnormalities in the printed component. We developed a deep fusion methodology that fills the gap in fusing in-situ images with ex-situ images to improve porosity detection. An ultrasonic infrared fusion network (UIF-Net), a deep fusion methodology for feature extraction of ultrasonic and infrared data is presented in this study. This is the first work for fusing in-situ infrared images and ex-situ ultrasonic scans using deep learning. The method is validated using real-world experiments, and the results show significant improvement in prediction accuracy via data fusion.

3 - A Prediction-oriented Optimal Design for Visualization Recommender Systems

Yingyan Zeng, Virginia Tech, Blacksburg, VA, United States, Xiwei Deng, Xiaoyu Chen, Ran Jin

A good visualization method can greatly enhance human-machine collaboration. Visualization recommender systems have been developed to provide the right visualization method to the right person in target contexts. A visualization recommender system often relies on a user study to collect data for personalized recommendations. However, a user study without an effective experimental design is expensive in terms of time and cost. In this work, we propose a prediction-oriented optimal design to determine the user-task allocation in the user study for the recommendation of visualization methods. The proposed optimal design will not only encourage the learning of the similarity embedded in the recommendation responses (i.e., users’ preference) but also improve the modeling accuracy of the similarities captured by the covariates of contexts (i.e., task attributes).

4 - Calibration And Validation For Lpbf Process Based On Models And Limited Experimental Data

Zhimin Xi, Rutgers University-New Brunswick, Piscataway, NJ, 08854, United States

To date, modeling techniques for the SLM process are either computationally expensive based on finite element (FE) modeling or economically expensive requiring significant amount of experiment data for data-driven modeling. We propose the combination of FE and data-driven modeling with systematic calibration and validation framework for the SLM process based on limited experiment data. The data-driven modeling is conducted based on virtual experiment data from the FE modeling instead of the real experiment data, and its accuracy is later improved based on limited real experiment data through the calibration and validation framework. The proposed work enables the development of highly efficient and accurate models for melt pool prediction of the SLM process under various configurations.

5 - Digital Twin To Enable Closed Loop Control Of Additive Manufacturing Processes

Jun Zeng, HP Labs, 1501 Page Mill Road, Palo Alto, CA, 94304, United States

While additive manufacturing sees accelerated applications in volume production, higher production yield competing with mainstream manufacturing will demand more sophisticated process control to deliver final products in both geometry and function with precision. We develop Digital Twin that replicates virtually the dynamics of manufacturing processes and product evolution. It exploits processing and sensing dataset collected to ensure prediction specificity overcoming process variations. It is deployed as closed loop control of additive manufacturing process flow in the form of automated product design correction and automated process tuning.

\[ \text{WVB25} \]

Virtual Room 25

Robust Prescriptive Analytics

Sponsored: Manufacturing and Service Operations Management Sponsored Session

Chair: Qinshen Tang, Nanyang Technological University, Singapore, 639798, Singapore

1 - Vehicle Repositioning under Uncertainty

Yu Zhang, Southwestern University of Finance and Economics, Northeastern University, Wenhua Road., Hejing Dis, Chengdu, 110819, China, Melvyn Sim, Qinshen Tang, Minglong Zhou

We consider a general multi-period repositioning problem in vehicle-sharing networks. This problem is subject to uncertainties along multiple dimensions and faces several operational constraints such as the service level and cost budget. We propose a robustness optimization model to tackle these uncertainties; thus we aim to satisfy operational constraints under a reference distribution yet also to protect against ambiguity in the true distribution. This paper is the first, as far as we know, to incorporate various time-dependent uncertainties. We then reformulate the model and efficiently obtain solutions by solving a sequence of mixed-integer linear optimization problems. Extensive simulation studies demonstrate that our model yields remarkable performance in various settings and is computationally scalable.

2 - The Analytics Of Robust Satisficing

Minglong Zhou, NUS, 1 Business Link, Singapore, 117592, Singapore, Melvyn Sim, Qinshen Tang, Taozeng Zhu

While there are many prescriptive analytics tools for maximizers, it is not the case for satisficers who are content with attaining a reasonable target. We develop a new optimization framework called robust satisficing to help a satisficer achieve her target expected reward under risks and prediction uncertainty. We extend the robustness optimization framework to incorporate predictions. We adopt linear regression as the predictive model and propose a estimator uncertainty and residual ambiguity set. We present useful robust satisficing models and provide approximations for adaptive linear optimization problems. Simulation studies elucidate the benefits of our framework in helping the firm attain the target expected profits, mitigate shortfalls, and limit target surplus. Paradoxically, maximizers can also benefit from the analytics of robust satisficing.

3 - Robust Capacity Management With Multiple Demand Classes

JUN Jiang, National University of Singapore, Singapore, Zhenyu Hu, Long He

We consider the demand matching problem of one product and multiple demand classes where demand distribution varies. We propose a conic programing formulation for the single-period Distributionally Robust Optimization (DRO) model under the Wasserstein ambiguity set. We provide a conic programming formulation for the multi-period DRO model is a rationing-level policy when demands are assumed to be temporally independent and ambiguity sets are rectangular. Efficient solution approaches are provided when distance of demands are defined in 1-norm or ∞-norm.

4 - Joint Prediction And Optimization For Multiproduct Pricing And Inventory Management

Qinshen Tang, Nanyang Technological University, Division of IT & Operations Management, 50 Nanyang, Singapore, 639798, Singapore, Ying Rong, Xin Zhang

We adopt the robust satisficing (RS) framework in Sim et al. (2021) to explore the multiproduct pricing and inventory management problem with covariate information. The RS model is reformulated into a second order conic programming problem. Our extensive numerical studies demonstrate that the RS model can be solved efficiently, and the RS model outperforms the empirical optimization model.

\[ \text{WVB26} \]

Virtual Room 26

Blockchain in OM

Sponsored: Manufacturing and Service Operations Management Sponsored Session

Chair: Dmitrii Sumkin, INSEAD, INSEAD, Singapore, 138676, Singapore

1 - Pricing In Service Platforms: Who Should Set The Prices?

Tolga Dizdarer, Wharton School of Business, Jon M. Huntsman Hall 3730 Walnut St 533.1, Philadelphia, PA, 19104-3615, United States, dizdarer@wharton.upenn.edu, Gerard P. Cachon, Gerry Tsoukalas

Motivated by emergence of blockchain-based decentralized service platforms and Uber’s recent driver-pricing practice in California, we investigate how a platform with large supply should set its fares when service providers are heterogeneous in costs. We use a stylized model to compare two prevalent methods in practice: platform-pricing, where the platform sets the prices for all servers, and server-pricing, where prices are defined by the competitive equilibrium of server decisions. We then, compare these methods to an optimal contract.
3 - Blockchain-Enabled Deep-Tier Supply Chain Finance
Fasheng Xu, Syracuse University, 721 University Avenue, Syracuse, NY, 13244-4418, United States, Lingxiu Dong, Yunze Qiu
For many supply chains, deep-tier suppliers, due to their small sizes and lack of access to capital, are most vulnerable to disruptions. In this paper, we study the use of advance payment (AP) as a financing instrument in a multtier supply chain to mitigate the supply disruption risk and compare the traditional system (deep-tier financing with limited visibility) with the blockchain-enabled system (financing with perfect visibility). The main goal of this paper is to shed light on how blockchain adoption impacts agents' operational and financial decisions as well profit levels in a multtier supply chain.

4 - Optimal Cash Management With Payables Finance
Xiaoyue Yan, Cornell University, Ithaca, NY, United States, xy393@cornell.edu, Li Chen, Xiaoao Ding
Payables finance provides a supplier with the option to receive a buyer’s payables early while allowing the buyer to extend its payment due date. Its recent adoption of blockchain technology has made the process more efficient and secure. In this paper, we study the supplier’s optimal cash management policy under such a “frictionless” payables finance arrangement, based on which we quantify the value of payables finance to the supplier and also determine the equilibrium payment term extension for the buyer. Our work extends the classic cash management models to allow all interest gains and costs to accure together with the cash balance. Our analysis reveals that the optimal cash policy has a cash balance-dependent (L, M, U) structure. We show that it is the cash liquidity enabled by payables finance to hedge cash flow uncertainty that generates value to the supplier.

5 - Selecting Remanufacturing Technology From The Perspective Of Assortment Planning
Ying Cao, Assistant Professor, Penn State Erie The Behrend College, Erie, PA, United States, yxc673@psu.edu, Kai Meng, Xianghui Peng
In a closed-loop supply chain, manufacturers are often exposed to various remanufacturing method alternatives. Choosing a subset of the potential options is a crucial decision for both profit and environment. We study the selection of remanufacturing technologies from the perspective assortment planning. We explore different demand models and develop properties of the optimal solution and managerial insights. In addition, we study the impact on the manufacturer’s profit from influencing the collection rate of end-of-life (EOL) product(s).

VWB27
Virtual Room 27
Sustainable Operations
Contributed Session
Chair: Ying Cao, Penn State Erie The Behrend College, 6390 Pond Vw, Fairview, PA, 16415, United States
1 - Examining The Sustainability Frontier: Sustainability Performance Versus Efficiency Meltem Denizel, Associate Professor, Iowa State University, Ames, IA, United States, mdenizel@iastate.edu, Yiming Zhuang, Frank Montabon
Sustainability undertakings require efficient use of resources to achieve the desired performance. This leads to the question of how efficient companies are in their sustainability practices. Relying on data from CSRHub, we employ DEA to evaluate the sustainability efficiency of 1141 large U.S. manufacturing companies from 2009 to 2018.

2 - Responsible Sourcing Traceability Jen-Yi Chen, Cleveland State University, Cleveland, OH, United States, jchen27@csuohio.edu
This paper aims to answer two questions: first, why some companies would rather risk great and costly reputational damage than trace the provenance of their projects and thus not fully comply with transparency regulations while the other companies of similar kinds would do the opposite? Second, what can external stakeholders, like government agencies, NGOs or investors, do to not just encourage more supply chain transparency but more importantly more responsible supply chains?

3 - Green Tech, Social Media And Uncertainty Wenqing Zhang, University of Minnesota Duluth, Duluth, MN, United States, Prasad Padmanabhan, Chia-Hsing Huang, Rajesh Raagurur
There has been increased pressure by a variety of internal and external stakeholders to persuade firms to invest in green technologies. For example, firms face social media pressures to adopt policies that promote non-financial objectives of the community. The adoption of green technologies by firms may provide benefits that do not exceed the costs of adoption many may seek alternate non-green methods that can provide output that can achieve a satisfying level of strategic performance. We use a game theoretic model to see how social media affect the green technology adoptions.

4 - Acquisition Of Used Products For Remanufacturing Akshay Mitha, University of Vermont, Burlington, VT, United States, akshay.mitha@uvm.edu, Saurabh Bansal
We develop models to analyze the process of acquiring used products for remanufacturing. We perform numerical analyses to show the applicability of our models.
1 - Operations Research Improves Biomanchuring Efficiency At MSD
Annick Nusselder, MSD Animal Health, Boxmeer, Netherlands, annicknusselder@gmail.com, Tuigce Martagan, Geert-Jan Houtum
Biom anchuring methods use living organisms to generate active ingredients, and this leads to challenges that are different to those incurred by other industries. We present a portfolio of optimization models and decision support tools to reduce biom anchuring costs and lead times. Real-world implementation at MSD resulted in 50 million savings.

2 - ONLINE LEARNING AND EDUCATIONAL INEQUALITY
Zhanzhi Zheng, Tianjin University, Tianjin, China, zzz15241179@tju.edu.cn, Ruomeng Cui, Shenyang Jiang
Online learning changes the learning environment compared to the brick-and-mortar learning at schools. The COVID-19 pandemic has forced students to face the sudden transition to online learning, leading to significant changes in home and school learning environments. How such huge and sudden changes in the learning environment affect educational inequality between students in high-resource and low-resource areas is an interesting and important research question. In this research, we use the performance of high schools in China at the national college entrance examination (NCEE) from 2018 to 2020 to answer this question. Results suggest that after transitioning to online learning, learning outcomes of students in low-resource areas have increased 20.44 percent relative to students in the high-resource areas, reducing educational inequality.

3 - Simulating Patient Backlog Mitigation Strategies For Non-emergency Procedures Under Reduced Capacity During The Covid-19 Pandemic
Aidan Haase, University of Michigan, Department Of Ioe 1205 Real Ave, Ann Arbor, MI, 48109-2117, United States, haasea@umich.edu, Adam VanDeusen, Amy Cohn, Sameer Saini, Jacob Kurlander
COVID-19 impacted the healthcare system in many ways, including the cancellation or deferral of non-urgent appointments due to reducing capacity to keep patients safe and abide by governmental orders. This capacity reduction led to a backlog of patients waiting for appointments. We developed a discrete-event simulation to model how a clinical facility may triage patients to either alternative or delayed appointment options. Our model considers tiered reopening stages, in which appointment capacity is incrementally added back as restrictions are loosened. We applied our model to outpatient endoscopy procedures at a Veterans Affairs (VA) clinic in Ann Arbor, Michigan. We considered patients at different risk levels who arrive each week and are seen by providers, with the highest priority patients being seen first and lower priority patients waiting in a queue.

1 - Information Updates In Supply Chains: Roles Of Blockchain
Xiutian Shi, Nanjing University of Science and Technology, Nanjing, China, xshi@njust.edu.cn, Yujun Cai, Tsan-Ming Choi, Suresh Sethi
Today, emerging technologies such as data analytics and blockchain can improve supply chain operations by updating information to reduce demand uncertainty and improving data quality. We conduct a theoretical exploration of the values provided by such technologies in the context of a newsupplier supply chain facing a normally distributed demand with an unknown mean. We use Bayesian learning to reduce demand uncertainty based on the observation data, and discuss the expected value of information. We then study the "asymptotically perfect coordination" challenge and extend the analysis to examine the case when blockchain is used for product information disclosures.

2 - Manufacture Selection In Multinational Supply Chain Based On Tariffs And Lead Time Compression
Feiyang Huang, Tongji University, Shanghai, China, shiningfeiyang@163.com, Jian Zhou, Chunyan Duan
Under the background of increased tariffs and uncertain market demand, this study establishes the newsupplier model consisting of a retailer and two multinational manufacturers. By quantifying tariffs and lead time, the impact on the selection of manufacturers is analyzed with simulation. The results show that, for short-life cycle products, compressing the lead time can offset the impact of tariffs and bring more benefits.

3 - Information Sharing In The Online Marketplace When Competing Sellers Make To Stock
Hu Huang, School of Business and Management, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, Hongtiao Zhang
We investigate the incentives for information sharing in a marketplace where multiple sellers distribute their partially substitutable products through a common online platform. The platform has information about the market state and may choose to share it with the sellers when they make stock decisions. Our analysis shows that the platform’s information sharing decision depends on the stock cost, commission rate, and competing intensity. The platform should share information with more sellers when the stock cost is high, the commission rate is low, or the competing intensity is low. Besides, information sharing always benefits the informed seller while hurts the uninformed one.
When a weak-brand firm and a strong-brand firm source from a common contract manufacturer, the weak-brand firm may advertise this relationship to promote its own product. This paper investigates whether the weak-brand firm should use such brand spillover as a marketing strategy and how this decision depends on the firm’s characteristics and market conditions.

2 - Green Packaging Or Greenwashing? Implication Of Bring-your-own-container

Yunlong Peng, Tsinghua University, Beijing, China, pengyl.17@sems.tsinghua.edu.cn, Fei Gu, Jian Chen

Bring your own container/cups, i.e., BYOC has become a new prevalent trend among eco-conscious consumers in the restaurant industry. In response to consumers’ environmental concerns, restaurants can make a choice between offering the green foodservice packaging or just engaging in greenwashing. In this paper, we develop a stylized model to study the impacts of BYOC on a firm’s foodservice packaging decisions. We further study the scenario where greenwashing is stopped. Firstly, we find that the emergence of BYOC might promote rather than discourage the firm to choose green packaging or greenwashing. Secondly, with the existence of BYOC, stopping greenwashing might increase the profit of greenwashing firms but decrease the profit of green firms. Finally, stopping greenwashing could generate a negative impact on the environment when consumers’ hassle cost is moderate.

3 - Retail Power: A Double Edged Sword For Suppliers

Shuya Yin, University of California-Irvine, Paul Merage School of Business, Irvine, CA, 92697-3125, United States, Yuhong He, Saibal Ray

In distribution channels, growing power of downstream firms (retailers) is a cause of both pleasure and pain for their upstream partners (suppliers). On one hand, suppliers rely on these key retailers to generate sales. On the other hand, these retailers may have the standing to negotiate vigorously on issues like sharing of channel revenues. We use an analytical model to explore how the level of competition from other channels shape a supplier’s perspective about retail power: specifically, her preference about the structure of downstream retail distribution channel for her own product variants.

4 - Needs Title

Xingyu Fu, Hong Kong University of Science and Technology, Kowloon, Hong Kong, xfua@connect.ust.hk, Ying-Ju Chen, Guillermo Gallego, Pin Gao

We study how a revenue-maximizing platform implements a new policy, from which a representative retailer also experiences a private externality. Our analysis suggests that: (1) when the policy is highly valuable for the platform’s own interest, the platform may charge a fee from the retailer and then promise a less aggressive policy coverage; (2) when the policy is considerably expensive, in order to implement it, the platform may compensate the retailer and then share the full pie of the latter’s revenue; (3) when the policy is mediocre to the platform, a hybrid occurs, where the platform may either charge a fee from the retailer or compensate to capture a portion of the retailer’s realized revenue. Lastly, we carry out a series of comparative statics to show the impact on policy implementation when the externality distribution and the platform’s self-interest change.

Modern slavery in supply chains warrants attention (New, 2015), but few papers on modern slavery exist in supply chain literature. Techniques are needed to detect forced labor and predict how likely a given product, sourced from a given place, was made using slave labor. To this end, we apply a new methodological approach to preventing modern slavery in supply chains.

2 - Coordination Of A Green Industry 4.0 Supply Chain

Peral Toktas-Palut, Dogus University, Istanbul, Turkey, ppalut@dogus.edu.tr

Due to the deteriorating environmental conditions, eco-friendly production is gaining more importance. This awareness has also affected the consumers so that the demand for green products is increasing. Industry 4.0 technologies are also expected to have positive effects on the environment. This study analyzes the coordination of a green Industry 4.0 supply chain serving a green-conscious market. A two-part tariff contract is developed for this purpose. The results denote that the economic and environmental sustainability of the supply chain increases through coordination.

3 - A Dynamic Model Considering Consumer Green Awareness And Environmental Subsidy

Xin Liu, Elon University, Elon, NC, United States, xliu3@elon.edu, Xiaoya Han, Moutaz J Khouja

We minimize a firm’s green level decisions considering consumer green awareness in a dynamic environment. The firm has the option of committing to a green level above the minimal regulatory green level (ARGL) and receive governmental subsidy depending on how much its green level in each period exceeds the ARGL.

4 - Supply Chain Management And COVID-19: Scientometric Analysis

Olga Biedova, Assistant Professor, College of Charleston, Charleston, SC, United States, biedova@cofc.edu, Maryam Mahdikhani

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

5 - Pareto Optimality And Contract Dependence In Supply Chain Coordination With Risk-averse Agents

Juzhi Zhang, University of Science and Technology of China, Hefei, China, Suresh P. Sethi, Tsan-Ming Choi, Edwin Cheng

This paper studies supply chain coordination (SCC) with risk-averse agents. We first explore the existing related literature and find that various definitions of SCC have been proposed to investigate SCC with risk-averse agents, among which the one based on the concept of Pareto optimality (PO) stands out. We then discuss the challenges of coordinating a supply chain under the PO criterion, notably the contract dependence of the achievability of PO. Finally, we provide methods and suggestions for SCC when it is impossible to establish PO.

1 - Unmasking Sex Trafficking Supply Chains With Machine Learning

Pia Ramchandani, Wharton School, 3730 Walnut Street, OID Dept, Fl 5, Philadelphia, PA, 19104, United States, piar2@wharton.upenn.edu, Hamsa Sridhar Bastani, Emily Wyatt

The covert nature of sex trafficking provides a significant barrier to generating large-scale, data-driven insights into the larger social context of the practice. We leverage massive deep web data in tandem with a novel machine learning framework to unmask recruitment-to-sales pathways, thereby providing the first global network view of sex trafficking supply chains. Key challenges to inferring supply chain relationships include the unscalable dataset, the objective mismatch; our framework addresses these issues through natural language processing, active learning, and domain expertise.
2 - Why Do Women Struggle To Climb The Corporate Ladder? 
Evidence From Retail Frontline Managers
Lauren Xiaoyuan Lu, Dartmouth College, 100 Tuck Hall, Hanover, NH, 03755-9080, United States, laurenx.lu@tuck.dartmouth.edu, Ruorun Chen, Susan F. Lu, Simin Huang
Today women are still struggling to climb the corporate ladder. While existing gender studies have focused on individual workers or C-suite executives, why men climb the corporate ladder faster than women remains a mystery. To fill this void in the literature, we explore gender differences and disparities in low-level management by empirically investigating the performance of frontline managers in a large sportswear retail chain. We observe a substantial performance gap between male and female managers. After matching stores based on sales-potential characteristics, the performance gap becomes quantitatively and statistically insignificant. These results suggest that the seemingly large gender gap in managerial performance reflects the fact that store assignment is inequitable across genders.

3 - Browsers Don’t Lie? Gender Differences In The Effects Of Covid-19 Lockdowns On Digital Activity And Time Use
Amalia R. Miller, University of Virginia, Charlottesville, VA, United States, Kamalini Ramdas, Alp Sungu
We study gender differences in the impact of the initial COVID-19 lockdown in India on internet activity. Our data combines survey data with URL-level internet browser history. Browser data provide an objective measure of online activity before and during the lockdown without reporting or recall biases. Online activity, as measured by time spent on clicks, increased substantially for both men and women, but men increased their activity levels by significantly more. The gender gap in response to the lockdown is present overall and within categories, such as production, leisure, and job search. It is driven mainly by parents. In our survey, men and women both report substantial increases in time devoted to domestic production. Surprisingly, men report significantly larger increases in childcare time than women do. Female respondents do not report the same about their spouses.

4 - The Last Crack To Break The Glass Ceiling - Examining How The CEO Influences TMT Gender Heterogeneity
David Bendig, Professor, University of Münster, Münster, Germany
Academia and practice agree that top management team (TMT) gender heterogeneity is beneficial for firm performance and firms implemented various initiatives to promote gender heterogeneity. Still, the glass ceiling seems to be hard to crack and many TMTs remain homogenous. The CEO decides who enters the TMT. We take an upper echelon view and scrutinize how CEO characteristics drive TMT gender heterogeneity. We draw on a sample of 561 500 firms from 2006 to 2017 to test our hypothesis. We find that CEOs’ narcissism, gender, and functional variety are significant predictors of TMT gender heterogeneity. Our findings contribute to TMT composition and diversity research.

3 - What Would The Simulated Climate And Optimal Policy Be If A Two-sector DICE Model Used
Liao Hua, Beijing Institute of Technology, 5 ZHONGGUANCUN SOUTH STREET, Beijing, 100081, China, liaohua55@163.com, Huiying Ye
Highly aggregated Integrated Assessment Models (IAM) capture limited information of economic structure. We modify DICE by diverging the output into consumer and capital goods, and consider their quite different characteristics of embodied carbon intensity and climate vulnerability. Under optimal policy path comparing with the modified model, the aggregate DICE-like model overestimates GDP growth, investment rate and CO2 emissions. As for policy variables, it overestimates the emission control rate as well as carbon tax.

WVB36
Virtual Room 36
Environment, Energy, and Natural Resources II
Contributed Session
Chair: Diwas Paudel, University of South Florida, Tampa, FL, 33613, United States
1 - Optimized Lease Planning For Real Estate Portfolios
Claudio Gambella, Research Staff Member, IBM Research Europe, Dublin, Ireland, Michael Barry, John D. Sheehan, Joern Ploenngis
Real Estate has long been the second or third highest annual operating expense for companies after labor cost. Real Estate portfolios therefore need to be both cost-effective and aim for an efficient utilization of space through optimized decisions on which leases should be adopted, dropped or extended.
We introduce an Integer Linear Programming formulation for Portfolio optimisation. The modelling framework identifies and evaluates several metrics that make certain leases preferable to others. We conduct numerical simulations on Lease Datasets in Real Estate Portfolio Management.

2 - Demand Response For Natural Gas Subject To Pipeline Network Constraint
Juyu Ju, Postdoc, Los Alamos National Laboratory, los alamos, NM, United States, hufuyu2010@gmail.com, Kaarthik Sundar, Shiriram Srinivasan, Russell Bent
Increasing Natural Gas (NG) needs of residential customers during the winter months presents an opportunity for developing NG-only Demand Response (DR) programs. This talk will introduce a simple NG-only DR program using Mixed-Integer Linear Programs for residential customers, show the benefits of such a program in simulation and discuss challenges, both research and technological, that need to be addressed to bring these programs into practice. The results highlight that DR brings significant benefits to residential users in terms of consumption savings and performance gains.

3 - Analysis Of Sales Of Electric Vehicles And Charging Infrastructure In Mexico
Adrian Ramirez Nafarate, Professor, Universidad Panamericana, Zapopan, Jalisco, Mexico, adrian.ramirez@asu.edu, Hugo Briseño, Ozgur M. Araz
In Mexico, the sales of electric and hybrid vehicles have also increased significantly between 2016 and 2020. However, compared with the sales of conventional vehicles, the EVs represent a very small proportion. In this presentation, we explore the factors associated with the adoption of EVs in Mexico using a linear regression approach and also present a simulation model to evaluate the charging infrastructure for interurban travel. The results show a high correlation between EV sales and sustainable practices in the states of Mexico and the need for more charging stations to allow low-range EVs travelling between main cities.

4 - Fleet Size And Charging Infrastructure Capacity For Ridehailing Services Using Autonomous Evs
Diwas Paudel, University of South Florida, Tampa, FL, United States, Tapas K Das
We develop a robust stochastic mixed integer model which, for any given part (percentage) of the current demands in the city that the SAEV fleet might intend to serve, yields optimal SAEV actions and corresponding capacity plan (fleet size and charging infrastructure) that maximizes profit. The model solution yields optimal capacity plan, which varies depending on the decision makers choice of the level of conservatism towards robustness. Expansion of the existing capacity to meet an increased demand and sensitivities of battery capacity and power network configurations are also explored.

2 - Dynamic Subsidy Policies With A Renewable Energy Target
Lei Zhu, Beihang University, Beijing, China, leizhu@buaa.edu.cn, Junqi Liu, Wei Zhang
This paper offers insights into quantifying FITs levels for the policy-makers to match the expected installed capacity target with minimum policy costs under uncertainty. We incorporate real options and stochastic dynamic programming to model the strategic behaviour between Policy-maker and investor while considering the learning effects of costs and the intermittent nature of renewable energy generation. An approach that combines binary tree scenarios generation and a least squares Monte Carlo method is adopted for the numerical solution to obtain the optimal FITs plan in practice. China’s offshore wind power investment is used as a case study to investigate the relationships among the optimal dynamic FITs level, total policy costs, the expected capacity target, and learning effects.

2 - Effectiveness Of Electric Vehicle Subsidies In China: A Pane Study
Tong Zhang, Australian National University, Australia
EVs are likely to emerge as the main means of zero-carbon road transport, and China is ahead of many other countries in terms of adoption. This study estimates the effect of EV purchase subsidies on the adoption of EVs for prefecture-level cities in China over January 2016-December 2019. The findings suggest that a 1,000 CNY increase in the per-vehicle purchase subsidy for domestic EVs on average leads to a 2-7% increase in uptake. However these subsidies drive a large uptake of imported EVs. Higher awareness of subsidies among consumers is associated with a larger proportion. Simulations indicate that an increase in the per-vehicle purchase subsidy on EVs in China is able to reduce CO2 emissions at a subsidy cost of about 589CNY (US$94) per tonne.
5 - EFFICIENT EV CHARGING VIA THROUGHPUT MAXIMIZATION
Yize Chen, University of Washington, Seattle, WA, United States, yizechen@uw.edu

The proliferation of electric vehicles calls for reliable and efficient operations of EV charging stations, which are often limited by the charging capacity and electrical network constraints. In this talk, by taking the state-of-charge information into account, we formulate the EV charging problem as a throughput maximization problem. The resulting adaptive charging algorithm can not only serve the most charging sessions, it can only schedule the charging rate by respecting the charging rate and demand congestion constraints.

### VWB37

Virtual Room 37


**Sponsored: ENRE/EnergyClimate**

**Sponsored Session**

Chair: Michael R Davidson, University of California, San Diego, University of California, San Diego, La Jolla, CA, 92093, United States

1 - **Renewable Energy Expansion In The Western U.S. Under Political Constraints**

Fikri Kucuksayagil, University of California San Diego, 8202 Regents Road Unit 304, San Diego, CA, 92122, United States, kucuksayagil@gmail.com, Michael R. Davidson

The Western U.S. will need to install 500-600 GW of wind and solar power by 2050 in order to stay on track for global targets to mitigate climate change. Building an integrated renewable energy system will require increases in flexibility and coordination across eleven states in the West. However, states differ in their policies on key renewable energy-enabling policies and steps such as renewable portfolio standards / clean energy standards, net-metering, regionalizing system operations, and transmission build-out. We analyze region-wide market operation with such political realities. Using an optimization model, we consider capacity and operational decisions in 2030 and 2045 given scenarios of state alignment by policy area. We consider in detail the current status and projected pipeline of transmission projects in addition to upgrade potentials.

2 - **Racial Equity in Energy and Sustainability: A Case Study in Mexico**

Rodrigo Mercado Fernandez, Appalachian State University, 1137 West Grace Street Apt 206, Richmond, VA, 23220, United States, rdmorfedez@gmail.com, Erin Baker

Using Mexico as a case study, we employ a bottom-up model of the electrical system to identify critical geographic areas of investment for installed capacity and transmission that are robust across a set of climate mitigation pathways derived from multiple Integrated Assessment Models. We find that more diverse energy portfolios are associated with relatively less transmission investment; and that despite a lack of robustness in the location of installed capacity investments, investment in transmission expansion is fairly robust across pathways.

3 - **Exploring The Role Of Electric Vehicles In Africa’s Energy Transition**

Michael DiOia, Carnegie Institution for Science, Stanford, CA, United States, mdioia@carnegiescience.edu, Lei Duan, Tyler Ruggles, Sara Bellocchi, Ken Caldeira

We employ a bottom-up modelling framework to examine the interplay of electric vehicles (EVs) and variable renewables (VRE) in Africa using Nigeria as a case study. Our results indicate that despite having a natural gas-dominated electricity system, the deployment of EVs can support the decarbonization of the Nigerian transport sector but at a relatively high cost. The cost of EVs would need to drop by ~40% to become cost-competitive. However, if VRE delivers the EVs power requirement with a bidirectional smart charging strategy, then the cost of EVs would need to decline by only ~30% to be a cost-effective option. Not all EVs need to participate in a bidirectional charging strategy in order to realize its full benefit; there is substantial benefit from flexibility in charging loads. Robust policies are needed to support EVs.

4 - **Energy Pathways For Southern Africa Under Socio-environmental Constraints And Climate Risks**

Ranjit Deshmukh, Assistant Professor, University of California Santa Barbara, Santa Barbara, CA, United States, AFM Kamal Chowdhury

The Southern African Power Pool, a twelve-country regional grid, is a unique power system because of its significant potential for all major generation fuels or technologies -- coal, natural gas, large hydropower, nuclear, wind, and solar -- to meet future electricity demand. We employ a modeling framework that combines geospatial (MapRE), hydrologic (VIC-Res), and electricity grid-investment (GridPath) models to study cost and emissions impacts of different energy pathways for southern Africa under technical, economic, and socio-environmental constraints and climate change risks that especially affect renewable energy siting and hydropower sustainability. Our results inform the strategic planning of generation capacity and transmission interconnections to affordably and reliably meet southern Africa’s rapidly growing energy demand.

### VWB38

Virtual Room 38

**Quantitative Approaches for Conservation, Natural Resource Management, and Energy**

**Sponsored: ENRE/Environment and Sustainability**

**Sponsored Session**

Chair: Ted Pavlic

1 - **The Value Of Remotely-Sensed Data In Terrestrial Habitat Corridor Design For Large Migratory Species**

Kailin Kroetz, Assistant Professor, Arizona State University, Tempe, AZ, United States, Kailin.Kroetz@asu.edu, Bryan Leonard, Arthur Middleton

Cost-effective conservation program design to support seasonal migratory species is urgently needed but is challenging and costly to implement in practice. Specifically, migratory species traverse large spatial scales and require path connectivity to complete migrations. However, the seasonality of migrations presents opportunities for cost savings relative to traditional species conservation approaches that involve year-round purchases or easements. These saving may be enhanced by advances in satellite data enabling tracking of animal movement and habitat quality. We use an integer programming approach to develop landscape-scale conservation plans for migratory species in the Greater Yellowstone Ecosystem and compare outcomes with and without high resolution satellite data.

2 - **Evaluation Of United States Biomethane Policies For Promoting Sustainable Use Of Resources**

Nathan Parker, Arizona State University, Tempe, AZ, United States, nc.parker@asu.edu

Biomethane from wastes promises to fulfill multiple sustainability goals but faces challenges in costs and local impacts. A range of federal, state and local policies are in place to encourage the development of this resource. This study evaluates the potential supply of biomethane in the United States using mixed integer programming to optimize the siting of infrastructure to bring the supplies to market. The expected industry with the existing policy mosaic is compared with optimal industry designs to maximize climate mitigation, minimize exposure to pollutants and maximize resource efficiency.

3 - **Interactions Between Lithium Mining, Aquifer, and Local Communities in Salar de Atacama, Chile: An Agent-based Model**

Wenjuan Liu, Arizona State University, Tempe, AZ, United States, Datu Buyung Agusdinata

The local impacts of lithium (Li) mining are not well understood. The study develops an agent-based model applied to the lithium mining industry in Salar de Atacama, Chile, to understand how Li-brine pumping behaviors of the mining industry affect the groundwater movements and stress dynamics of local livelihoods under different future mining scenarios. We investigate how uncertainties in the groundwater system affect the stress dynamics of social actors and find these uncertainties delay feedbacks to the social system, leading to mismatched evolution of dynamics in both systems. We suggest possible ways to build livelihood resilience and incorporate such ways into model improvement.
1 - Inefficient Tariffs and the Escalating Welfare Losses
Associated with Distributed Energy Resource Deployment
Niall Farrell, Queen’s University Belfast & Economic and Social Research Institute, Dublin, Ireland
Distortionary electricity tariffs create a platform for growing welfare losses with expected technological change. If tariffs are inefficient, utilities may adjust their tariffs on foot of changes in demand, to recover costs. Deployment of distributed energy resources (e.g. solar) benefits adopters at the expense of non-adopters as tariffs are recalibrated to recover fixed costs. Reform on Coasian principles avoids these welfare losses and the resulting inefficiencies. Incentives on tariffs will therefore determine whether technological change is beneficial to consumers.

2 - A Network-Aware Peer-to-Peer Market Mechanism for District Heating Systems
Linde Frölke, Technical University of Denmark, Kgs. Lyngby, Denmark, linfr@dtu.dk, Tiago Sousa, Pierre Pinson
District Heating systems become more distributed with the rise of heat producers. This calls for suitable heat market mechanisms that optimally integrate these actors. We propose a network-aware heat market with peer-to-peer trades as a Quadratic Program, which determines the optimal dispatch and nodal marginal prices. While heat network dynamics are generally represented by non-convex constraints, we convexify this formulation by fixing temperature variables and neglecting pumping power. Through a dual analysis we reveal loss components of nodal prices, as well as relations between nodal prices and between seller and buyer prices. A case study illustrates the dynamics of the network-aware market by comparison to our proposed loss-agnostic benchmark. We show that the mechanism effectively promotes local heat consumption and thereby reduces losses and total cost.

3 - Fairness in Distribution Network Management
Archic Chapman, Senior Lecturer, The University of Queensland, Brisbane, Australia, archic.chapman@uq.edu.au
The rapid rise of rooftop PV installations has triggered detrimental impacts on distribution networks, which risk being replicated with other distributed energy resources (DER), such as residential batteries and electric vehicles. In response, distribution network operators have begun to mandate connection codes, such as inverter Volt/Var control (VVC) and/or PV active power curtailment (APC), to mitigate network problems. However, these can cause an unfair amount of network support to be sourced from DER in certain circumstances. In this context, we discuss techno-economic considerations of fairness in distribution networks by introducing a distributed optimal power flow method for fair DER coordination with VVC and APC inverter control modes.

4 - Application of the Level Method for Computing Locational Convex Hull Prices
Nicolas Stevens, UCLouvain, Louvain la Neuve, Belgium, Anthony Papavasiliou, Ilyes Mezghani
Convex hull pricing is a well-documented method for coping with the non-existence of uniform clearing prices in electricity markets with non-convex costs and constraints. We revisit primal and dual methods for computing convex hull prices, and discuss the positioning of existing approximation methods in this taxonomy. We propose a dual decomposition algorithm known as the Level Method and we adapt the basic algorithm to the specificities of convex hull pricing. We benchmark its performances against a column generation algorithm that has recently been proposed in the literature. We provide empirical evidence about the favorable performance of our algorithm on large test instances based on PJM and Central Europe.

5 - A Distributed Market Architecture for Local Energy Communities
Bertrand Cornélusse, University of Liège, Liège, Belgium
We study the possibility to distribute the computation of an equilibrium of a centralized local market design that enables members of an energy community to exchange energy and services among themselves, next to the usual interactions they can have with the public grid. The market aims at maximizing the social welfare of the community, through a more efficient allocation of resources, the reduction of the peak power, and the increased amount of reserve, achieved at an aggregate level. Each member is incentivized to participate in the community on a voluntary basis. The overall framework is formulated in the form of a bilevel model, where the lower level problem clears the market, while the upper level problem plays the role of the community microgrid operator.

6 - Insights from the Global Observatory on Peer-to-Peer, Community Self-Consumption and Transactive Energy Models (GO-P2P) by IEA
Alexandra Schneider, Energy Institute (University College London, UCL), London, United Kingdom
This presentation will be given as part of the panel session “Market Design for Smart Local Energy Systems”. It will be on the latest findings from the Global Observatory on Peer-to-Peer, Community Self-Consumption and Transactive Energy Models (GO-P2P), a project of the User-Centred Energy Systems Technology Collaboration Programme by the International Energy Agency (IEA). Its aim is to study and analyse peer-to-peer energy trading, transactive energy and community self-consumption pilots being rolled out across the world, including the US. I will speak about the pilots we are analysing and also delve into legal and policy issues pertinent to peer-to-peer energy trading.

Risk-Aware Electricity Grids and Markets Operations
VWB40
Sponsored: ENRE/Other Energy
Sponsored Session
Chair: Ali Daraeepour, Princeton University, Princeton University, Princeton, NJ, 08540-5222, United States
1 - Presenter
Ali Daraeepour, Princeton University, Acee Bldg 086 Olden St # 016, Princeton, NJ, 08540-5222, United States
Risk-aware reserve requirements (RRL) are found with a stochastic unit commitment model that minimizes the risk-adjusted expected cost of satisfying electricity demand. This study investigates the effect of RRL on costs and other outcomes, in systems with high penetration of variable renewable electricity (VRE). We simulate the operations of PJM system and examine the commitment and dispatch of energy and reserves, energy costs, and generator’s cycling. We compare the performance of RRL relative to risk-neutral deterministic and stochastic unit commitments.

3 - Implications Of Risk-aversion, Strategic Behavior And Elastic Electricity Demand For Capacity Market Designs
Stefien Kaminski, KU Leuven, Leuven, Belgium, stefien.kaminski@kuleuven.be, Mihaly Dolanyi, Kenneth Bruninx, Hanspeter Höschle, Erik Delareux
Assuming perfectly competitive market participants and an optimal demand curve, a capacity market will deliver the optimal capacity mix. However, real-life investors may exhibit risk-averse and/or strategic behavior, as well as changes in the consumers’ resources, which may lead to higher demand elasticity. This talk sheds light on the impact of potential risk-averse, strategic behavior, and a price-elastic electricity demand on the evolution of the power system and its implications for capacity market design revealing a need for capacity markets if electricity demand becomes price-elastic and providing methods for regulators to disentangle risk-averse and strategic behavior.

4 - Enabling Inter Area Reserve Exchange Through Market Mechanisms
Orcun Karaca, ETH Zurich, Zurich, Switzerland, okaraca@control.ee.ethz.ch, Stefanos Delikaraoglou, Maryam Kamgarpour
Considering the sequential clearing of energy and reserves in Europe, enabling inter-area reserve exchange requires optimally allocating inter-area transmission capacities between these two markets. To achieve this, this talk provides a market-based allocation framework and derive payments with desirable properties. The proposed min-max least core selecting payments achieve individual rationality, budget balance, and approximate incentive compatibility and coalition stability. The results extend the works on private discrete items to a network of continuous public choices.

5 - Risk-hedging In Renewable-dominant Electricity Markets
Robert Mith, New York University, Brooklyn, NY, United States, Yury Dvorkin
This talk presents a risk-complete electricity market and proposes a set of mechanisms allowing for identifying and hedging against physical and financial risks in renewable-rich power systems. We take the perspective of the system operator and derive a risk-aware market design, which deals with the stochasticity of renewable resources and credible contingencies. Additionally, we introduce suitable financial products, e.g., variance swaps, that facilitate hedging against financial risks and incentivize system-beneficial behavior.
1 - Learning Optimal Prescriptive Trees From Observational Data
Nathanael Jo, University of Southern California, Los Angeles, CA, United States, Phebe Vayanos, Sina Aghaei, Andres Gomez

We consider the problem of learning from observational data, i.e., a personalized treatment assignment policy in the form of a binary tree of moderate depth. This problem arises in numerous socially important domains such as public health and personalized medicine, where interpretable and data-driven interventions are sought based on data gathered from deployment rather than from controlled, randomized trials. We propose a method for learning optimal prescriptive trees using mixed-integer optimization (MIO) technology. Moreover, we show that under mild conditions our method is asymptotically exact, i.e., will converge to an optimal out-of-sample treatment policy as the number of historical data samples tends to infinity. This sets us apart from existing literature on the topic which either requires data to be randomized or impose stringent assumptions on the trees.

2 - Large-scale Inference Of Sparsely-varying Markov Random Fields
Salar Fattahi, Assistant Professor, University of Michigan, 1433 Dwight Way Apt C, Ann Arbor, MI, 49702-2147, United States, fattahi@umich.edu, Andres Gomez

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

3 - Learning Hierarchical Interactions At Scale: A Convex Optimization Approach
Wenyu Chen, Massachusetts Institute of Technology, 70 Pacific St Apt 640c, Cambridge, MA, 02139-4204, United States, Hussein Hazimeh, Rahul Mazumder

We consider models that have the main features as well as pairwise interactions, with variable selection under the strong hierarchy: an interaction is non-zero only if its associated main features are non-zero. Existing methods cannot scale for problems with $p^2$ features and more, where $p$ is the number of variables. We develop a convex relaxation that enforces strong hierarchy and develop a highly scalable algorithm based on active set method and proximal gradient descent. We novel proximal screening rules and gradient screening strategy to further speed up the computation. We establish linear convergence guarantee for our framework. In practice, our framework outperforms the state of the art in terms of prediction and variable selection and can achieve over a 4900x speed-up. It can also handle much larger problems with $p = 50,0005$ ($\$50,000$ $\times 10^5$ interactions).

4 - Scalable Sparse PCA: A Tractable MIP Under Statistical Assumptions
Kayhan Behdink, Massachusetts Institute of Technology, Cambridge, MA, United States, behdink@mit.edu, Rahul Mazumder

We consider Sparse Principal Component Analysis (SPCA) under the spiked covariance model. The SPCA problem can be reformulated as a Mixed Integer Problem (MIP) with optimal statistical properties. However, current MIP formulations for SPCA do not scale beyond datasets with 1000s of variables. In this work, we propose new MIP formulations for SPCA via statistical modeling and reduction. By utilizing properties of the spiked model, we provide Mixed Integer Quadratic Program (MIQP) and Mixed Integer Second Order Cone Program (MISOCP) formulations for SPCA. We provide statistical guarantees for our MIQP formulation in terms of estimation error. In addition, we provide tailored cutting plane algorithms based on outer approximation. Numerical experiments on synthetic and real datasets show that our algorithms scale to large datasets with up to 100 variables in tens of minutes.

5 - Fast Semidefinite Optimization With Latent Basis Learning
Rajiv Sambharya, Princeton University, Princeton University, Princeton, NJ, United States, rajivs@princeton.edu

We introduce a data-driven method to quickly solve semidefinite programs (SDPs) coming from the same family. These SDPs often arise in machine learning and real-time decision making, where a sequence of similar problems needs to be quickly solved. Our method leverages common structure across the family to learn a latent basis representation, which is then used as input to a second-order cone program, whose solution approximates the original SDP solution. To do this, we marry the strength of neural networks in uncovering structure from data with differentiable optimization which allows end-to-end training of the bases and approximate problems to minimize suboptimality and infeasibility.
1 - Vertical Integration in Auction Markets
Sander Onderstal, University of Amsterdam, Postbus 15953, Amsterdam, 1001 NL, Netherlands, Ruben Van Oosten
We analyze the effects of vertical integration in auction markets. We do so using a symmetric independent private-values model in which the auctioneer sets a reserve price and invests in the end product’s (match) quality. We find that in the integration scenario the auctioneer invests more than in the separation scenario on average, and that she gives a bidding advantage to the integrated bidder relative to the other bidders. The merging parties always benefit from vertical integration. Vertical integration has ambiguous effects on consumer surplus, non-merging bidder surplus, and total welfare. Our results are relevant for vertical integration in ad auctions, platform markets, and procurement.

2 - Does Expectation-based Loss Aversion Explain Non-Truthful Preference Reporting In Strategy-proof Matching Mechanisms?
Thomas Kittsteiner, RWTH Aachen University, Lehrstuhl für VWL, inbes. Mikroökonomie Templergra, Aachen, 52062, Germany
Expectation-based loss aversion (EBLA) has been suggested as an explanation of true preference misreporting in strategy-proof matching mechanisms. EBLA implies disappointment aversion. Reporting the true ranking might create an expectation that proves too optimistic ex post, leading to a disappointment. To avoid such disappointment, it might be optimal to over-rank a less desirable, but a more probable, option over a more desirable, but less probable, option. We test this hypothesis in a simple experiment with only two options. Varying probabilities of availability of different options in a between-subject design, we find a small and statistically insignificant effect in the direction predicted by EBLA. However, responses to debriefing questions suggest that the small effect is more likely to be due to a preference vs. probability tradeoff thinking rather than EBLA.

3 - Coordination And Predation In Multi-unit Auctions: Why Pricing Rules Matter
Daniel Marszalec, Assistant Professor, ICU (International Christian University), Tokyo, Japan, daniel.marszalec@gmail.com, Alexander Tetyeboym, Sanna Laksä
Auctions with below-bid pricing (e.g., uniform-price, and ascending auctions) have remarkable theoretical properties, but practitioners are skeptical about their implementation. We present a dynamic model of collusion in multiunit auctions that explains this gap between theory and practice. To sustain collusion at the reserve price, bidders submit crank-handle bids. The cost of sustaining crank-handle collusion depends on the degree of below-bid pricing in the auction. Our model predicts that crank-handle collusion is easier to sustain in auctions with more below-bid pricing and when bidders are more symmetric. Evidence from auctions of fishing quota in the Faroe Islands supports our predictions.

4 - Exploiting Uncertainty About the Number of Competitors in Procurement Auctions
Nicolas Fugger, University of Cologne, L 7 1, Mannheim, 68161, Germany
Most of the literature on auctions assumes that participants observe the number of competitors. However, this is typically not the case in procurement practice. We investigate how the buyer should react to suppliers’ uncertainty and whether she should commit to a specific auction format before observing the number of qualified suppliers or benefits from making the auction design depend on the actual number.

Suppliers’ risk aversion makes commitment to first-price auctions attractive for the buyer. However, suppliers’ inability to interpret the buyer’s auction format choice correctly makes it attractive to make the format choice depend on the number of suppliers. We test these theoretical predictions in a lab experiment. We find evidence for both behavioral patterns and observe that the buyer yields significantly better prices if she commits to a first-price auction.

5 - Heterogeneity In Multi-unit Common Value Procurement Auctions
Marion Ott, ZEW – Leibniz Centre for European Economic Research, L 7 1, Mannheim, 68161, Germany, marion.ott@zew.de, Karl-Martin Ehrrath, Jan Kreiss
Bidders’ profits and their frequency of losses in an experiment on multi-unit procurement auctions when bidders have common costs develop differently than theory predicts when the number of goods increases, and bidders are not better off in the pay-as-bid than in the uniform-price auction. We show how bid heterogeneity works in favor of the bidders under uniform pricing but not under pay-as-bid pricing as the number of goods increases, so that for the largest number of goods bidders are better off and less susceptible to the winner’s curse than in equilibrium.

1 - Deep Learning-based Disease Diagnostic Biomarker Detection With Metabolomics Data
Seonyoung Kim, Chungnam National University, Daejeon, Korea, Republic of, 1020pc@gmail.com, Taewon Go, Dongil Kim
Biomarkers play important roles in the early diagnosis of disease to improve the survival rate of patients. To determine the type and stage of diseases and the corresponding treatment options, the target biomarkers should be identified. Metabolomics provides information on cellular metabolic processes that drive tumorgenesis and tumor progression. In this study, we propose deep learning methods to detect disease diagnostic biomarkers with metabolomics. Through experiments, we compare the performance of the proposed method and other machine learning methods.

2 - Impact Of Market Factors On Demand And Prices Of Remanufactured Products: A Machine Learning Approach
Yeun Soo Park, University of Birmingham, Birmingham, United Kingdom, YXP089@student.bham.ac.uk, Gu Pang, Joseph Sanderson
The majority of the existing research into market factors, sold prices and demand of remanufactured products is largely based on conventional statistical models. Such models are not capable of capturing the non-linear behaviour. In this study, we deploy machine learning approaches to shed light on the non-linear effect of e-commerce market factors as predictors of sold prices and demand of remanufactured electronics. Our results suggest our proposed approach can achieve better prediction. The managerial implication is to make correct decisions based on comparisons of the impact of these market factors on the sold prices and demand of remanufactured products.

3 - Classification Of Human Habits From Voice Data Using Machine Learning
Takaya Yokoo, Tokyo University of Science, Chiba, Japan, 7420529@ed.tus.ac.jp, Ryo Hatan, Hirokou Nishiya
The human voice is influenced not only by physical factors such as gender and age, but also by habitual factors such as drinking, smoking, and sleep, from human voice data. We extract acoustic features from voice data of subjects, train machine learning models to classify their habits, and evaluate the performance of each learning models. As for the acoustic features, we also employ i-vector which are commonly used in the research field of speaker identification.

4 - Interpretable Trees
Zheng Zhang, University of Tennessee, Knoxville, Tennessee, TN, 37996-4515, United States
The trained predictive models form a set of decision rules that are easy to understand in practice. Existing methods select the best model by minimizing the prediction errors on both child nodes (i.e., too much or too little) and predict values as the average of all observations in each terminal node. In this paper, we propose a split criterion based on rank concordance and a rule by fitting each terminal node with a linear function. The proposed method rather than the traditional performed better in accuracy and interpretability (e.g., capture the variations and associations between target variable and predictors).
1 - Impact And Risk Models On COPD-related Hospitalizations And Emergency Room Visits By Combining Multi-year Claims Data With Environmental Data Sets
Divya Mehrish, CapsicoHealth Intern; Stanford University Student, CapsicoHealth, Palo Alto, CA, United States, divyamehrish@gmail.com, J. Sairamesh, Laurent Hasson, Monica Sharma, Rudy Banerjee, Jakob Bjorner

Chronic obstructive pulmonary disease (COPD) is the fourth-leading cause of death in the U.S. Our study examines clinical and environmental impacts on 90-day hospitalizations, ER visits and readmissions. We integrate 2017-18 CMS claims data with daily weather and pollution data in FL, NY and PA (high annual hospitalization rates). Our logistic regression models show 88% accuracy for 90-day hospitalizations and 74% for ER visits; 94% and 79% with boosted tree-based models. Our models all show 64% accuracy for 30-day readmissions. Our results, which show the clear relationship between the environment and COPD hospital and ER cases, can help care managers target high-risk populations.

2 - Estimation Of Obesity Based On Personal Behaviors And Physical Condition
Wei Zou, Clark University, WORCESTER, MA, United States, zouwei_lab@sina.com

Obesity is a complex health issue caused by many factors such as personal behaviors, medication use, and genetics. The number of obese people has increased rapidly. To decrease the possibility of obesity and help people keep healthy, we study the features that cause obesity directly by employing several machine learning models such as Logistic Regression, Tree-based method, support vector machine, and K Nearest Neighbors. We will conduct K-fold cross-validation to choose the best model and obtain a prediction accuracy. Our results show that the three most important obesity factors are weight, height, and gender. We also will discuss and compare our results to others in the existing literature.

5 - Uncertainty Counts: Bayesian deep learning-based tensor factorization and application in Recommender Systems
shikai Fang, The university of utah, United States

We apply Bayesian deep learning models as novel tools to handle tensors, the most common data form in Recommender Systems. As deep neural networks offer a strong fitting ability, the robustness and uncertainty from the Bayesian framework enable potentials on the domain-specific interpretability and decision-making during the recommend pipeline.

2 - Can Machine Learning Help To Select Portfolios Of Mutual Funds?
André A.P. Santos, University of Edinburgh, Edinburgh, United Kingdom, andreportela@gmail.com

We apply Bayesian deep learning models as novel tools to handle tensors, the most common data form in Recommender Systems. Our study is driven by the need to develop effective methods to handle tensors, the most common data form in Recommender Systems. As deep neural networks offer a strong fitting ability, the robustness and uncertainty from the Bayesian framework enable potentials on the domain-specific interpretability and decision-making during the recommend pipeline.
1 - Analysis For The Continuous Version Of The Alternative Fuel Refueling Station Location Problem
Sara F. Abu Aridah, Ph.D. Student, Pennsylvania State University, University park, PA, United States, Omar Abbaas, Jose Antonio Ventura

We address the deviation-flow refueling station location problem. We start with a continuous network where any point is considered as a candidate station location. Then the network is discretized by rounding distances and the driving range to the closest integer multiple of a common divisor value. This reduces the required computational effort to solve the problem. In this network, we prove that given any feasible solution with refueling stations located at non-integer distances from network vertices, it is always possible to find an equivalent integer solution. These results are used to discretize the network and propose an efficient polynomial time algorithm to locate a set of refueling stations.

2 - Predicting Utility Power Line Risk From Tree Failure Via An Interpretable Convolutional Neural Network
Nasko Apostolov, Graduate Research Associate, University of Massachusetts Amherst, Amherst, MA, United States, napistolov@umass.edu, Ryan Suttle, Jimi Oke, Sanjay Arwade, Brian Kane

Automating tree risk assessments, which are critical to the integrity of utility power lines, could potentially yield significant cost savings while boosting community resilience. We train a novel convolutional neural network to predict tree failure likelihood categories using augmented inputs from expert-assessed tree images. Via cross-validation and hyperparameter optimization, we obtain a binary classifier with an accuracy of 0.94 (SD = 0.1). We assess the visual interpretability of the classifier using techniques such as gradient-weighted class activation maps. Our framework demonstrates the potential of artificial intelligence for sustainable infrastructure management.

3 - Classifying Soil Moisture Levels Of Grazeland Using Uav Imagery Data Based On A Convolutional Neural Network Method
Angela Avila, University of Texas at Arlington, Arlington, TX, United States, angela.avila2@mavs.uia.edu, Jianzhong Su, Heidi Taboada, Huilu Zhang

In field management, soil moisture is a key predictor in yield success. With acres of fields and mindfulness of water conservation, our goal is to maximize crop production at minimal cost. Unmanned Aerial Vehicles can be used to take images and provide information on ground moisture. We can then derive vegetation indices and use Convolutional Neural Network to distinguish well maintained areas from areas that are in water deficit. With imaging data collected in Fort Collins ARS, we will train the CNN system to successfully reach about 89% accuracy in predicting an image class correctly. With UAV data and CNN method we can precisely predict soil moisture levels and tend to areas with more irrigation needs.

4 - Do Neural Networks Have A Mean Dimension?
Roman Hahn, Bocconi University, Milan, Italy, roman.hahn@unibocconi.it, Emanuele Borgonovo, Christoph Felnau

Neural networks are considered black-box models. Among other things, the interaction size of inputs for forming a decision is unknown to its user. The mean dimension of neural networks can provide such an average interaction size. We show that we can estimate the mean dimension accurately for neural networks in a known setting. This notion then can shed light into the network by providing information on the effect of the architecture on the interaction size and how the average interaction size evolves during training. We demonstrate these findings using image classification experiments on the cifer10 database and the LeNet, ResNet and DenseNet architectures.

1 - Scalable High-dimensional Bayesian Optimization With Black-box Constraints
Matthias Poloczek, Amazon, San Francisco, CA, United States, cwang717@gatech.edu, Srinivas Peeta

The global optimization of a high-dimensional black-box function under black-box constraints is a pervasive task in machine learning, control, and engineering. These problems are difficult for current approaches due to the curses of dimensionality, the heterogeneity of the underlying functions, and the often small and non-convex sets of feasible points that impact the performance of Bayesian optimization methods that otherwise have become the de-facto standard for sample-efficient optimization in unconstrained settings. In this talk I will present the scalable constrained Bayesian optimization (SCBO) algorithm and show experimental results that demonstrate a SOTA performance.

1 - The Mitigating Impact Of Family Firm Narcissism On Companies' Carbon Emissions
Florian Bartels, University of Muenster, Muenster, Germany, florian.bartels@uni-muenster.de, David Bendig

Family firms (FF) play a central role in mitigating climate change through the reduction of carbon emissions (CE; cf. Dyer & Whetten, 2006). Drawing on narcissistic organizational identification (NOI) theory (Galvin et al., 2015), we introduce the Family Firm Narcissism (FFN) scale, measuring how central the family sees itself for the organization’s identity. We find a negative relationship between FFN and direct CE (p < .01) for our S&P 500 sample, being amplified by industry dynamism (p < .01) and strategic rival flexibility (p < .05). We advance NOI theory to the group-level, introduce the novel FFN measure addressing FF heterogeneity, and are the first to empirically analyze CE in the FF context.

2 - The Effect Of Religious Board Members On Corporate Digital Innovation
Fabian Ernst, Research Associate, Westfälische Wilhelms-Universität, Münster, Germany, David Bendig

Religious beliefs of executives influence corporate outcomes such as earnings management (Cai et al., 2019). We argue that religiosity fosters increased risk-aversion (Hilary & Hui, 2009) and that religious executives promote values such as traditionalism and security (Saroglou et al., 2004), reducing their appetite for digital innovation (DI).

We propose a novel measure for the religiosity of board members based on their education and leisure activities. We utilize patent data to measure DI orientation for our S&P 500 sample.

Our results show that firms with religious boards put less emphasis on DI, attenuated by the religiosity of the firm’s employees and industry-specific IT intensity.

2 - Multi-information Source Optimization Through Gaussian Process Sparsification
Antonio Candelieri, Assistant Professor, PhD, University of Milano-Bicocca, Milan, Italy, antonio.candelieri@unimib.it

This paper presents a Multi-Information Source Optimization (MISO) approach which significantly differs from methods based on Gaussian Processes (GPs). Analogously to these methods, each source is modelled as a GP, but instead of fusing GPs accounting for correlation between sources, GP sparsification is adopted to select only “reliable” observations from cheap sources, depending on a simple model discrepancy measure and the GP’s prediction uncertainty. Reliable observations are used to “augment” the set of those collected from the objective function, then a single model, named Augmented GP, is trained on this augmented set. An acquisition function is designed to choose the next source-location pair to query. Results on test problems and a hyperparameter optimization task are presented, comparing the proposed MISO-AGP against its fused-GP counterpart.
3 - Pure Exploration In Multi-armed Bandits With Graph Side Information
Gautam Dasarathy, Arizona State University, Tempe, AZ, United States, gautamdasarathy@asu.edu, Parth Thaker, Nikhil Rane

We consider the problem of identifying the best arm(s) in a multi-armed bandit. In particular, we consider the setting where the algorithm additionally has access to similarity information amongst the arms in the form of a graph. In order to demonstrate the advantage this extra information bequeaths us, we introduce a novel combinatorial complexity measure. Using this measure, we devise novel algorithms that provably identify the best arm(s) while requiring far fewer samples than the traditional pure exploration techniques for multi-armed bandits. We finally provide experimental demonstrations that support our theoretical findings.

4 - A Comparative Study Of BO Algorithms
Szu Hui Ng, National University of Singapore, Singapore, Singapore, senzhenl@nus.edu.sg, Haowei Wang

Bayesian optimization (BO) has been widely applied to solve black-box global optimization problems. Its sequential approach adaptively learns to effectively search in often complex spaces. In this article, we consider several recent versions of BO and conduct a comprehensive empirical comparison of these algorithms under various scenarios. The algorithms’ accuracy and computation times are reported, and some practical guidelines are provided.

5 - Constrained Two-step Look-ahead Bayesian Optimization
Yunxiang Zhang, Cornell University, 113 Valentine Pl, Apt 968, Ithaca, NY, 14850, United States, Peter Frazier, Xiangyu Zhang

Non-myopic Bayesian optimization (BO) offers improved query efficiency over traditional myopic methods, but computationally efficient BO methods for constrained problems have not yet been developed. We argue that being non-myopic is even more important in constrained problems because fear of violating constraints pushes myopic methods away from sampling the boundary between feasible and infeasible regions, slowing the discovery of optimal solutions with tight constraints. In this talk, we introduce a computationally efficient two-step lookahead constrained BO acquisition function with a novel likelihood-ratio-based acquisition function optimization technique, which achieves state-of-the-art performance in experiments.

6 - Beyond The Pareto Efficient Frontier: Constraint Active Search For Multiobjective Experimental Design
Gustavo Malkomes, Intel, San Francisco, CA, United States, gustavo.malkomes@intc.com

Many problems in engineering design and simulation require balancing competing objectives under the presence of uncertainty. Sample-efficient multiobjective optimization methods like Bayesian optimization focus on the objective values in metric space and ignore the sampling behavior of the design configurations in parameter space. Consequently, they provide little actionable insight on how to choose designs in the presence of metric uncertainty. We propose a new formulation that accounts for the importance of the parameter space through defining a region of satisfaction. We introduce an active search algorithm to efficiently discover the region and diversely sample satisfactory designs.

2 - The Impact of Chatbot Disclosure and Anthropomorphism on Users’ Switching Intentions
Jonilda Bajrati, PhD Student, Virginia Tech, Blacksburg, VA, United States, Paul B. Lowry

The dilemma how chatbot features effect users’ behavioral intentions remains an ongoing debate. Previous literature on chatbot disclosure and its human-like features converges to the notion that results are contextual and vary greatly based on the type of user’s behaviors. Furthermore, it is recognized that users perceive chatbot aspects to be more important in the context of chatbot service failure. Yet, little attention is given to the interaction joint effect among these characteristics, and if through trust and social presence they lead to switching intentions. Hence, the purpose of this study is to examine the joint direct effect of chatbot identity disclosure and anthropomorphism on user switching intentions, by focusing on the context of the chatbot service failure. Specifically, the targeted population is hotel chatbot users in the United States. A factorial survey method design will be employed with three factors: anthropomorphism, chatbot identity disclosure, and chatbot service outcome. Final data will be collected via Amazon Mechanical Turk online platform during January-February 2021. The findings of this study will advance the literature by providing evidence on the influence of chatbot disclosure and anthropomorphism in users’ switching intentions. Furthermore, the interaction of these variables will shed light on the importance of both constructs in influencing directly social presence and trust. This study will pioneer the way for more research in understanding the effects of chatbot cues in the context of chatbot service failure and hospitality and tourism. Lastly, businesses invested in chatbots will benefit by gaining insights on the interaction of chatbot features and their ultimate effect on the users’ switching intentions.

3 - Improving Social Media Presence Of Firms Under Budget Constraints: A Multi-method Approach
Mayukh Majumdar, PhD Candidate, Mays Business School, College Station, TX, United States, mmajumdar@mays.tamu.edu, Subodha Kumar, Chelliah Sriskandarajah

The use of social media platforms by firms to promote their products among the public has received major attention among researchers and practitioners, especially the image-based content given the widespread availability of multimedia-based platforms. In this study, we examine the role of post features in driving user engagement and the operational value in the analysis of social media content. We use a combination of deep learning method, econometric approach, and optimization framework to offer relevant managerial insights under budget constraints.

WVB52
Virtual Room 52
Artificial Intelligence for Social Media
Sponsored: Social Media Analytics
Sponsored Session
Chair: Enhao Liu, Ohio State University, Ohio State University, Columbus, OH, 43210-1273, United States

1 - A Sentiment Analysis Of Covid-19 Vaccine Ins Social Media
Mehdi Mashiayekhi, 629 Harley Dr Apt 4, Columbus, OH, 43202-1805, United States

Vaccine hesitancy one of the major issues fighting COVID19. There is misinformation about the symptoms of the vaccines, their efficacies, their approval process, etc. The misinformation could contribute to people avoiding getting vaccinated. In this research, we perform a sentiment analysis about COVID-19 vaccine in social media.

2 - Is The Data Suitable? The Comparison Of Keyword Versus Location Filters In Crisis Informatics Using Twitter Data
Ben Alexander Rachunko, Ph.D., Stanford University, Stanford, CA, 94305, United States, rachunko@stanford.edu
Ben Alexander Rachunko, Ph.D., Purdue University, West Lafayette, IN, United States, rachunko@stanford.edu

Twitter’s Terms of Service, restrict the quantity and types of data which can be collected from the platform. Accordingly, there are multiple ways to retrieve data from Twitter with no consensus among researchers as to standard data collection procedures. In this work, we compare two Tweet datasets gathered around Hurricane Harvey—the second-most expensive US hurricane on record—via different methods and show the significant role of the tweet retrieval source on study insights and results. One dataset was collected using keywords to filter relevant data, the other using geographical location. We find that while keyword-based data is more suited to tracking public engagement and identifying information brokers, location-based data is needed to characterize local situational information and communication behaviors.
3 - Improving Drinking Water Access In Sub-Saharan Africa
Chengcheng Zhai, Kelley school of Business, 1750 north range road, apt b301, bloomington, IN, 47408, United States, zhai19@iu.edu, Kurt M. Breithauer, Jorge Mejia, Alfonso J. Pedraza-Martinez
Access to water remains a significant problem for poor communities in many developing countries. In 2017, over 135 million people in sub-Saharan Africa (SSA) walked more than 30 minutes to get water each day (UNICEF and WHO 2019). New water projects, such as building water wells, have been the primary operational response to mitigate the drinking water crisis. These projects can reduce households’ distance to safe drinkable water, improving the water accessibility level. Thus, where to build additional water projects to achieve such a goal is the consistent question among non-governmental organizations (NGOs) dedicated to improving access to water and it is of vital importance due to limited financial resources available in the rural areas. It is also the research question we investigate in this project.

4 - Risk-averse Placement Optimization In Refugee Resettlement
Narges Ahani, Worcester Polytechnic Institute, 100 Institute Road, MA, Worcester, MA, 01609, United States, nahnani@wpi.edu, Osman Ozalpin, Andrew C Trapp
Refugees are resettled into communities in many ways, and more recently with the carefully designed use of analytical approaches. The refugee placement optimization software Annie™ MOORE estimates refugee-locale match quality scores using predictive modeling of past refugee placement and outcomes data to generate the likelihood of employment for incoming refugees. While estimated scores are used for offline optimal matching, we use 15 refugee placement periods, inherent uncertainty exists with respect to the quality score estimation. This uncertainty can lead to different optimized outcomes that risks adverse effects on refugee welfare. We explicitly incorporate risk into the optimization of refugee outcomes and propose new methods to hedge against this risk, while retaining a majority of the total expected employment.

5 - Presenter
Manoj Vanajakumari, NC, United States

INFORMS Anaheim 2021
5 - A Scenario-based Stochastic Model For VRP In PD-HL
Azadeh Sadeghi, University of Michigan-Flint, Flint, MI, United States, as262914@ohio.edu, Felipe Aros-Vera
We develop a two-stage stochastic programming model for the distribution of water in Post-Disaster Humanitarian Logistics (PD-HL). The model solves the Social Cost Vehicle Routing Problem incorporating uncertainty in travel times. The objective of the model minimizes social cost which includes logistics and deprivation costs. Deprivation costs incorporate the survivors' suffering due to the lack of access to critical supplies. The case study of water distribution in the aftermath of Hurricane Maria in 2017 evaluates the efficacy of the distribution and compares it with the deterministic version of the model.

VWB56
Virtual Room 56
Retail Management I
Contributed Session
Chair: Jingran Zhang, Marshall University, Huntington, WV, 25755, United States
1 - Strategic Choice Of Sales Channel In The Presence Of Consumer Showrooming And Webrooming
Prasenjit Mandal, Indian Institute of Management Calcutta, Kolkata, India, prasenjitm@iimcal.ac.in, Preetam Basu, Samir Biswas
Consumers often involve in hybrid shopping behaviors, such as showrooming and webrooming, in which they use one channel to gather product information but complete product purchases in a different channel. This paper studies the impact of such free-riding consumer behaviors on the multichannel sales operations of a supply chain consisting of a manufacturer and a downstream brick-and-mortar (B&M) retailer. We find that both the manufacturer and the retailer may benefit from the former's dual-channel sales strategy. Contrary to the common wisdom, our findings reveal that both consumer showrooming and webrooming may benefit the B&M retailer and the manufacturer, thereby leading to a win-win outcome.

2 - Selling To Nanostores Directly Or Through A Platform?
Jiwen Ge, Assistant Professor, Dongbei University of Finance and Economics, Dalian, China, jiwenge@dufe.edu.cn, Han ZHU
Lingshoutong is a new platform which bridges CPG manufacturers and over a million nanostores in China. Competing manufacturers can either serve nanostores directly or through the platform with the option to market products to consumers directly. We study the platform’s role in the manufacturer competition.

3 - Routing Of Ecommerce Orders In An Omnichannel Retailer With Fulfillment Centers
Sanchoy Das, Professor, New Jersey Institute of Technology, Newark, NJ, United States, das@njit.edu, Jingran Zhang, Sevlay Oneral
To grow their online business and meet the need for fast fulfillment, retailers have built ecommerce fulfillment centers to complement the store-ending distribution channel. Online orders can be fulfilled from either the center or the store. Store inventory is more expensive to locate and maintain but serves both walk-in and online customers. Center inventory is more economical but serves only online customers. Store demand is localized and at risk of discounting. We propose a dynamic order routing models based on real-time sales and inventory data across the retailer network.

VWB57
Virtual Room 57
Sreekumar Bhaskaran
Sponsored: Technology, Innovation Management and Entrepreneurship
Sponsored Session
Chair: Sreekumar R Bhaskaran, Southern Methodist University, Southern Methodist University, Dallas, TX, 75275-0333, United States
1 - Never Too Late? The Role Of Visiting Delay In Crowdsourcing Contests
Anant Mishra, Carlson School of Management, University of Minnesota, 321 19th Ave S, Minneapolis, MN, 55455, United States, mish0049@umn.edu, Brian Lee
We capture the heterogeneity in contest awareness on a platform among solvers in terms of visiting delay (i.e., the time that elapses between the start of a contest and a solver’s first visit to the contest) and examine how it impacts submission behavior as well as contest outcomes.

2 - Entrepreneurial Mindset And Behavior For Product Introduction Decisions
Sitan Erzurumlu, Babson College, 231 Forest St, Tomasso 123, Babson Park, MA, 02457, United States, sborghieri@babson.edu, Sreekumar R. Bhaskaran, Karthik Ramachandran
Firms often face a choice between developing a risky, advanced, product and launching an on-hand product. While launching the on-hand product might bring much needed revenues, it could affect the profitability of the advanced product under development depending on the consumer experience with the launched on-hand product. We present evidence from behavioral studies that study how product managers in established and startup firms make these decisions. We particularly examine the impact of cash constraint, available options and trade-off, our findings reveal insights on how to position product continuation with respect to cash on hand, value of the project and the leanness of development process.

3 - The Emergence Of Novel Product Uses: An Investigation Of Ikea Hacks
Shi-Ying Lim, National University of Singapore, 15 Computing Drive, Singapore, 117418, Singapore, Tian Chan
Exaptation refers to the emergence of novel functionalities in existing products. We examine how different search triggers for creative problem solving affect the occurrence of exaptations by comparing “problem-first” searches with “product-first” searches in a user-innovation context. In a problem-first search, a user-innovator defines the problem before arriving at a viable solution; in a product-first search, a user-innovator identifies the product to be used before seeking out a viable need. Using a novel data set comprising user hacks of IKEA products, we present evidence that hacks originating from a product-first search are less likely to generate exaptations than those originating from a problem-first search. However, we also show that this difference is mitigated when the user-innovator has hacking experience or when the product is more modular.

4 - Where To Pop-up? Channel Operation Strategies Under Price Harmonization
Arumina Chhikara, University of Kansas, Lawrence, KS, United States, arumina.chhikara@warrington.ufl.edu, Avinash Geda, Nazli Turken, Janice E. Carrillo
Price harmonization across different channels is a widely practiced marketing strategy. Contrary to the intuition that dual-channel firms utilize both channels under channel-specific pricing strategy, we find conditions when a single (online/offline) channel dominates the dual-channel policy under the price harmonization strategy. We find that for the price harmonization strategy, the optimal channel selection, and the optimal prices depend on market sizes, on-hand inventory, and salvage value. Our results are important to channel managers’ coordinated decisions when offering a product in their respective channels to optimize the overall profits at the retailer level.

5 - Adapting To Unknown Unknowns: Shepherding Radical Innovations To Market
Gulru F. Ozkan-Seely, University of Washington Bothell, 18115 Campus Way NE, University of Washington Bothell, Bothell, WA, 98011, United States, gulru@uw.edu, Surya D. Pathak, Mohan V Tatikonda
In this paper, we investigate the adaptive mechanisms employed by managers of projects that aim to yield novel innovations and involve high levels of uncertainty and ambiguity. We consider that project planning may enable or constrain the downstream ability to enact different adaptive mechanisms during the execution phase. We employ data collected from sixteen new product development projects from the organization and compound it with an optimization problem. We first model customer self-selection in a novel way through an optimization problem. We then characterize different types of competitive equilibria between the SPs. We find that customer composition plays an integral role in determining the nature of equilibrium.
3 - Selling Fewer Better Things: Serving Variety With Slow Fashion

Montre Jalili, Bentley University, Waltham, MA, United States, mjallili@bentley.edu, Michael Pangburn, Seyed Alireza Yazdani Tabaci

The promise of slow fashion is to induce the consumption of longer-lasting items, thus reducing waste. Rather than purchase every latest fashion, consumers benefit from reusing products from their closet, if they have low sensitivity to trends or when a popular trend returns to fashion, hence potentially saving money over time. In a market where popular trends change periodically, we consider a seller facing customers with heterogeneous sensitivity to those trends. The seller has the flexibility to choose between serving the market with disposable (low quality) or reusable (high quality) products, or a mix of the two, and we analyze the seller’s optimal segmentation and pricing strategy.

4 - Agency Or Wholesale? The Role Of Retail Pass-through

Honggang Hu, PhD student, University of Florida, Gainesville, FL, United States, hongganghu@ufl.edu, Quan Zheng, Xiajun Amy Pan

Previous studies suggest that e-tailers prefer agency selling to traditional wholesale selling due to channel efficiency. However, in a common e-tailer channel, we discover that the e-tailer’s choice of selling format is critically moderated by the relative intensity of supplier competition, driven by the cross-brand retail pass-through behavior and competition mode (Bertrand or Cournot) among suppliers. Moreover, we caution against the seemingly-innocuous cost normalization under agency selling, and surprisingly find that the suppliers may benefit from higher marginal costs.

4 - Agency Or Wholesale? The Role Of Retail Pass-through

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WVB64

Virtual Room 64

Federated learning and multi-task learning-I

Sponsored: Opt/Machine Learning

Sponsored Session

Chair: Kaizheng Wang, PhD, Columbia University, NY, United States

1 - An Efficient Framework For Clustered Federated Learning

Dong Yin, DeepMind, Mountain View, CA, United States, yindong10@gmail.com

We address the problem of federated learning (FL) where users are distributed and partitioned into clusters. This setup captures settings where different groups of users have their own objectives but by aggregating their data with others in the same cluster, they can leverage the strength in numbers in order to perform more efficient federated learning. For this new framework, we propose the iterative Federated Clustering Algorithm (IFCA), which alternately estimates the cluster identities of the users and optimizes model parameters for the user clusters. We analyze the convergence rate of this algorithm first in a linear model with squared loss and then for generic strongly convex and smooth loss functions. We also present experimental results showing that our algorithm is efficient in non-convex problems such as neural networks.

2 - Straggler-resilient Federated Learning: Leveraging the Interplay Between Statistical Accuracy and System Heterogeneity

Ramin Pedarsani, UC Santa Barbara, ECE Department, UCSB, Santa Barbara, CA, 93106, United States

Federated learning involves learning from data samples distributed across a network of clients while the data remains local. Federated learning is prone to multiple system challenges including system heterogeneity where clients have different computation and communication capabilities. We propose a novel straggler-resilient federated learning method that incorporates statistical characteristics of the clients’ data to adaptively select the clients. The key idea of our algorithm is to start the training procedure with faster nodes and gradually involve the slower nodes in model training once the statistical accuracy of the data corresponding to the current participating nodes is reached.

3 - Learning With User-Level Differential Privacy

Ananda Theertha Suresh, Google Research, New York, NY, United States

Much of the literature on differential privacy focuses on item-level privacy, where loosely speaking, the goal is to provide privacy per item or training example. However, recently many practical applications such as federated learning require preserving privacy for all items of a single user, which is much harder to achieve. Therefore understanding the theoretical limit of user-level privacy becomes crucial. We study the fundamental problems of discrete distribution estimation, high-dimensional mean estimation, and empirical risk minimization under user-level differential privacy. For all these problems, we provide polynomial time algorithms and information theoretic lower bounds.

WVB65

Virtual Room 65

Recent Advances in Integer Programming

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Moira MacNeil, University of Toronto, Toronto, ON, M4Y 1E5, Canada

1 - Achieving Consistency With Cutting Planes

John Hooker, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States, jlh38@andrew.cmu.edu, Danial Davarnia, atefeh rajaabzadeh

Cutting planes can accelerate branch-and-bound search by cutting off fractional solutions of the linear programming relaxation. Yet they can also reduce backtracking by excluding inconsistent partial assignments -- that is, partial assignments that cannot be extended to a full feasible assignment. The constraint programming community has studied consistency extensively and uses it to reduce backtracking. We extend this approach to integer programming. We present a theoretical framework and elucidate the connection with the convex hull and cutting planes. We propose a cutting plane algorithm for achieving partial consistency and show that it can substantially reduce the search tree. More broadly, we suggest that consistency concepts offer a new perspective on IP that can lead to a better understanding of what makes branching methods work.
We develop a distributed parallel algorithm for block-structured nonconvex constrained optimization problems. Our algorithm performs Jacobi-type proximal updates of the augmented Lagrangian, requiring only local solutions of individual block nonlinear programming (NLP) problems. We provide a cheaply computable Lyapunov function that allows us to establish local and global convergence, and a simple and practical rule for updating the parameters. This in contrast to existing algorithms for nonconvex optimization based on ADMM, which rely on at least four iterations to converge to a sufficient accuracy. The convergence rate is strongly correlated with the choice of penalty or step-size parameters, which are often defined heuristically. We develop a policy that learns the parameter values iteration-to-iteration that accelerate the convergence rate. We use reinforcement learning techniques to select parameters and train our policy using advanced neural network models. We demonstrate this method for ADMM via the distributed AC Optimal Power Flow problem.
We propose a distributed cubic regularization of the Newton method for solving empirical risk minimization problems over a network of agents, modeled as undirected graph. The algorithm employs an inexact, preconditioned Newton step at each agent’s side: the gradient of the centralized loss is iteratively estimated via a gradient-tracking consensus mechanism and the Hessian is subsampled over the local data sets. No Hessian matrices are exchanged over the network. Our convergence analysis reveals that statistically accurate solutions are achievable in roughly the same number of iterations of the centralized cubic Newton, at the cost of limited communications per iterations. This represents a significant improvement with respect to existing, statistically oblivious, distributed Newton-based methods over networks.

3 - A Stochastic Newton Algorithm For Distributed Convex Optimization
Brian Bullins, Toyota Technological Institute-Chicago, Chicago, IL, United States, Kumar K Patel, Ohad Shamir, Natasha Srebro, Blake Woodworth

We propose and analyze a stochastic Newton algorithm for distributed convex optimization. At the heart of our approach is recent work showing that quadratic objectives can be optimized to high accuracy using a parallel algorithm with only a single round of communication. Our algorithm expresses the Newton update as the solution to a quadratic problem which we optimize using stochastic gradients and stochastic Hessian-vector products for the objective, both of which can typically be computed efficiently. We analyze our method for quasi-self-concordant objectives (e.g., logistic regression), and demonstrate that it can in some instances achieve faster convergence rates than comparable first-order methods while requiring less communication and a similar amount of computation.

4 - A Hybrid Algorithm For Distributed Consensus Optimization
Ermin Wei, Northwestern University, Northwestern Univ 2145 Tech Dr # L310, Evanston, IL, 60208-0884, United States, ermin.wei@northwestern.edu, Xiaochnu Niu

We consider a consensus optimization problem in a multi-agent network, where all agents are connected to a central server. Current distributed algorithms fail to capture the heterogeneity in agents’ local computation capacities. We propose a new primal-dual algorithm framework that allows different agents to perform various types of updates. Specifically, each agent can choose to perform first-order or second-order Newton-type updates. Theoretically, we prove that our algorithm achieves a linear convergence rate regardless of the distribution of first and second order updates used. Numerical studies are provided to demonstrate the efficacy of our method in practice. To the best of our knowledge, this is the first hybrid algorithmic framework allowing heterogeneous local updates for distributed consensus optimization with a provable convergence guarantee.

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2 - Newton Method Over Networks Is Fast Up To The Statistical Precision
Amir Daneshmand, Purdue University, 221 S. 9th Street, Apt 8, Lafayette, IN, 47901, United States, Gesualdo Scutari, Pavel Dvurechensky, Alexander Gasnikov

We propose a distributed cubic regularization of the Newton method for solving empirical risk minimization problems over a network of agents, modeled as undirected graph. The algorithm employs an inexact, preconditioned Newton step at each agent’s side: the gradient of the centralized loss is iteratively estimated via a gradient-tracking consensus mechanism and the Hessian is subsampled over the local data sets. No Hessian matrices are exchanged over the network. Our convergence analysis reveals that statistically accurate solutions are achievable in roughly the same number of iterations of the centralized cubic Newton, at the cost of limited communications per iterations. This represents a significant improvement with respect to existing, statistically oblivious, distributed Newton-based methods over networks.

2 - Peeling Back the Layers of Deep Neural Networks
Aritra Dutta, KAUST, Division of Computer, Electrical and Mathemat, Al Thuwal, 23955-6900, Saudi Arabia

When there are a lot of training data, or the deep neural network is too large, distributed parallel training becomes essential, which refers to either data or model parallelism. In both cases, parallelism introduces various overheads. Network communication is one such significant overhead in large-scale distributed deep learning. Many compressed communication schemes, in the form of sparsification or quantization of stochastic gradients, have been proposed to minimize the problem. However, there exists a significant discrepancy between theory and practice. Theoretical analysis of most existing compression methods assumes compression is applied to the gradients of the entire model. However, practical implementations in popular deep-learning toolkits such as TensorFlow or PyTorch operate independently on the gradients of each layer of the model. In this talk, we show that theoretically, layer-wise compression is better because the convergence rate is upper bounded by that of entire-model compression for a wide range of biased and unbiased compression methods. However, despite the theoretical bound, our experimental study of six well-known compression methods demonstrates that convergence, in practice, may or may not be better, depending on the actual trained model and compression ratio. Our findings suggest that it would be advantageous for deep learning frameworks to include support for both layer-wise and entire-model compression.
1 - Finite Sample Analysis Of Off-policy Natural Actor-critic Algorithm
Saajd Khodadadian, Georgia Institute of Technology, Atlanta, GA, United States

In this paper, we provide finite-sample convergence guarantees for an off-policy variant of a natural actor-critic (NAC) algorithm based on Importance Sampling. In particular, we show that the algorithm converges to a global optimal policy with a sample complexity of $O(\cdot\log(1/\varepsilon))$ under an appropriate choice of stepsizes. In order to overcome the issue of large variance due to Importance Sampling, we propose the Q-trace algorithm for the critic, which is inspired by the V-trace algorithm. This enables us to explicitly control the bias and variance, and characterize the trade-off between them. As an advantage of off-policy sampling, a major feature of our result is that we do not need any additional assumptions, beyond the ergodicity of the Markov chain induced by the behavior policy.

2 - Causal Reinforcement Learning
Devavrat Shah, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

We shall discuss adaptation of methods from causal inference with observational data to enable model estimation and policy learning in the context of reinforcement learning using observational or offline data. We will report on what can be solved and where challenges remain.

3 - Langevin DQN
Vikrath Reddy Dwarkanetha, Stanford University, Stanford, CA, United States

Algorithms that tackle deep exploration -- an important challenge in reinforcement learning -- have relied on stochastic uncertainty representation through ensembles or other hyperparameters, exploration bonuses, or visitation count distributions. An open question is whether deep exploration can be achieved by an incremental reinforcement learning algorithm that tracks a single point estimate, without additional complexity required to account for epistemic uncertainty. We answer this question in the affirmative. In particular, we develop Langevin DQN, a variation of DQN that differs only in perturbing parameter updates with Gaussian noise and demonstrate through a computational study that presented algorithm achieves deep exploration. We also offer some intuition to how Langevin DQN achieves deep exploration.

4 - Global Optimality Guarantees For Policy Gradient Methods
Jalal Bhandari, Cold Spring Harbor Lab, 500, Riverside Drive, Room 832, New York, NY, 10027, United States; Jalal Bhandari, Columbia University, New York, NY, United States; jb3618@columbia.edu, Daniel Russo

Policy gradients methods apply to complex, poorly understood, control problems by performing stochastic gradient descent over a parameterized class of policies. Unfortunately, even for simple control problems solvable by standard dynamic programming techniques, policy gradient algorithms face non-convex optimization problems and are widely understood to converge only to a stationary point. This work identifies structural properties - shared by several classic control problems - that ensure the policy gradient objective function has no suboptimal stationary points despite being non-convex. When these conditions are strengthened, this objective satisfies a Polyak-Łojasiewicz (gradient dominance) condition that yields convergence rates. We also provide bounds on the optimality gap of any stationary point when some of these conditions are relaxed.

5 - Finite-Sample Analysis Of Reinforcement Learning Algorithms: A Lyapunov Approach
Zaïwei Chen, Georgia Institute of Technology, Atlanta, GA, 30318, United States

This paper develops an unified framework to study finite-sample convergence guarantees of a large class of value-based asynchronous Reinforcement Learning (RL) algorithms. We do this by first reformulating the RL algorithms as Markovian Stochastic Approximation (SA) algorithms to solve fixed-point equations. We then develop a Lyapunov analysis and derive mean-square error bounds on the convergence of the Markovian SA. Based on this result, we establish finite-sample convergence bounds for asynchronous RL algorithms such as Q-learning, n-step TD, TD(λ), and off-policy V-trace. As a by-product, by analyzing the performance bounds of the TD(λ) (and n-step TD) algorithm for general (λ) (and n), we demonstrate a bias-variance trade-off, i.e., efficiency of bootstrapping in RL. This was first posed as an open problem in (Sutton, 1999).
6 - Learning To Schedule Heuristics In Branch And Bound
Antonia Chmiela, Zuse Institute Berlin, Berlin, Germany, chmiela@zib.de, Elias B. Khalil, Ambros Gleixner, Andrea Lodi, Sebastian Pokutta
Primal heuristics play a crucial role in exact solvers for Mixed Integer Programming (MIP). While much of MIP research focuses on designing effective heuristics, the question of how to manage them has not received equal attention. Generally, solvers follow hard-coded rules that might not yield the best performance when considering specific problem classes. In this work, we propose the first data-driven framework for scheduling heuristics in a MIP solver. By learning from data describing the performance of primal heuristics, we obtain a problem-specific heuristic schedule that finds many solutions at minimal cost. We provide a formal problem description and propose an efficient algorithm for computing such a schedule. Compared to a state-of-the-art academic MIP solver, we are able to reduce the average primal integral by up to 49% on two classes of challenging instances.

Plenary Session

Wednesday, 9:45AM - 10:45AM

WP01
CC - Ballroom A/Virtual Theater 1
Plenary: Improving Supply Chain Resilience: Looking Back and Looking Forward
Plenary Session
1 - Plenary: Improving Supply Chain Resilience: Looking Back and Looking Forward
Christopher S. Tang, University of California-Los Angeles, UCLA Anderson School of Management, Operations and, Los Angeles, CA, 90095-1481, United States
Prolonged shortages of PPE, vaccines, and semiconductor chips during the Covid-19 Pandemic exposed the vulnerabilities of global supply chains. In this plenary talk, I share my observations and discuss potential steps that government representatives, industry leaders, and INFORMS members can take to improve supply chain resilience.

Wednesday, 11:00AM - 12:30PM

VWA62
Virtual Room 62
Emerging Technologies and Methods for Airline and Airport Operations
Sponsored: Aviation Applications
Sponsored Session
1 - Investment Optimization For Electric And Hydrogen Aircraft Fueling Operations
Simon J van Oosterom, Delft University of Technology, Delft, Netherlands, simon.vano@xs4all.nl
In this presentation, we discuss optimization models to determine the most cost-effective airport infrastructures that support electric and hydrogen-propelled flights. Specifically, we determine optimal electric battery-charging and hydrogen-canister charging infrastructures that satisfy the energy demand of electric/hydrogen aircraft. Our approach is illustrated in a case study for a large European airport.
2 - Incorporating Network Properties In Modelling And Solving The Airport Slot Allocation Problem
Konstantinos G. Zografos, Lancaster University, Lancaster, United Kingdom, k.zografos@lancaster.ac.uk, Merve Keskin

The demand at congested airports is managed through allocation of slots to airlines’ requests. Since these allocations are initially performed individually for each airport, the single airport schedules need to be coordinated to ensure seamless schedule coordination at network level. We introduce a novel mathematical model and an efficient solution algorithm for optimizing the allocation of airport slots at network level. The proposed model incorporates properties of the underlying network to: i) adjust the slot allocations of individual airports, ii) ensure airline schedule feasibility throughout the network, and iii) minimize the deviation from the initial schedules.

3 - Understanding Collision In Multilevel Markets
Nicole Adler, The Hebrew University of Jerusalem, Jerusalem, Israel, Amir Brudner, Riccardo Gallotti, Jose J. Ramasco, Filippo Privitera

We propose a game-theoretic formulation that integrates consumer behavior data, drawn from information and communication technologies, with economic data. Utilizing discrete choice models and developing a catchment area game which analyzes the Great London multi-airport region, we search for horizontal collusion between airports and vertical collusion with airlines. We find horizontal collusion is defined as very likely in the symmetric case but unlikely once we analyze the real world because of market-specific imbalances. This approach overcomes the information asymmetry issue long defined but not yet solved when regulating two-sided platforms such as airports, malls, Amazon and Ebay.

4 - Comparative Ranking Of The Effect On Re-routed Aircraft Due To Historical Space Vehicle Launches
Sanjiv Shresta, DOT, Washington, DC, United States

The growth of commercial space operations has resulted in increased frequency of space vehicle launches. To ensure safe operations, airspace around launch trajectories are closed to aircraft during a launch. Aircraft that plan to fly through a launch airspace must reroute to avoid the launch airspace. Measuring the effect of launches on flights is difficult because rerouting is a common occurrence, irrespective of a launch. We present a methodology for identifying the set of flights that are affected by a space vehicle launch, by comparing flight plans across multiple non-launch days with the launch day flight plan. In this way, a consistent methodology can be applied across many launches.

VWC01
Virtual Room 01
Advanced Data Analytics in Healthcare
Sponsored: Data Mining
Sponsored Session
Chair: Cheng-Bang Chen, University of Miami, University of Miami, Miami, FL, 33143, United States
Co-Chair: Bing Yao, Oklahoma State University, Oklahoma State University, Stillwater, OK, 74075, United States

1 - A Hybrid Computer Simulation Approach to Manage No-Shows in Primary Care Operations
Ammar Abdul Motaleb, University of Texas at Arlington, Arlington, TX, United States, Amith Viswanatha, Yuan Zhou, Yan Xiao, Kay Yut Chen, Ayse Gurses, PROMIS Lab Investigators

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

2 - A Novel Heterogeneous Recurrence Analysis For Medical Imaging Characterization
Yuju Wang, University of Miami, Miami, FL, United States, Cheng-Bang Chen

Prior research has shown that the complex geometric patterns of medical images, providing rich and precise information to the tissues or cells, directly correlate with patient’s health status. Since over 50% of medical data are in medical imaging formats, there is an urgent need to develop an effective and efficient analytical framework to characterize the complex spatial patterns from the medical images. This research presents a novel heterogeneous recurrence analysis of spatial data, developing an innovative recurrence hyperplane representation to capture, extract and quantify the heterogeneous spatial recurrences in the medical images. Both simulations and real-world studies illustrate that the proposed methodology can effectively characterize the complex spatial patterns from the medical images and provide subtle information to improve the diagnosis.

3 - Trustworthy AI Based Hospital Census Forecasting Application
Mihir Mehta, Penn State University, University Park, PA, 16801-4585, United States, Biplab Sudhin Bhattacharya, Eric Reich, Sounadarkumar

COVID-19 hospital census forecasting provides crucial insights to clinical leadership for developing effective resource allocation and scheduling policies. We develop a sequence-to-sequence deep learning-based trustworthy and deployment-friendly application to forecast COVID-19 hospital census for a multi-hospital health care system. The application demonstrates actionable results and proposes a trust index to quantify the trustworthiness of the model performance. Based on the same, we develop a visualization-based trust evaluation and monitoring procedure.

4 - Monte Carlo Tree Search For Optimal Cancer Intervention Strategies Among BRCA Mutation Carriers
Wuyang Qian, Oklahoma State University, Stillwater, OK, United States, wuyang.qian@okstate.edu, Bing Yao

Breast and ovarian cancer is the second and fifth leading cause of cancer death in the US. Prophylactic surgeries involving removing organs from the patient’s body would significantly reduce the risk of cancer for mutation carriers. The problem is when should mutation carrier women receive prophylactic surgeries to not only decrease cancer incidence rate but also maintain a high level of quality-adjusted life years (QALYs). The proposed research aims to develop a sequential decision-making framework for optimal cancer intervention strategies through Monte Carlo Tree Search (MCTS), which increases the computation efficiency. The proposed framework will be validated through a simulation and further evaluated using real-world breast cancer and ovarian cancer data.
A novel robustness certification method is introduced that lower-bounds the probability that neural network outputs are safe when the input is subject to random noise from an arbitrary probability distribution. The bound is cast as a chance-constrained optimization problem, which is then reformulated using input-output samples to make the optimization constraints tractable. We develop sufficient conditions on the number of samples needed to make the robustness bound hold with overwhelming probability, and we show for a special case that the proposed optimization reduces to an intuitive closed-form solution. Synthetic, MNIST, and CIFAR-10 case studies experimentally demonstrate that this method is able to certify robustness against various input noise regimes over larger uncertainty regions than prior state-of-the-art techniques.

4 - A Closer Look At Accuracy Vs. Robustness
Yao-Yuan Yang, University of California, San Diego

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

3 - Data-Driven Certification Of Neural Networks With Random Input Noise
Brendon Anderson, University of California, Berkeley, Berkeley, CA, 94709-1543, Unof Tal State, Sojudi Samayeh

We consider the common setting where one observes probability estimates for a large number of events. Selecting events corresponding to the most extreme probabilities can result in systematically underestimating the true level of uncertainty. We develop an empirical Bayes approach "Excess Certainty Adjusted Probabilities" (ECAP), a variant of Tweedie's formula, which updates probability estimates to correct for selection bias. ECAP directly estimates the score function associated with the probability estimates, so it does not need to make any restrictive assumptions about the prior on the true probabilities. ECAP also works well in settings where the probability estimates are biased. We demonstrate through theoretical results and empirical analysis that ECAP can provide significant improvements over the original probability estimates.

Sponsored Session

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3 - Statistical Quality Control Using Image Intelligence: A Sparsity Learning Approach
Yicheng Kang, Bentley University, Waltham, MA, United States
In image-based quality control, image of the wafer take the form of image streams in the sense that images from the process are being collected over time. In such applications, a fundamental task is to properly analyze image data streams. In this paper, we propose to transform images using a two-dimensional wavelet basis and monitor the wavelet coefficients by sparsity learning-based multivariate control charts. By adapting the sparsity learning algorithm to our quality control problem, the proposed method is able to detect shifts in the wavelet coefficients in a timely fashion and simultaneously identify those shifted coefficients. Combining this feature with the local property of the wavelet basis, our method also enables accurate diagnosis of faulty image regions. In addition, the proposed charting statistics have explicit formulas, so they are easy to compute.

4 - A Combined Physical-statistical Approach For Estimating Storm Surge Risk
Whitney Huang, Assistant Professor, Clemson University, Clemson, SC, United States, Emily Timdwell
Storm surge poses severe threat to property and life in a coastal region. Thus, it is crucial to assess the storm surge risk, typically summarized by the surge return level. However, it is challenging to reliably estimate this quantity due to the limited observations in space and time. This talk presents an approach to integrate physical and statistical models to estimate extreme storm surge. Specifically, a physically-based hydrodynamics model is used to provide the needed interpolation in space and extrapolation in both time and atmospheric conditions. Statistical modeling is used to 1) estimate the input distribution for running the computer model, 2) develop a statistical emulator in place of the computer simulator, and 3) estimate uncertainty due to input distribution, statistical emulator, and missing/unresolved physics.

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VWC05
Virtual Room 05
Time to Introduce Digital Hygiene: How to Avoid Data Privacy Pitfalls in Pandemic-era
Sponsored: Data Mining
Sponsored Session
Chair: Hongyi Huang, University of Maryland-College Park, College Park, MD, 20740, United States
1 - Safeguarding Data Privacy In The Era Of Artificial Intelligence
Kwan-Yuet Ho, United States
Because knowing individuals’ preferences is a lucrative business, personalization has become a common task among data science teams in various commercial and government sectors. The inevitable use of personal data puts people’s privacy at risk. Some hackers might simply steal the data illegally. Some employees who are working in the data and machine learning models might make inappropriate use of the data for their own purpose. Sometimes even if the data are turned “anonymized,” the use of artificial intelligence can sometimes reveal the identity of the individuals represented by the data. In this talk, I will talk about how to protect the privacy of everyone in three aspects: 1) the system architecture design; 2) the rule-based removal of the sensitive information; and 3) the use of machine learning models to further eliminate information about the individuals.

2 - Digital Hygiene Emergency Under The Pandemic
Hongyi Huang, University of Maryland-College Park, College Park, MD, 20740, United States
As Covid hit the globe, our privacy is exposed to unexpected vulnerabilities. From camera breach to invasive proctoring software, from digital trails intrusion to DPI data markets, the data hygiene issues have stuck out as the foremost concerns and threats. Unfortunately, currently no national level privacy legislation serves credible deterrence. Except the pioneer state California has passed Consumer Data Protection Act (CDPA), only few other states have proposed data privacy bills. Companies are limited to the practices such as hiring third party audit or self-regulatory tentative within finite domain. It is time to detect, measure, and manage the data privacy risks avoiding the big lost for every stakeholder. Online privacy, or eventually virtual identity life privacy will only mean more after the pandemic is alleviated. This pandemic is just a catalyst.

3 - Opportunities And Challenges Of Personalization In Digital Health
Kerry Weinberg, League, Boston, MA, United States
This talk will cover several opportunities and challenges to personalizing digital health experiences using machine learning and other data driven methods. These opportunities and challenges are inferred from general industry and regulatory trends as well as specific insights from Kerry’s work as VP Data at League and prior experience leading Data Science & Engineering for Amgen Digital Health. In particular, the role of health data interoperability, consumer trust of digital health, and evolving nature of data privacy will be explored in the context of personalization of digital health applications, platforms, and experiences.

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VWC06
Virtual Room 06
Al-enabled Precision Medicine
Sponsored: Data Mining
Sponsored Session
Chair: Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong
1 - Dynamically Subtyping of Patients with Decompensated Cirrhosis for Predictive Analytics
Haolin Wang, Chongqing Medical University, Chongqing, China
Cirrhosis is the final common pathway for most liver diseases, leading to significant morbidity and healthcare costs. To track the progression of the disease and address the heterogeneity in the patients, this study investigates data-driven approaches for patient subtyping and develops predictive models enhanced by dynamic classifier selection to facilitate the development of effective interventions tailored to patient-specific health conditions.

2 - Network-based Prediction of the Disclosure of Suicidal Ideation in Online Counseling Sessions
Zhongzhi Xu, City University of Hong Kong, Hong Kong, 410000, China
In psychological services, the transition to the disclosure of suicidal ideation is a critical point warranting intervention. Towards this goal, we developed and tested a network-based model to predict such transitions in online synchronous text-based counseling services. This model can potentially help improve the preparedness and efficiency of text-based counseling services.

3 - Bayesian Network Learning for Heart Failure Risk Stratification
Jiadong Zhou, City University of Hong Kong, Hong Kong, Sharen Lee, Gary Tse, Qingpeng Zhang
Risk stratification has been a quite important module in computational cardiovascular sciences. Bayesian network learning becomes an emerging solution to interpretable cardiovascular risk prediction. We construct the model and present a retrospective cohort study about how Bayesian network learning approach can provide casual inference evidences for rational risk predictions.

4 - A Weakly-supervised Approach For Thoracic Diseases Detection
Sadaf Kabir, West Virginia University, Morgantown, WV, 26505, United States, Ali Dabouei, Lilly Farrokhyar
Recent advances in medical imaging have significantly helped healthcare providers with clinical diagnosis and treatment decisions. Deep learning algorithms can provide physicians with consistent second opinions using enhanced clinical image processing. In this study, we propose a weakly-supervised approach with the aim of efficient downsampling of high-resolution chest X-ray images. Using this approach, the spatial information of input images is preserved for a precise thoracic disease prediction. Based on initial results, the proposed framework successfully improves the performance of the diagnosis of thoracic diseases.
Disinformation: An Evaluation of Its Presence, Impacts, and Defenses

1 - Disinformation Targeted
Kathleen M. Carley, Carnegie Mellon University, Sewickley, PA, 15143-8871, United States

Most disinformation has a short half-life with no target. In other cases, communities or individuals are targeted, their social environment manipulated, and the stories they read altered thus increasing the target’s disinformation vulnerability. Bots, trolls sub-conscious cues and memes are used to socially and cognitively manipulate users to achieve strategic disinformation spread. Information maneuvers used to strategically disperse disinformation and manipulate underlying community structures to achieve strategic goals are described and their use during various events discussed.

2 - Human-constrained Machine Learning For Deception Detection In Text
Travis Bauer, Sandia National Laboratories, Albuquerque, NM, United States

We discuss the application of psychology-informed machine learning models to the problem of disinformation detection, termed Human-Constrained Machine Learning. Being grounded in psychology research, the modeling approach explicitly represents and makes predictions based upon knowledge of human behavior. Past research suggests that linguistic cues can be indicative of intentionally deceptive writing. We applied a compression-based algorithm, Prediction by Partial Matching, over sequences of parts of speech (e.g., adjective, adverbs) to differentiate deceptive from credible writing. Four studies demonstrate an ability to differentiate fraudulent from non-fraudulent data. These studies are complimented by a validation study with experienced human raters. This work suggests a domain agnostic generally usable capability for deception detection in text.

3 - Misinformation as a Political Weapon
Julie Ricard, Mozilla Foundation, Mexico

Bolsonaro’s Brazil Since the 2018 presidential elections, the Brazilian public sphere has been prone to widespread misinformation. We will focus on misinformation campaigns that involve and/or have been endorsed by the highest levels of government, including the current president himself. Ranging from fires in the Amazon rainforest, to Covid-19 and hydroxychloroquine, we will discuss how misinformation spreads and what its political goals are.

4 - Characterizing And Comparing Covid-19 Misinformation Across Languages, Countries And Platforms
Jacqueline Otala, Clarkson University, Potsdam, NY, United States, Golshan Madraki, Isabella Grasso, Yu Liu, Jeanna Matthews

We investigate COVID-19 misinformation in multiple languages/countries: Chinese/China, English/USA, and Farsi/Iran; on multiple platforms: Twitter, Facebook, Instagram, WhatsApp, Weibo, WeChat and TikTok. Utilizing opportunistic sampling, we compiled 200 items of viral and debunked misinformation across these languages, countries and platforms from January 1-August 31 2020. While it was observed that COVID-19 misinformation on social media varied across different languages, politics was observed as the root of most collected misinformation across all three languages. We further observe the impact of government platform restrictions on content in China, Iran, and USA.

Innovation/ Entrepreneurship II

1 - An Empirical Assessment Of The Role Of Multinational Vs Entrepreneurial Firms In The Development Of Markets: Evidence From African Mobile Telecommunications Industry
Mohammad Jahanbakhs, Assistant Professor, University of Texas at Arlington, Fort Worth, TX, United States, Romel Motala, Soheil Hooshangi

Although the impact of pre-entry knowledge on firms’ innovative decisions and performance is known in the industry evolution literature, the nature of relationship between firm-level innovations and market-level competitive outcomes is not well-established. Using GMM method with instrument on a panel data from African mobile telecom industry, we find that a small number of firms are capable of implementing trailblazing strategies which result in a disproportionally large impact on evolution of market-level outcomes, such as adoption, price, and industry capital expenditure. We discuss that a differentiating attribute of these firms is their superior pre-entry knowledge of local markets.

2 - Fundamental Limits Of Learning: A Mathematical Framework
Yian Yin, Northwestern University, Evanston, IL, United States, Dushan Wang

A key aspect in human activities concerns how one learns from past experience. The learning curve literature has documented a robust relationship between experience n and unit cost c = c - n - with [0,1]. Yet rich empirical results across industries have consistently reported a typical n = 0.32 and lack of high > 0.5, raising a fundamental paradox: Is the limit n = 1 achievable? Here we develop a general learning model and prove a fundamental limit of learning ≤ 0.5. We further show that both the technology landscape and strategic explorations of new technology are critical for achieving those limits, which have direct implications for the diagnosis, improvement, and planning of many innovative activities.

3 - Do Elite Innovation Companies Need CSR? An Investigation Of The Interactions Between Innovation And Ethical Pay, CSR, And Firm Profits
Patti Miles, Associate Professor of Management, University of Maine, Bangor, ME, United States, John N. Angellis

Companies that invest in CSR or Ethical Pay usually benefit from improved reputation and legitimization in the eyes of the public, investors, and their employees. However, a company that is highly rated by investors for its innovation may be less likely to need such investments. Using an elite sample of innovation companies created by Clay Christensen (Forbes Top 100 Innovative Companies list), we find that innovative companies are significantly more likely to pay median employees more and be more profitable. However, innovative companies do not necessarily spend more on CSR, and CSR does not successfully mediate the relationship between innovation companies and profits.

4 - A Field Experiment On Diversity And Collaboration In Multi-disciplinary Technological Innovation
Nilam Kaushik, Indian Institute of Management Bangalore (IIMB), Bangalore, India,

We report on a field experiment in which 860 university-educated individuals were randomly assigned into teams to participate in ideating and innovating Internet-of-Things applications. We study how surface-level team diversity and knowledge diversity affect team performance.

Equity and Social Justice in Health Care Operations

1 - Fair Allocation Decisions In Multi-stakeholder Healthcare Scenarios
David Rea, Lehigh University, Bethlehem, PA, 45221-0211, United States, Leonardo Lozano, Craig Froehle

Healthcare is rife with difficult multi-stakeholder tradeoffs. Decisions have direct implications for the well-being of patients, providers, and healthcare systems. In such scenarios, inter-stakeholder fairness is a natural concern. Importantly, stakeholder groups are not monoliths. Individual patients and providers differ in their needs, preferences, and expectations. Simultaneously management of these intra-stakeholder and inter-stakeholder tradeoffs is further complicated by the discrete nature of healthcare allocation decisions. This research proposes a framework for incorporating fairness into algorithmic objectives. The generalizability of the framework is shown through examples from teleradiology and inter-hospital transport.

2 - The Role Of Race And Socio-economic Factors In Appointment No-show
Shannon Harris, Assistant Professor, Virginia Commonwealth University, Richmond, VA, 23223-7631, United States, Michele Samorani, Paolo Roma

Existing research in predicting no-show probabilities for outpatient appointments has found no-shows to be correlated with race and socio-economic factors, with more vulnerable populations having a higher probability of no-show. However, existing research has not disentangled the role of race from that of socio-economic factors. In this study we empirically study a large appointment data set and attempt to answer the question: are no-shows a racial or a socio-economic issue?
We show that the traditional objective of minimizing patients’ waiting time and provider overtime leads to scheduling the patients at higher risk of no-show farther into the future than other patients. The reason is that by doing so, the clinic increases the show probability of the patients that are more likely to show up while decreasing the show probability of the patients that are less likely to show up. This strategy will consequently reduce the variability in number of shows, and ultimately decrease the schedule cost. However, because no-show probabilities are often correlated with race, this scheduling strategy results in unintended racial disparities in terms of access to care.

4 - A Decision-making Model To Optimize The Impact Of Community-based Health Programs
Eduardo Pérez, Associate Professor, Texas State University, San Marcos, TX, United States, eduardop@txstate.edu, Yan Li, José A. Pagán

Hospitals and clinics are increasingly interested in building partnerships with community-based organizations to address the social determinants of health. Choosing among community-based health programs can be complex given that programs may have different effectiveness levels and implementation costs. This study develops a decision-making model that can be used to evaluate multiple key factors that would be relevant in resource allocation decisions related to a set of community-based health programs. The decision-making model compares community-based health programs by considering funding limitations, program duration, and participant retention until program completion. Specifically, the model allows decision makers to select the optimal mix of community-based health programs based on the profiles of the population given the above constraints.

5 - Disparity in Medical Appointment Scheduling: An Analytical Study of Waiting Time
Karen T. Hicklin, University of Florida, Gainesville, FL, 32611, United States

Recent studies have shown that access to timely and effective health care is associated with racial/ethnic identities, which creates and perpetuates disparities in health outcomes. This disparity also exists in appointment scheduling. In previous work, it was shown that traditional scheduling systems cause the wait time for Black patients to be approximately 30% longer compared to non-Black patients. We extend the previous work to develop an analytical model to characterize disparity in wait times for patients with historically lower no-show probability rates. Through this characterization, we identify conditions in which disparity occurs.

VWC11
Virtual Room 11

Advances in Health Care Policy
Sponsored: Health Applications Society
Sponsored Session
Chair: Joel Goh, NUS Business School, Singapore, 119245, Singapore

1 - Lung Transplantation Policy Design: Tradeoff Curves Through Optimization
Theodore P. Papalexopoulos, Massachusetts Institute of Technology, Cambridge, MA, 02114-4383, United States, Dimitris Bertsimas, Nikolaos Trichakis

The Organ Procurement & Transplant Network (OPTN) has recently embarked on a program to migrate all US organ allocation policy to a continuous distribution model, starting with lungs. The OPTN’s policy design process seeks to strike a balance between multiplicity and fairness objectives, while reconciling disparate value judgments from a diverse set of stakeholders. In this work, we introduce a novel decision-support tool for policymakers that is designed to facilitate efficient and wide-ranging exploration of policy outcomes and their inherent tradeoffs. We describe the underlying optimization methodology at a high-level and tradeoff analysis that helped guide the OPTN Lung Transplantation Committee’s decision making process.

2 - Outcome-based Pharmaceutical Contracting With Heterogeneous Patient Groups
Andrew Elhabr, Georgia Tech, Atlanta, GA, 30318-8272, United States, Can Zhang, Turgay Ayer

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

3 - Universal Newborn Genetic Screening For Pediatric Cancer Predisposition Syndromes: Model-based Insights
Jennifer M. Yeh, PhD, Harvard Medical School/Boston Children’s Hospital, Boston, MA, 02115, United States

Genetic testing for pediatric cancer predisposition syndromes (CPS) could augment newborn screening programs, but with uncertain benefits and costs. Using data available from ClinVar, gnomAD, SEER cancer registries and published studies, we developed the Precision Medicine Policy and Treatment (PreEMPT) model to estimate the clinical benefits and cost-effectiveness of population-based newborn screening for 11 CPS genes. Our findings suggest that population-based genetic screening of newborns may reduce mortality associated with childhood cancers and could be cost-effective as sequencing costs decline. This study demonstrates how advances in genetics can be applied to populations, what the implications might be for public health, and how decision modeling can be used to evaluate the impact of genetic screening on population health.

3 - Implicit Racial Bias In Healthcare Scheduling Delays
Michele Samorani, Santa Clara University, Leavey School Of Business, Santa Clara University, Santa Clara, CA, 9503, United States, Nan Liu, Shannon Harris, Haibing Ju

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

2 - Enhancing Field Trials Of Genetically Modified Organisms With Optimization
Valeri Vasquez, Berkeley, Berkeley, CA, United States

Optimization is crucial to defining effective deployment strategies for genetically engineered mosquitoes (GEMs). These transgenic organisms are designed for use as public health interventions; release details can be calibrated to save on implementation costs, to avoid the ecological consequences of excessive deployments, or to mitigate the potential epidemiological shortcomings of inadequate scheduling. I develop a nonlinear mathematical program to optimize
Concerns are growing that annual vaccinations will be needed to guard against COVID-19 outbreaks from new variants and immunity loss. Using an agent-based simulation that is calibrated to the greater Seattle area, we simulate different vaccination schedules and non-pharmaceutical interventions to control outbreaks of COVID-19. Vaccination schedules include timing, age prioritization, and requirement policies. Non-pharmaceutical interventions that we simulate include face mask use, testing, and contact tracing. Several factors, including vaccination willingness and vaccine effectiveness against variants are considered.

**4 - Using Agent-based Simulation To Optimize Vaccination Schedules And Non-pharmaceutical Interventions To Control Covid-19 Outbreaks**

Zelda B. Zabinsky, Shan Liu

Virtual Room 13

**Health Care, Modeling and Optimization VII**

**Contributed Session**

Chair: Haolin Feng, Sun Yat-sen University, Guangzhou, China

1 - VRP With Release Dates And Deadlines: A Blood Sample Collection Application

Fernando A. C.C. Fontes, Faculdade de Engenharia, Universidade do Porto, NI, Porto, 4200-465 PORTO, Portugal, Dalila B. M. M. Fontes, Helena V Ferreira

Blood sample collection is critical due to the blood short lifespan. Once extracted, the blood samples are stored until collected, transported, and delivered to the lab. Biological degradation imposes a limit on the time between extraction and delivery. If this limit is not respected, the blood must be disposed of and a new extraction arrangement is needed, in addition to the extraction, collection, and delivery costs, which implies environmental costs associated with the disposal of biological residues. This problem can be cast as a VRP with release deadlines (the extraction times) and deadlines (the lifespan). We propose a MILP model to solve this problem.

2 - Advanced Evolutionary Algorithm For Routing And Scheduling Problem In Home Health Care

Yoram Clapper, Vrije Universiteit, Amsterdam, Netherlands, Joost Berkhout, Rene Bekker, Dennis Moeke

Home health care service providers seek to deploy their staff as effectively as possible, which often translates to the well-known Home Health Care Routing and Scheduling Problem (HHRSCP). The larger part of the available algorithms that are applied to the HHRSCP focus on the operational level and less on the tactical level. In this study, we develop an advanced evolutionary algorithm by extending the permutation Gene-pool Optimal Mixing Algorithm (pGOMEA) that optimizes the HHRSCP on an operational level, while paying attention to the tactical level as well.

3 - Optimizing The Patient Logistics In A Hospital Regarding Fairness Aspects And Break Assignments

Jens Brunner, University of Augsburg, Augsburg, Germany.

In hospitals, patients often have to wait a very long time before they are transported from one ward to another. One of the main reasons for this is incorrect staff and route planning for patient transportation. The resulting waiting times of patients lead to a reduction in patient care. We formulate this problem as a vehicle routing problem with route balancing and time windows. We present a MIP model that minimizes patient waiting times, balances the workload of the staff, and also takes into account the planning of a break. Since up to 900 patients have to be transported every day in practice, we decompose our compact model by a Dantzig-Wolfe reformulation to speed up the solution process.

4 - Balancing Accessibility And Efficiency In The Distribution Of The Covid-19 Vaccine In Oregon: A Mixed-integer Programming Approach

Defeng Tao, Student, Oregon State University, Corvallis, OR, United States, Joseph Kapena Agor, Hector Vergara, Jessina McGregor, Alex Brown

In the Covid-19 vaccine distribution problem, balancing accessibility and operational costs can be challenging. Accessibility is a quality with which services can be easily obtained or used traditionally measured via distance. Total operation cost includes fixed cost, labor cost, transportation cost, and holding cost of inventories when running facilities. We propose a mixed-integer programming model to determine sites for COVID-19 vaccination in the state of Oregon to maximize accessibility while minimizing operational costs. The trade-off between those objectives will be discussed.

5 - The Impact Of Advanced Digital Technologies On Patient Referral And Healthcare Operations

Xiaolong Wang, Professor, Renmin University of China, Beijing, China, Yuhan Yan

Patient referral between different hospitals can be facilitated by high-level digitalization. But more frequent referrals and information sharing may harm some hospitals’ revenue. We analyze the tradeoffs and discuss relevant incentive schemes to provide insights from the perspective of social welfare optimization.

6 - Appointment Scheduling For A Multi-physician Outpatient Clinic: The Convexity Results

Haolin Feng, Sun Yat-sen University, Guangzhou, China, Zitian Li

We study the appointment scheduling problem of outpatient clinics with multiple physicians. Stochastic service time is considered, and the decisions are appointment time for the given set of patients. The objective of the scheduling problem is to optimize the (weighted) expected value of the sum of patient waiting, the server’s idling and overtime. We derive the expression of the performance measures and provide the theoretical results regarding the convexity of the optimization problem.

3 - Mitigating Strategies and Operations in Confronting Covid-19

Sponsored: Health Applications Society

Sponsored Session

Chair: Jin Qi, Hong Kong University of Science and Technology, Hong Kong, Hong Kong

1 - Presenter

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong

2 - Capacitated SIR Model With An Application To Covid-19

Chaoyu Zhang, University of Toronto, Toronto, ON, Canada, Ming Hu, Ningyuan Chen

The classical SIR model and its variants have seen great success in understanding and predicting infectious diseases’ spread. We extend the SIR model to incorporate the limited testing capacity, which is one of the most notable challenges in the COVID-19 outbreak. Specifically, based on the SIR model, we impose a testing capacity that is shared among the infected and uninfected people. We show first- and second-order structural properties of one measure, the number of infected people, concerning the testing capacity, degree of testing, and predicting turnaround time, and infection rate. In particular, we show that in the early stage of a pandemic, the total number of infections is concavely decreasing in the testing capacity. We use the COVID-19 data to calibrate our model and point out its policy implications.

3 - Resource Planning And Operations Rescheduling Under An Epidemic

Xiangrong Qi, Hong Kong Univ of Science & Technology (HKUST), Dept of IELM, HKUST, Kowloon, Hong Kong

The outbreak of an infectious disease will occupy a huge amount of medical resource, causing serious disruption to the regular service of the public health system. In this talk, we introduce a framework of handling such disruptions in the context of operating theaters. The framework includes a centralized resource planning for multiple hospitals in a region, multiple-days operations planning for one hospital, and detailed daily schedule for arranging operating rooms. We develop models and solutions for the above decision-making problems.

4 - The Effect Of Correlations On Group Testing Against COVID-19

Aqi Z. Zhang, Chinese University of Hong Kong, Hong Kong

Group testing has been widely adopted during COVID-19 due to the shortage of testing resources. It essentially helps to screen for the presence of a virus within a large population. We study the optimal group testing policies where the infection of subjects may be correlated and the information of prevalence rates and correlations may be unknown. We examine the joint effect of the parameters on the efficiency of testing procedures, and characterize important structural properties of the optimal testing policies.
1 - Labor Cost Free-Riding in the Gig Economy

Co-Chair: Hamid Nazer, Uber, San Francisco, CA, 94103, United States
Co-Chair: Chiwei Yan, University of Washington Seattle, San Francisco, CA, 94158-1507, United States

The boom of online medical crowd-sourcing platforms provides more equal access to medical resources for patients. A distinct feature of the on-demand medical crowd-sourcing platform we considered is that they provide an affordable way to enable patients to seek multiple opinions from experienced doctors participate. We consider an on-demand medical crowd-sourcing platform that designs the optimal price and reward scheme with operational leverage such as a control limit on the number of doctors. We extend the analysis to two more realistic scenarios when consumers are delay sensitive and service level are heterogeneous. We collect data from one on-demand doctor platform and empirically validate the main results of the analytical model. Our research contributes to the literature on on-demand platforms and online healthcare services.

2 - Evaluating Success Rate of Threshold Public Good Project: Theory and Experiment

Shihong Xiao, The Hong Kong University of Science and Technology, Hong Kong, Hong Kong, Ying-Ju Chen, Yu Ping Chen

In this study, we examine how the success rate of a discrete threshold public good project depends on the threshold through both theory and experiment. We consider a setting where a population of individuals make binary private contribution decisions to a public good project. The project is successful only if the number of contributions exceeds a certain threshold. Individuals are heterogeneous in their cost of contribution. We find that the project success rate may be non-monotonic on the threshold in theory and use experiments to evaluate our theoretical findings.

3 - Delivering Multi-speciality Care Via On-demand Telemedicine Platforms

Lingjiong Zhu, Florida State University, Tallahassee, FL, 32306, United States, Sergei Savin, Yuqian Xu

The on-demand telemedicine platforms represent a rapidly growing segment of the healthcare industry. In this paper, we examine a key feature of such multi-specialty telemedicine platforms, namely, the presence of interaction between the demand for general and specialized care by developing and analyzing a model that combines the decisions by patients, physicians, and the platform, and contrast it with the no-interaction benchmark setting. We find that for moderately compensated specialists, the demand interaction between the general and specialized care lowers the barrier for specialists to join the platform, but also that the benefits of demand interaction subside as specialist wage levels increase.

4 - Matching Drivers to Riders: A Two-stage Robust Approach

Oussama Hanguir, Columbia University, New York, NY, 10025, United States, Omar El Houssni, Vineet Goyal, Clifford Stein

Matching riders to drivers efficiently is a fundamental problem for ridesharing platforms who need to match the riders as soon as the request arrives with partial knowledge about future requests. A myopic approach that computes an optimal matching for current requests ignoring future uncertainty can be highly sub-optimal. In this paper, we consider a two-stage robust optimization framework for this matching problem where future demand uncertainty is modeled using a set of demand scenarios (specified explicitly or implicitly). The goal is to match the current request to drivers (in the first stage) so that the cost of first stage matching and the worst case cost over all scenarios for the second stage matching is minimized. We show that the two-stage robust matching is NP-hard under various cost functions and present constant approximation algorithms for different settings.
platform. The results also reveal that our policy exhibits good performance even if its associated performance. It yields significant improvements over SAA for small policy. Using real-life data from a large online travel platform, we show that our algorithm through its worst-case relative expected regret, compared to an oracle customer purchasing decisions. The platform does not know how cropped images map existing data to an optimal decision. We evaluate the performance of any chooses a cropping window and observes the resulting conversions, i.e., the customers to help with their purchasing decisions. For each image, the platform makes decisions to trade-off underage and overage costs. In contrast to the typical setting, we assume that the decision-maker does not know the underlying distribution driving uncertainty but has only access to past data drawn from the underlying distribution (e.g., past demand). In turn, the key question is how to map existing data to an optimal decision. We evaluate the performance of any algorithm through its worst-case relative expected regret, compared to an oracle with knowledge of the distribution. We provide the first finite sample exact analysis of the classical Sample Average Approximation (SAA) algorithm for this class of problems across all data sizes. We further derive an optimal algorithm and its associated performance. It yields significant improvements over SAA for small data sizes.

4 - Deep Learning For Visual Advertising On Digital Platforms
Yuexiong Li, Duke University, Durham, NC, 27703-6548, United States, N. Bora Keskin, Shaoxuan Liu, Jing-Sheng, Jeannette Song
We consider a digital platform that aims to crop and display N images to its customers to help with their purchasing decisions. For each image, the platform chooses a cropping window and observes the resulting conversions, i.e., the customer purchasing decisions. The platform does not know how cropped images influence conversions. We design a neural network policy that dynamically learns this relationship and adjusts images to maximize conversion. We derive a theoretical performance guarantee proving the asymptotic optimality of our policy. Using real-life data from a large online travel platform, we show that our policy achieves considerable improvement over the incumbent policy of the platform. The results also reveal that our policy exhibits good performance even if the functional relationship between images and conversion is misspecified.
3 - Price Discrimination With Robust Beliefs
Jun Han, EPFL, Lausanne, Switzerland, Thomas A. Weber
We consider the problem of price discrimination when the type distribution is unknown or specified by an ambiguity set. A performance index, equivalent to relative regret, is proposed to quantify the worst-case attainment ratio between actual payoff and ex-post optimal payoff. We also provide a simple representation of this performance index. For a standard linear-quadratic screening model, a worst-case performance index of 75% guarantees that the robust product portfolio exhibits a profitability that lies within a 25%-band of an ex-post profit, over all possible model parameters and beliefs.

4 - Appointment Scheduling With Customer Preferences And Service Constraints
Carlos Cardonha, Assistant Professor, University of Connecticut, Storrs, CT, United States, Miao Bai
In this problem, we have a set of service providers, each associated with a service capacity, a revenue per service and overcapacity penalty, and a set of customers choosing providers according to multinomial logit choice models. Our goal is to identify a probabilistic assortment offering that maximizes the overall revenue. The assortment offering may be restricted by service constraints, such as the number of selected providers and service level among customers’ demand. We prove the NP-hardness of the problem, characterize the optimal solutions of the appointment scheduling sub-problem, and present a fully polynomial-time approximation scheme to solve the problem.

VWC19
Virtual Room 19
Advances in stochastic convex and non convex optimization algorithms
Sponsored: Applied Probability Society
Sponsored Session
Chair: Digvijay Boob, Southern Methodist University, Dallas, TX, 30318, United States
1 - Complexity Of A Damped Proximal Admm For Linearly-constrained Nonseparable Nonconvex Composite Optimization
Wewei Kong, Georgia institute of Technology, Atlanta, GA, 30318, United States
This talk presents a damped proximal ADMM for finding approximate stationary points of linearly-constrained nonseparable nonconvex composite optimization problems. Using an under-relaxed multiplier update and several recent techniques from the analysis of nonconvex proximal augmented Lagrangian methods, we establish a complexity bound that significantly improves on the state-of-the-art. Some important properties of the method are that: (i) it can be started from any point where the objective function is finite (and hence, not necessarily a feasible point), (ii) it does not require any regularity conditions on the linear constraint, and (iii) it can be applied to a large class of nonconvex, nonsmooth, and nonseparable objective functions.

2 - A Proximal Bundle Type Method For Smooth And Nonsmooth Convex Optimization And Its Application To Reinforcement Learning
Jingjing Liang, Georgia Institute of Technology, Solace Atlanta, GA, 30308-1214, United States, Renato D. C Monteiro
This talk presents a proximal bundle (PB) method for solving convex smooth and nonsmooth composite optimization problems. Like other proximal bundle variants, PB solves a sequence of prox bundle subproblems whose objective functions are regularized composite cutting-plane models. Moreover, PB uses a novel condition to decide whether to perform a serious or null iteration which does not necessarily yield a function value decrease. Iteration-complexity bounds for PB are established for a large range of prox stepsizes. We further extend PB to the stochastic setting where the objective function only has stochastic first-order oracles. To the best of our knowledge, this is the first time that a proximal bundle variant has been shown to be effective to solve convex stochastic programming problems.

3 - Minibatch And Momentum Model-based Methods For Stochastic Non-smooth Non-convex Optimization
Qi Deng, Shanghai University of Finance and Economics, School of Information, Shanghai, 201900, China
Stochastic model-based methods have appealing robustness to the stepsize and efficiency guarantees for non-smooth non-convex optimization. We improve the performance of these methods further. First, we present a minibatch extension which takes a set of samples to approximate the model function in each iteration. For the first time, we show that these stochastic algorithms can achieve linear speedup over the batch size even for non-smooth and non-convex problems. Second, we propose a new stochastic extrapolated model-based method to possibly improve the convergence further. We obtain complexity guarantees for a fairly flexible range of extrapolation terms. Finally, we use experiments to show the empirical advantage of our proposed methods.

VWC20
Virtual Room 20
New Applications of Queueing Theory
Sponsored: Applied Probability Society
Sponsored Session
Chair: Jamol Pender, Cornell University, Ithaca, NY, 14850, United States
1 - Algorithms For Queueing Systems With Reneging And Priorities Modeled As Quasi-birth-death Processes
Amir Rastpour, Assistant Professor, Ontario Tech University, Oshawa, ON, Canada, Arman Ingolfsson, Burhaneddin Sandicki
We develop an iterative algorithm for a class of infinite level-dependent quasi-birth-and-death (LDQBD) processes. These LDQBDs can model the Erlang A system with two priority classes of impatient customers with different arrival, service, and abandonment rates. Our algorithm provides bounds for the level-dependent rate matrices and uses these bounds to endogenously truncate the system and to provide bounds on system performance measures. We show that the running time of this class of LDQBDs either suffers from low accuracy or from long solution times.

2 - Stochastic Models for Community Bail Funds
Jamol Pender, Cornell University, Ithaca, NY, 14850, United States
Bail funds have a long history of helping those who cannot afford bail in order to wait for trial at home. Not only have bail funds help release those who cannot afford their bail, but it also has had an immeasurable impact on the decision of the defendant. In this paper, we consider the first stochastic model for a community bail fund. To build our stochastic model, we uniquely combine insurance models and infinite server queues to model the bail fund. As a result, we are able to not only model the bail fund, but also assess the impact that a bail fund will have on a community. In this regard, we determine the amount of money a county might save by implementing a bail fund. Although, we cannot measure the impact on the human spirit, we can start to understand in a rigorous way, the impact of the bail fund on the community.

3 - Queues with Updating Information
Philip Doldo, Cornell University, Ithaca, NY, 14853, United States
Many service systems provide customers with information about the system so that customers can make an informed decision about whether to join or not. Many of these systems provide information in the form of an update. Thus, the information about the system is updated periodically in increments of size . It is known that these updates can cause oscillations in the resulting dynamics. However, it is an open problem to explicitly characterize the size of these oscillations when they occur. In this paper, we solve this open problem and show how to exactly compute the amplitude of these oscillations via a fixed point equation. We also compute closed form approximations via Taylor expansions and show that these approximations are very accurate, especially when is large. Our analysis provides new insight for systems that use updates as a way of disseminating information to customers.

INFORMS Anaheim 2021
1 - Silent Abandonment In Contact Centers: Estimating Customer Patience From Uncertain Data
Antonio Castellanos, Technion – Israel Institute of Technology, Haifa, Israel, Galit B. Yom-Tov, Yair Goldberg

Contact centers are one of the favorite channels of communication with companies. However, they face operational challenges - common proxies for customer experience are subject to information uncertainty. A main source of such is silent abandonment by customers. These customers leave the system while waiting for a reply, but give no indication for doing so. As a result, agent capacity is wasted. In two case studies we show that up to 70% of the abandoning customers abandon silently, and that such behavior reduces system efficiency by up to 15%. We develop methodologies to identify silent abandonment and to estimate customer patience. We show how accounting for silent abandonments in a queuing model improves the estimation accuracy of key measures of performance. Finally, we suggest strategies to operationally cope with the phenomenon.

2 - The Impact Of Information On Strategic Customer Behavior In A Transportation Station
Antonis Economou, National and Kapodistrian University of Athens, RoAthens, 15772, Greece,

Nowadays, a transportation station can provide its potential passengers with information regarding the arrival times of the facilities, the congestion in the station and the space availability of future facilities. Such information influences the behavior of strategic passengers and the welfare generated by the system. In this talk, we will describe a general model of a transportation station where strategic customers decide whether to stay or balk based on their expected waiting costs and the probability of being served, conditioning on the information provided. The information may include the capacity of the next facility, the elapsed time from the previous visit of the facility and/or the number of waiting customers. We will show how the customer equilibrium strategies can be derived and will discuss the ideal level of information that should be provided.

3 - Behavior Aware Service Staffing
David D. Cho, Woodbury University, School Of Bus. CA, 91504-1052, United States, Kurt M. Breithauer, Kyle D. Cattani, Alex Mills

Empirical studies of service systems have shown that workers exhibit different service rates depending on their assigned workload. We model two commonly observed behavioral effects, speedup and slowdown, then incorporate the model into a multi-period workforce staffing problem to study their joint impact on service staffing. Our results show that a workload that maximizes the service rate is typically not optimal. We also find that the effectiveness of the widely practiced single-ratio workload staffing policy depends on the strength of the speedup and slowdown effects.

4 - On Two Models Of Choice Between An Observable And An Unobservable Queue With Heterogeneous Servers
Jonathan Millo, Tel Aviv University, Tel Aviv, Israel, Irael Hassin

We consider a queueing system where customers arrive according to a Poisson process and select one out of two servers with exponentially distributed service durations. Customers observe the first queue length and make an irrevocable decision on whether or not to enter it, without observing the second queue. We analyze two models where the first server is slower than the second. In both models there is no queue in front of the first server. In one model there is also no queue at the second server and customers who reach it when it is busy are lost. In the second model, there is a queue in front of the second server. We characterize the equilibrium behavior and investigate the relation between the equilibrium and optimal strategies, including the price-of-anarchy.
2 - Detection And Recognition Of Mixed-type Defect Patterns In Wafer Bin Maps Via Tensor Voting
Rui Wang, Assistant Professor, Harbin Institute of Technology (Shenzhen), Shenzhen, China, Nan Chen
Spatial defect patterns on semiconductor wafer bin maps (WBM)s provide valuable information on the root causes of process abnormality. The identification of these patterns is thus important for yield improvement. The recognition of mixed-type patterns is challenging as the patterns need to be separated into clusters and then each cluster is classified as a pre-defined defect pattern type. In this study, we propose a tensor voting-based method for mixed-type defect pattern detection and recognition in WBM.s. Marching algorithms are developed to extract region and curve patterns based on the structural saliency information of the voting process. Our method is inherently robust to noise and flexible to deal with complex shapes of defect patterns. The results obtained using both real and simulated data demonstrate the effectiveness of the proposed method.

3 - Intelligent Operation and Maintenance (O&M) Policies for Multi-location Manufacturing Network based on Data Analytics
Tongbin Xia, Deputy Director, Shanghai Jiao Tong University, Shanghai, China, Guojin Si
Increasing machine investments and expensive operation and maintenance (O&M) costs have made manufacturing system leasing and maintenance service outsourcing gaining a momentum. Individual equipment degradations, complex system structures and global network layout bring challenges for real-time decision-making. It is parameter for decision makers to fully utilize the monitoring data to characterize and update the individual path of each equipment’s degradation signals, thus developing timely and cost-effective schemes for geographically distributed factories. This work addresses recent advances in O&M for service-oriented manufacturing paradigm to forecast health trends, avoid production breakdowns, reduce maintenance cost and achieve rapid decision-making.

4 - Location-scale Monitoring of Ordinal Categorical Processes
Kaizong Bai, Xi’an Jiaotong University, Xi’an, China, Ian Li
In many applications, some process variables are measured by categorical data with some natural order among their attribute levels. They are known as ordinal categorical factors and determined by their latent continuous variables. We consider shifts in either location or scale parameters of latent variables, as well as in correlation parameters of multiple ordinal factors, but only the ordinal attribute levels are observable. To this end, univariate and multivariate location-scale log-linear models are first established to describe a single ordinal factor and multiple ones, respectively. Based on these, univariate and multivariate location-scale ordinal control charts are proposed.

15 - Reinforcement Learning For Process Control With Application In Semiconductor Manufacturing
Yanrong Li, Shanghai Jiaotong University, Shanghai, China, Juan Du, Wei Jiang
Process control is widely discussed in multistage manufacturing, especially for semiconductor manufacturing. In practice, various data is collected during manufacturing processes due to Internet of Things (IoT). This work introduces reinforcement learning (RL) process control methods based on sensor data and proposes model-based and model-free RL algorithms. Two simulation cases in semiconductor manufacturing are presented to validate the performance of RL controllers and compare them with traditional controllers. The results demonstrate that model-based RL is suitable when the process model is available; model-free RL addresses various disturbances when the process model is unclear.
4 - The Effect Of Multi-sensor Data On Condition-based Maintenance Policies
Heletjie Van Staden, KU Leuven, Leuven, Belgium, Robert Boute Industry 4.0 promises reductions in maintenance costs through access to digital technologies such as the Internet of Things. Many of the promised benefits are, however, dependent on the quality of the data obtained. In this work, we consider the effect of access to different levels of deterioration data quality, resulting in partial information about the underlying state of the system being monitored, by means of sensors, on condition-based maintenance policies. We analyze the structure of the optimal policy, where the actions are either to perform maintenance, to pay for external sensor information or to continue system operation with internal sensor information only. We show that the optimal policy consists of at most four regions and numerically investigate a decision maker’s willingness to pay for additional information.

5 - Predictive 3D Printing With IoT
Yue Zhang, Pennsylvania State University, University Park, PA, 16827-1750, United States, Jing-Sheng Song
We consider the context of a 3D printer supplying spare parts for a critical part installed in multiple machines that are embedded with sensors and interconnected via IoT. We demonstrate that 3D printing should be conducted predictively with the optimal policy described by a system-state-dependent threshold. Among all parameters, the printing speed is the key determinant for the optimal policy to exhibit a special mode, print-on-demand-demand (PoAD), that permits minimum inventory. In addition, the impact of IoT in enabling predictive 3D printing can be decomposed into one portion attributed to the advance information from embedded sensors, and another attributed to the real-time information fusion due to sensors interconnected via IoT. This information fusion amplifies the well-known complementary relationship between inventory and advance demand information.

- Virtual Room 26
Sustainability and Social Responsibility in Supply Chains
Sponsored: Manufacturing and Service Operations Management
Sponsored Session
Chair: Robert Swinney, Duke University, Durham, NC, 27708-9972, United States
1 - Are Fast Supply Chains Sustainable?
Ali Kaan Tuna, Duke University, Durham, NC, 27708, United States, Robert Swinney
We study the environmental implications of a firm’s efficient (prioritizing cost) or responsive (prioritizing speed) supply chain choice. Using a model in which it increases costs but decreases leadtimes, we show that responsiveness is most likely to benefit the environment when it is least likely to be profitable. Thus, aligning firm and environmental preferences with responsiveness is challenging. We show that this can occur in settings with localized production and/or high demand variability, or if the product generates significant environmental impact during its use phase. We also discuss how competition changes our insights and how policymakers can influence firms to choose environmentally superior supply chains. In a numerical study, we determine the likely environmental performance of responsiveness in different industries.

2 - The Impact Of Variety On The Economic & Environmental Performance Of A Fashion Rental Business Model
Anna Saez de Tejada Cuenca, ISE Business School, A, Barcelona, 08034, Spain, Vishal Agrawal, Ekaterina Astashkina
Fashion rentals companies constitute a rapidly growing industry. Renting clothes allows consumers to enjoy a larger variety of products without purchasing them, thus potentially solving the problem of underutilization of garments and waste. In this paper we analyze the impact of variety on consumers’ usage behavior and on the company’s operational performance as a whole, using real data from a US-based clothing rental company. We find that higher variety leads to clients keeping their rented items shorter, renting substitute items sooner, and overall renting more items. This increases items’ utilization: they get rented more times, and spend less time idle. However, when product variety is too high, item utilization starts to decrease. With these empirical results, we build a simple analytical model to quantify the economic and environmental impact of variety levels.

- Virtual Room 27
Operations Management I
Contributed Session
Chair: Cao Xuejingu
1 - Selling Online Display Advertising By Guaranteed Contracts Combined With The Real-time Bidding Auctions
Junchi Ye, Trinity College Dublin, Dublin, Ireland, Yuefei Huang, Bowei Chen
There are mainly two selling channels for impressions of online display advertising: guaranteed contracts and the real-time bidding (RTB). This paper focuses on the problem that how should the publisher pricing the guaranteed contracts with the presence of RTB to maximize her revenue. In the basic model, the publisher sells a certain number of impressions to a certain number of advertisers with unit demand during two periods. In each period only one channel available. We show that this mechanism combining guaranteed contracts and RTB is more flexible and profitable than only one channel. We also extend our model to a uncertain number of impressions.

2 - Organizational Challenges And Root Cause Interpretations: Evidence From A Longitudinal Study Of Business Executives
Robert N. Eberhart, Associate Director of Entrepreneurship and Society, Stanford University, Palo Alto, CA, United States, George Foster, Jim Andrew Best-Devereux
How managers respond to their challenges is central to studies of both strategy and organizational theory, but how challenges are interpreted is much less studied. Strategic literature examines managerial responses from a performance-oriented perspective; organizational scholars theorize that actions are selected to maintain legitimacy. We employ LDA topic modeling to analyze 1,648 written challenges and cause interpretations from CEOs and executive officers who attended executive education programs over a twenty-three-year period at Stanford University. We test how the type of challenge matches the type of interpretation and observe changes in these responses.

3 - Human Discretion In Automated Supermarket Replenishment And Self-inflicted Stockouts
Bengt Nur Özdemir, IE Business School, Madrid, Spain, Antti Tenhiala
In the retail industry, automatic store replenishment (ASR) systems balance inventory costs and shelf availability. Yet, decision-makers have the discretion to cut ASR order proposals to avoid excessive inventory when they expect deteriorating demand conditions. Using data from a supermarket chain, we analyze the effects of deviations from ASR orders. We investigate the implications of different cognitive biases. We employ two-stage econometric models to address endogeneity. Results show that cognitive biases predict deviations, and biased deviations lead to higher likelihood of stockouts. Based on the results,
counterproductive use of discretion can be identified and discouraged.

4 - Impact Of Vertical Integration In A Referral-based Healthcare System

We investigate how vertical integration influences the referral behavior in primary care and the corresponding service provision at specialists. We use a novel modeling feature to capture the level of integration and its impact on specialist and generalist decisions. We find that the system efficiency can be improved with a moderate integration level. However, aiming for a moderate level of integration is especially appropriate if congestion at the specialist stage becomes substantial or the generalist’s ability to treat complex patients is limited. Our work also shows that physicians get higher payment without necessarily improving service quality when the integration level is higher.

- VWC28

Virtual Room 28

Healthcare Analytics in action: using data-driven models to effect change

Sponsored: MSOM/Healthcare

Sponsored Session

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

Co-Chair: A. Cecilia Zenteno, Massachusetts General Hospital, Boston, MA, 2114, United States

Co-Chair: Taghi Khaniyev, MIT Sloan School of Management, Cambridge, MA, 02142-1508, United States

1 - Optimal Resource Pooling For Effective Use Of Future Operating Room Capacity

Seung-Yup Lee, Vanderbilt University Medical Center, Nashville, TN, 37212, United States, Vikram Tiwari

We investigate the optimal timing for release of unfilled operating room (OR) block capacity to improve the efficiency and effectiveness of OR use. A Markov decision process structure is designed that incorporates not only the number of remaining days until the day of surgery but also the remaining capacity of the OR block as well as historical demand for the block. In this presentation, we propose the decision-making modeling structures for both the single- and multi-OR block cases and discuss the applicability of the resulting policies in practice and expected improvements. Our results provide insights into pursuing proactive management of pooling limited resources in the healthcare setting where both system-wide efficiency and specialty-specific characteristics of resources should be considered.

2 - Evaluating Medical Disaster Planning Exercises Using Mathematical Programming

Derya Demirtas, University of Twente, Postbus 21 Enschede, Netherlands, Gerbrich Holzbrink, Patricia Rogetzer, Nancy ter Bogt

During a mass casualties incident (MCI), treatment capabilities of the regional hospitals are overwhelmed. In the Netherlands, emergency care networks prepare their regions for an MCI by organizing analog simulation exercises called Emergo Train System (ETS) exercises. In 2019, two separate emergency medical teams simulated the allocation process of casualties to ambulances and hospitals using ETS. The results differed significantly between the teams. Although the ETS exercises are widely used in the world, the optimal solutions are not known before or after, leaving how much better a team could perform a mystery. In this research, we propose an ILP that allocates each casualty of an MCI to an ambulance and a hospital. We demonstrate the effectiveness of our models by comparing our results to the outputs of the ETS exercises of 2019 and provide sensitivity analysis.

3 - Predictive Analytics For Post-partum Hypertension

Jinxin Tao, UW Madison, Madison, WI, United States, Ramsey Larson, Yonatan Minz, Kara Hoppe

Hypertensive disorders of pregnancy (HDP) complicate approximately 10% of pregnancies in the United States but account for the majority of postpartum readmissions. Postpartum readmission is costly both in financial terms and in quality of life measures for mothers and new families. However, using a predictive model to help predict postpartum readmission due to hypertension has not been proposed yet. In this study, we used a cost-sensitive random forest method to predict which patients would experience a hypertension-related postpartum readmission. With the records of 32,645 patients who delivered between 2009-2018 and 170 readmissions included, our model achieved a sensitivity of 85%, specificity of 79% and a balanced accuracy of 82% in predicting readmission.

4 - A Prescriptive Approach To Surgical Inpatient Discharges

Taghi Khaniyev, MIT Sloan School of Management, Cambridge, MA, 02142-1508, United States, Kyan Safavi, Martin Copenhaver, A. Cecilia Zenteno

We first trained a neural network model to accurately predict next-day’s inpatient discharges using structured EHR data which was represented based on whether it indicated a clinical or administrative barrier to discharge which was defined as an event that may postpone the patient’s discharge. Discharge predictions were categorized as NO/MAYBE/YES. An optimization model was developed to select the minimal subset of barriers for each patient that need to be resolved in order to move a patient to YES category. This minimal list was intended to serve as a prioritized action list for each patient. When we augmented the prediction model with free-text clinical notes using a recurrent neural network, the prediction accuracy was improved by up to 20%.

- VWC29

Virtual Room 29

Financial Frictions and Operations Management

Sponsored: MSOM/iForm

Sponsored Session

Chair: Christopher J Chen, Indiana University Kelley School of Business, Indiana University Kelley School of Business, Bloomington, IN, 47405-1703, United States

1 - Trade Credit Late Payment And Industry Structure

Jing Wu, Chinese University of Hong Kong, Decision Sciences and Managerial Economics, Hong Kong, Hong Kong, Hsiao-Hui Lee, John R. Birge

Trade credit studies pay little attention to firms’ late payment behavior due to the lack of extensive panel data. From the perspective of industry structure, this paper is the first to empirically study firms’ trade credit late payment. We show that a firm’s late payment behavior is positively associated with market power and downstream cost-shifting, and firms strategically choose to whom and for how long to delay their trade credit payment. We also examine several moderating factors, including a firm’s capacity to borrow and speed to borrow, inventory turnover, and prior contract breach record.

2 - Using Digital Footprints To Understand American Covid Product Manufacturing

Alan Kwan, Hong Kong University, Hong Kong, Hong Kong, Ben Charoenwong, May Li

Using a dataset from North America’s largest digital platform for B2B product sourcing, we study demand for Covid-related products and study supplier entry into the market for PPE. Manufacturers which produced closely-related products prior to the pandemic were more likely to repurpose production into Covid-related products when demand increased, but several market-level factors inhibited supplier entry. Demand and epidemiological forecast uncertainty negatively impacted supplier entry and suppliers’ labor-intensive products, especially in areas where labor supply was more constrained. Conversely, potential suppliers display significantly higher probability of entering when they expect stronger governmental support, highlighting the importance of government procurement for public health emergencies.

3 - Inventory Productivity In Manufacturing Networks

Nikolay Osadchyi, Emory University, Atlanta, GA, 30322-1059, United States, Deepak Agrawal

We identify drivers of inventory productivity in manufacturing networks, including traditional and novel ones based on the supply chain position, and discuss implications for performance benchmarking and valuation.

4 - A Data-driven Model Of A Firm’s Operations: An Application To Cash Flow Forecasting

Vishal Gaur, Cornell University, Ithaca, NY, 14853-6201, United States, Kashish Arora

Financial variables reported in the financial statements of firms are essential for performance analysis. Yet, such analysis is made complicated by the fact that these variables are endogenous to the decisions made by firms. In this paper, we propose a generalizable and data-driven model of a firm’s operations to disentangle this endogeneity and estimate cross-variable causal impacts among variables. We model the relationship between a firm’s operational variables and its evolution over time. We estimate the model using public operational. Thereafter, we (i) quantify the contemporaneous and dynamic impacts of structural shocks in variables on the system, (ii) generate joint forecasts for cash flows and other operational variables. We show that the joint forecasts generated from the model are more accurate than those generated from univariate time-series models.
Machine learning is a growing method for causal inference. In machine learning settings, prediction errors are a commonly overlooked problem that can bias results and lead to arbitrarily incorrect parameter estimates. We consider a two-stage model where (1) machine learning is used to predict variables of interest, and (2) these predictions are used in a regression model for causal inference. Even when the model specification is otherwise correct, traditional metrics such as p-values and first-stage model accuracy are not good signs of correct second-stage estimates when prediction error exists. We show that these problems are substantial and persist across simulated and empirical data. We propose general methods to identify when prediction errors are biasing estimates and provide consistent corrections for the case where an unbiased subset of the data is available.

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

Structural parameters in many clinical, operational, and economic settings can be described in terms of conditional moment problems. Important structural or causal parameters in many clinical, operational, and economic settings can be described in terms of conditional moment problems. Prominent examples include treatment effects under noncompliance and demand curves in industrial organization. We propose the variational method of moments (VMM), which solves the conditional moment problem by reformulating it as a zero-sum game, which can be solved using either kernel methods or algorithms for smooth game optimization with deep neural networks. Unlike related machine-learning-based approaches, VMM is globally semiparametrically efficient due to a careful reweighting of the infinitely-many implicit moment conditions. Practically, it provides excellent small sample performance, improving on both classic nonparametric methods and recent machine-learning-based methods.

AI impact on what we eat in a restaurant.

Contracting with an online search intermediary.

Causal decision-making in value chains.

Supply chain management II.
4 - Financial Sustainability of Non-profit UGC Platforms: The Role of Content Creation and Donations
Ziqi Dong, Temple University, Philadelphia, PA, United States, Emre M. Demirezen, Subodha Kumar
User-Generated Content (UGC) online communities are gaining popularity since the mid-2000s. Among UGCs, Wikipedia is regarded as the most popular and successful example. This multilingual online UGC platform is created and maintained as an open collaboration project by a community of volunteer editors, with more than 300 language editions. Further, as users donate due to both altruism and service usage, Wikipedia's financial aspects are very similar to that in the pay what you want (PWYW) contexts. We fill the gap in the literature by studying PWYW and UGC concurrently to shed light on the business practices of organizations like Wikipedia and generate managerial insights.

VWC33
Virtual Room 33
Supply Chain Management VI
Contributed Session
1 - Supply Chain Contracting For Network Goods
Dawei Jian, University of California-Riverside, Riverside, CA, United States
How should manufacturers sell network goods through retail channels? We study this new supply chain contracting problems, where the retailer can privately observe and control the evolving market conditions. The optimal contract resembles the classic second-best in the short run, but converges to the dynamic first-best in the long run.

2 - Order Batching And Driver Routing In An Uber Style Restaurant Delivery Operation
Wen Zhu, New Jersey Institute of Technology, Newark, NJ, United States, Marena Marco, Sanchoy Das
The time variant state of a restaurant delivery model is described by a set of customer orders and a set of available drivers. Order attributes are the associated restaurant, promised delivery time, and delivery location. Driver attributes are the available time and current location. We model a fixed cycle scheduling model with M orders, N drivers, and R restaurants. The batching and routing objectives are to minimize driver travel distance and order delivery tardiness. Drivers are capacitated but can pick orders from multiple restaurants.

3 - Economically Viable Sustainable Supplier And Route Selection For Food Supply Chains
Ranjini B. Guruprasad, Research Scientist, IBM, Bangalore, India, Kumar Saurav, Ivan Kayongo, Kedar Kulkarni
Decreasing GHG emissions of food supply chains in an economically viable manner is critical as they contribute to 26% of global GHG emissions. Existing methods carry out life cycle analysis (LCA) using emissions factors from databases. However, there are limitations in terms accuracy as emissions factors are averages and not current. We address this by proposing a framework that includes a collection of satellite data, physical models, static and LCA tools to estimate the GHG estimates. The framework jointly optimizes GHG emissions and costs while selecting suppliers and routes. We illustrate the working of this framework and the sustainability-cost tradeoffs using a global pizza supply chain.

VWC34
Virtual Room 34
MSOM/Sustainable Operations Cluster
Sponsored: MSOM/Sustainable Operations
Sponsored Session

VWC35
Virtual Room 35
Electrical Markets I
Contributed Session
Chair: Hsiao-Dong Chiang, Ithaca, NY, 14853, United States
Sina Baghali, University of Central Florida, Orlando, FL, United States, Zhaomiao Guo
We investigate the effects of private electric vehicles (EVs) on the restoration of distribution systems (DSs) after disruptions. We propose a framework of network-based multi-agent optimization problems with equilibrium constraints (N-MOPEC) to explicitly model the decentralized decision making of stakeholders in transportation and energy systems and their interactions during DS restoration.

We further develop an exact convex reformulation for computation efficiency. The proposed modeling and computational strategies could provide a foundation for the future analyses of power system resilience with private EVs in coupled transportation and power networks.

VWC37
Virtual Room 37
Assessing the Impacts of Weather Extremes and a Changing Climate on the Energy Sector
Sponsored: ENRE/EnergyClimate
Sponsored Session
Chair: Konstantinos Oikonomou, Pacific Northwest National Laboratory, Salt Lake City, UT, 84108, United States
Co-Chair: Edward Byers, Switzerland
1 - Analytical Tool for Assessing Climate-related Risks for the Texas Power System
Lu Liu, Iowa State University, Ames, IA, United States, Ethan Yang, Hongyi Li, Xingpeng Li, Carlos Gamarra, Gavin Dillingham
An improved understanding of the climate-related risks is needed to support Texas power system planning given its failed performance during past climate disasters. This study develops a modeling framework - Pythias, that advances a system-level understanding of climate and power system by combining physical and socioeconomic modeling. The novelty of Pythias lies in characterizing the feedback between power system and physical environment with the consideration of the adaptive capacity of power system under different climate and policy scenarios. Project phase I will produce a skeleton modeling framework for calibration and validation to be conducted in phase II.
Hannah Bloomfield, University of Reading, United Kingdom

Large quantities of weather-dependent renewable generation are expected in power systems under climate change mitigation policies. The impacts of these renewables on potential power system operation therefore requires significant attention. In this talk the importance of using multi-decadal time series of meteorological data for power system modelling will be demonstrated with a case study of Great Britain. Following this the impact of power system composition on the type of weather events most likely to cause extreme power system conditions will be explored. The predictability of weather-dependent power system components is of great importance for reliable system operation. The talk will conclude with a summary of the predictability of European national energy variables one to four weeks ahead using state-of-the-art sub seasonal forecasting methods.

3 - Implications Of Climate Change For Decarbonized Electricity System Planning: Examples From California
Brian Tarroja, Professional Researcher, University of California, Irvine, Irvine, CA, United States

Regional electricity systems are evolving to incorporate more zero-carbon energy resources and transform the infrastructure that underpins such electric grids. To ensure that these efforts are successful, these must be adapted to account for how climate change affects regional electricity supply, demand, and infrastructure. Here, we provide examples of how climate change affects decarbonized electricity system planning through effects on hydropower generation, water availability for thermally-based electricity resources, and building electricity demand. California is used as an example due to its combination of susceptibility to drought, temperature extremes, and policies to decarbonize their electricity system. Further, we explore the effectiveness of different solutions to mitigate undesirable impacts on decarbonized electricity system planning.

4 - Flexible Power Network Topologies for Multi-sector Grid Studies
Konstantinos Oikonomou, Pacific Northwest National Laboratory, Richland, WA, 98408, United States

We develop a systematic approach for designing reduced network configurations for power grid operation studies to explore multisector dynamics. The proposed approach introduces categories of strategic decision-making design criteria that dictate the optimal spatial resolution of the reduced network by assessing tradeoffs between computational needs and adequate model fidelity to address the desired science questions and compatibility with other sectoral models. We design and evaluate multiple reduced network topologies over the Western US for addressing science questions around hydro-meteorological variability, global change, and the adoption of new technologies.

VWC38
Virtual Room 38
Energy Policy and Planning I
Contributed Session
Chair: Jeffrey Lineberry, University of Oklahoma Galloy College of Engineering, Stillwater, OK, 74074, United States

1 - Optimal Operation For Shared Mobility-on-demand Electric Vehicle Fleet Via Combined Reinforcement Learning And Operation Research Approach
Yimeng Sun, North China Electric Power University, Beijing, China, Yanchang Liang, Zhaohao Ding

Shared mobility-on-demand (MoD) electric vehicle fleet can meet a significant percentage of traffic demand by conducting order serving and rebalancing. Meanwhile, it can provide dispatch-able charging demand for power system in both spatial and temporal manner by flexible routing and charging. Thus, it becomes a critical issue to find the optimal operation scheme for MoD fleet under the coupled power and transportation system. We propose a method combining deep reinforcement learning with binary linear programming to develop a near-optimal operation policy for MoD fleet operator. The simulation experiments with real-world data from Haikou City verify the effectiveness of the proposed method.

2 - Co2 Infrastructure Planning For Fossil - And Bio-energy With Carbon Capture And Storage
Emma JAGU, IFP School, RueULL-Malmaison, France, Olivier Massol

BioEnergy with Carbon Capture and Storage (BECCS) is a critical technology to limit global warming. However, its up-scaling requires the installation of a costly CO2 transportation infrastructure, which will likely be shared between BECCS plants and fossil Carbon Capture and Storage (CCS) plants. We examine the conditions for the deployment of such an infrastructure using an adapted cooperative game theoretic framework. We then apply this model to a contemporary project in Sweden. Our results support pragmatic policy recommendations to organize the deployment of the BECCS technology.

3 - Optimization-based Analysis Of Decarbonization Pathways And Flexibility Requirements In Highly Renewable Power Systems
Alvaro Lorc, Pontificia Universidad Catolica de Chile, Santiago, Chile, Felipe Verastegui, Daniel Olivares, Matias Negrete-Pincetic

This paper develops a planning model including an effective representation of the operational aspects of the power system to understand the key role of flexible resources under strong decarbonization processes in highly renewable power systems. A case study is developed for the Chilean power system. The results show that highly renewable generation mixes are feasible, but rely on an effective balance of the key flexibility attributes of the system.

4 - Long-term Joint Capacity Expansion Planning For Highly Renewable Power And Hydrogen Networks
Javier Jorquera, MSc Student, Pontificia Universidad Catolica de Chile, Santiago, Chile, Alvaro Lorc, Enzo E. Sauma, Matias Negrete-Pincetic

Coupled power-hydrogen networks will lead to highly decarbonized systems. Existing capacity expansion models either are monopropert, simplify a network or preset if hydrogen will be produced off-grid. We propose a multiperiod linear optimization model that plans for the least-cost coupled system, models electricity and hydrogen flows, allows for on and off-grid hydrogen production and models various hydrogen transport modes. We conduct a Chilean case study over a 30 year horizon. Our results show its capabilities to study centralized and decentralized hydrogen production trade-offs, and highlights hydrogen-renewable integration synergies, subject to policy and operational constraints.

5 - Sensitivity Analysis of the Market Penetration in China’s Passenger Vehicle Market Through Monte Carlo Method
Mohamed Ali Saafi, Lab Scientist, Aramco Services Company, Novi, MI, United States, Shiqi Ou, Zhenhong Lin, Xin He

This study uses the python version of the New Energy and Oil Consumption Credits (NEOCC) model - a tool integrated consumer discrete choice and optimization methods - to quantify the impact of fuel price, battery cost, markup and fast-charging power on the electric vehicle market success as well as the industry profit in 2020-2050. Through integrating the Monte Carlo Simulation, it tests the robustness of the NEOCC model, and highlights the parameters that could affect the market penetration projection. The results show that markup affects the market the most, while the market becomes more sensitive to the fuel price and battery cost after 2035 which is explained by less policy constraints.

6 - Economic Analysis Approach to Critical Infrastructure Resilience Investment
Jeffrey Lineberry, University of Oklahoma Galloy College of Engineering, Norman, OK, United States

Critical infrastructure resiliency is an imperative global concern. The consideration of critical infrastructure interdependencies is paramount to decision makers. Determining overall economic impacts associated with critical infrastructure disruptions is a desirable approach. Real data consisting of Sweden’s rail network, power supply network, and associated economic commodity data is implemented in a tri-level model approach utilized to pinpoint vulnerability considering critical infrastructure interdependencies. This Defender-Attack-Defender model representative of vulnerability reductions, network disruptions, and recoverability enhancements is used to determine vital interdependent nodes associated with the rail and power supply networks. The analysis from this model gives insight into associated economic impacts, thus providing the framework necessary to link economic sectors to critical infrastructure interdependencies in order to determine optimal resilience investment. This model results in an overall ability to guide resilience investment based on overall economic sector considerations.
This study considers the job shop scheduling problem with order rejection and earliness and tardiness penalties using an agent-based approach with a combinatorial auction mechanism. A set of jobs is offered. Each job has a revenue, ready time, due date, deadline, and consists of a set of operations with unique precedence relationships. A mathematical model is presented, then Lagrangian relaxation is used to decompose the problem into a set of job-level scheduling problems. Profitable jobs at the individual level submit their bids to an auctioneer. Then, the auctioneer resolves conflicts to reach a feasible solution, records the profit upper and lower bounds, and updates the dual variables.

This work proposes a novel machine learning approach for predicting AC-OPF solutions that features a fast and scalable training. It is motivated by the two critical considerations: (1) the fact that topology optimization and the stochasticity induced by renewable energy sources may lead to fundamentally different AC-OPF instances; and (2) the significant training time needed by existing learning approaches for AC-OPF. The proposed approach is a 2-stage methodology that exploits a spatial decomposition of the power network that is viewed as a set of regions. The first stage learns to predict the flows coupling the regions, and the second stage trains, in parallel, the learning models for each region. The predictions can then seed a power flow to eliminate the minor constraint violations. Experiments on test cases up to 9000 buses demonstrate the potential of the approach.

There are significant disparities and inequities in health outcomes among people with different demographic, socioeconomic, and other characteristics. To reduce the disparities, we propose quantile regression with fairness constraints on the residuals. A mixed-integer linear programming model is proposed to estimate the coefficients, and an aggregation-based algorithm is developed to speed up the estimation procedure. We study the efficiency of the proposed models and effect of the fairness constraints for predicting the length of stay and time to readmission for patients in the USA based on a real-world dataset.

This study proposes a new mathematical formulation and a Memetic Algorithm for a novel integrated maintenance and production scheduling problem. The novelty lies in the combination of two constraints, i.e. (1) a single maintenance activity can only be scheduled in one of its set of available time windows, and (2) a maintenance activity demands additional scarce resources. A case study is performed with real-world production data from a semiconductor manufacturer, where production and maintenance are currently scheduled separately. It is shown that scheduling production and maintenance activities simultaneously enables significant improvements.
2 - Graphing The Empirical Research Process
Aleksi Aaltonen, Assistant Professor, Fox School of Business, Temple University, Philadelphia, PA, United States

I use simple graph theory to propose an approach for modeling empirical research processes. The approach is based on minimal assumptions about empirical research and is as agnostic as possible to particular methods or fields of study. I merely assume that an empirical study process can transform observations to analytical outputs and, consecutively, to more refined outputs. I demonstrate how such a process can be modeled as a directed acyclic graph. A simple way to formalize the progression of empirical research can help scholars to collaborate more effectively, and to develop information systems that offload administrative work to research infrastructures.

3 - Exact Clustering And Ranking Of Ordinal Data Via Integer Programming
Romena Yasmin, Arizona State University, United States

Ordinal preference data are of great interest in a number of contexts and disciplines, such as Psychology, Politics, Marketing, etc. In these fields for evaluation purposes, individuals are asked to create a preference ordering of a given set of items. These ordered evaluations are then combined into a single consensus ranking that minimizes the extent of disagreement between the preferences. However, these orders can have inconsistent information due to conflicting preferences of the individuals. Aggregation of these evaluations without taking into account these differences leads to incomplete or often incoherent results. In this paper, we introduce a Kendall Tau correlation coefficient-based binary programming formulation that can be used for identifying segments comprising of different underlying beliefs which can lead to a better aggregation.

4 - Overcoming Anchoring Effects In Multimodal Input Elicitation To Extract More Accurate Crowd Estimates
Yeawon Yoo, Arizona State University, Tempe, AZ, 85281-0212, United States, Adolfo Raphael Escobedo

In various areas of group decision-making and crowdsourcing, independent human judgments are gathered and then aggregated with the goal of obtaining a wiser collective judgment. In fact, there is a longstanding debate whether it is better to use ranking or rating information in many of these contexts. This study considers the use of both of these types of inputs by conducting a crowdsourced experiment where participants are asked to estimate the number of dots within a set of images in two ways: ranking and numerical estimates. Also, it tests the anchoring effect on cardinal estimates from the ordinal estimates. We find that asking cardinal estimates independent from the ordinal estimates helps to achieve better collective accuracy. Moreover, improved ordinal and cardinal estimations are obtained when the inputs are aggregated via multimodal optimization models.

5 - Integrated Subset Selection And Bandwidth Estimation Algorithm For Geographically Weighted Regression
Hyunwoo Lee, Samsung Electronics, Hwasung-si, Korea, Republic of, Young Woong Park

This study proposes a mathematical programming-based algorithm for integrated subset selection and bandwidth estimation of Geographically Weighted Regression (GWR). Unlike the standard approaches in the literature, where independent variable subsets of focal points may vary, and bandwidth and regression parameters are updated based on different criteria, our model presents a single objective function for the integrated estimation of regression and bandwidth parameters while selecting consistent subsets for all focal points. Numerical experiments are provided to validate our model.

3 - Scaling Graph Neural Networks With Biased Random Walk Based Graph Sampling
Yeongcheol Kim, Graduate Student, Chungnam National University, Daejeon, Korea, Republic of, Sungsu Lim

Given a large-scale graph, how can we learn its representation efficiently? Graph Neural Networks (GNNs) have been successfully applied to various machine learning tasks. Recently, several sampling-based algorithms have been proposed for representation learning on large-scale graphs; however, scaling GNNs remains challenging. In this work, we propose a fast algorithm for efficient mini-batch training that samples a given graph via a biased random walk sampler and then build a full GNN on the sampled graph. We show that our proposed algorithm provides faster and more accurate node classification results compared to state-of-the-art algorithms.

■ VWC42
Virtual Room 42
Graphs and Networks
Contributed Session
Chair: YeongCheol Kim,

1 - A Network-based Approach To Evaluate the Impact of Environmental Changes on the Inland Water Transportation in Bangladesh
Sayyed Molsen Vazirizade, Vanderbilt University, Nashville, TN, United States, Amirhassan Kermanshah, Tristan Kindig, Ken Rahman, Jonathan Gilligan, Hiba Baroud

Inland waterways are among the most environmentally-friendly and cost-effective modes of transportation. These systems are constantly threatened by natural hazards that impact their operations. Specifically, the Inland Water Transportation (IWT) network in Bangladesh has been deteriorating due to natural and morphological processes in the Ganges delta, the world's largest river delta. This study presents a data-driven approach founded in graph theory to investigate the changes in the IWT network size, connectivity, and navigability. Assorted network-based performance metrics are developed to determine the system vulnerability.

2 - Graphs and Networks
Chair: YeongCheol Kim,

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■ VWC43
Virtual Room 43
Marketplace Design and Operations
Sponsored: Auctions and Market Design
Sponsored Session
Chair: Wenchang Zhang, United States

1 - Empirical Studies of Network Effects
Chiara Farrasso

This paper presents experimental results to answer the following questions: in the presence of geographic network effects, should a platform company spread their advertising budget homogeneously across geographies, or should it focus on a few geographies where network effects are strongest? Which underlying model of consumer behavior explains the network effects captured in the experiments?

2 - Price Competition And Assortment Display In Online Marketplace
Weiming Zhu, IESE Business School, Barcelona, Spain, Hanwei Li, David Simchi-Levi, Michelle Wu

In this study, we consider a platform where each seller provides a single-unit product and competes with each other through price. We investigate sellers' optimal pricing decisions and how the pricing strategy gets affected by the platform's assortment display policies. In addition, we also study the optimal assortment rotation scheme that maximizes the platform's revenue. Using data from a leading online marketplace, we gauge the revenue gain from adopting the optimal policy.

3 - Consuming Misinformation In Online News
Jiding Zhang, Wharton School, U. Penn, Philadelphia, PA, 19104, United States

We study the trade-off and preference for consumption of news items. We are particularly interested in the consumption behavior and its consequences related to misinformation. From a practical perspective, it is also essential to measure the difference in consumption behaviors among people, and tie such difference to their preference.
3 - Economic Policy Research For Problems From Increased Polarization Of Wealth In South Korea
Donghun Yoon, Professor, Kyonggi University, Suwon, Korea, Republic of, nature@kyonggi.ac.kr
South Korea has achieved high economic growth but the polarization of wealth continues to intensify. It is becoming a very serious social problem in South Korea. In this study, we conduct an analysis of economic trends and the polarization of wealth in South Korea. We discuss the economic policy research based on analysis results.

VWC46
Virtual Room 46
AI for Cybersecurity
Sponsored: Artificial Intelligence
Sponsored Session
Chair: Tung Cu, Northeastern Illinois University, Northeastern Illinois University, Chicago, IL, 60625-4625, United States
1 - Practical Applications Of AI For Cybersecurity - Case Studies
Bonnie Holub, Vice President, Data Science and Analytics, NTT DATA, Sunfish Lake, MN, 55118-4700, United States,
This presentation will cover several case studies in which AI has been fielded in operational commercial settings to enhance cybersecurity. These cases include: Improving quality control, consistency and quality in online transactions in a financial services company; Automated data mining for improved regression-testing in asset portfolio balance; Operational risk assessment using predictive analytics to prioritize case risk for audits. Each of these cases will include technical discussions of the fielded solutions and results of their operational roll out.

2 - How We Browse: Measurement And Analysis Of Digital Behavior
Yuliia Lut, Columbia University, New York, NY, United States, Michael Wang, Elissa Redmiles, Rachel Cummings
In this work, we design and conduct a user study to collect browsing data ($n=31$) continuously for 14 days and self-reported browsing patterns. We combine self-reports and observational data to provide an up-to-date measurement study of online browsing behavior. We use these data to empirically address the following questions: (1) Do structural patterns of browsing differ across demographic groups and types of web use? (2) Do people have correct perceptions of their behavior online?, and (3) Do people change their browsing behavior if they are aware of being observed? In response to these questions, we find significant differences in level of activity based on user age, but not based on race or gender. We also find that users have significantly different behavior on Security Concerns websites, which may enable new behavioral methods for detection of security concerns online.

3 - AI Driven Cybersecurity: An Assessment Of Cybersecurity Defense Systems
Tung Cu, Northeastern Illinois University, Chicago, IL, 60625-4625, United States
Cybersecurity is simply classified into four popular categories including Data Security, Information Security, Network Security, and Internet/IoT Security. To solve these cybersecurity problems, people usually use popular AI techniques involving machine learning and deep learning methods, the concept of natural language processing, knowledge representation and reasoning, as well as the concept of knowledge or rule-based expert systems modeling. Based on these AI methods, in this paper, I present a comprehensive assessment on how these AI Cybersecurity methods can play an important role in cybersecurity defense systems. In conclusion, I also highlight several research directions within the scope of our study, which can help researchers do future research in the area.

VWC47
Virtual Room 47
Equilibrium Games in Mathematical Finance
Sponsored: Finance
Sponsored Session
Chair: Moritz Voss, University of California, Los Angeles
1 - Continuous-time Hierarchical Principal-Agent Problems
Emma Hubert, Imperial College London, London, United Kingdom
We study continuous-time optimal contracting in a hierarchy which generalises the model of Sung (2015). The hierarchy is modelled by a series of interlinked principal-agent problems, leading to a sequence of Stackelberg equilibria: the principal can contract with the managers to incentivise them to act in her best interest, and managers in turn subcontracts the agents below them. Both agents and managers each control a stochastic process representing their outcome. We will see through a simple example that even if the agents only control the drift of their outcome, the managers control the volatility of the agents’ continuation utility. This justifies the use of recent results on optimal contracting for drift and volatility control, and thus the theory on 2BSDEs. We also discuss some extensions of this model, in particular to a larger-scale principal-agent hierarchy.

VWC48
Virtual Room 48
Finance - Risk Management
Contributed Session
Chair: Takju Matsumoto, Central Research Institute of Electric Power Industry, Saitama-Shi, 350-0846, Japan
1 - The Dispersion Bias
Alexander Shkolnik, University of California-Santa Barbara, Santa Barbara, CA, United States,
We identify and correct excess dispersion in the leading eigenvector of a sample covariance matrix, when the number of variables vastly exceeds the number of observations. Our correction is data-driven, and it materially diminishes the substantial impact of estimation error on weights and risk forecasts of minimum variance portfolios. We quantify that impact with a novel metric, the optimization bias, which has a positive lower bound prior to correction and tends to zero almost surely after correction. The sample eigenvalues are used to correct excess dispersion in the leading eigenvector. We illustrate the result with case studies in equity investments.

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2 - Effect Of Logistics Performance On Economic Growth: Evidence Based On A Regularized Regression Approach
Youqin Fan, Salem State University, Salem, MA, United States, Jian Gu
This paper examines the impacts of logistics performance on economic growth using regularized regression. The findings show that infrastructure is a key factor that affects all economies while other identified significant variables including international shipment and logistics quality are specifically important to economic growth of countries in Europe and Asia. The results highlight the need for countries to prioritize specific logistics indicators and trade policies to boost their economic growth.

3 - Pricing Electricity Day-Ahead Cap Futures Using Multifactor GAMLSS Density Forecasts
Takiju Matsumoto, Central Research Institute of Electric Power Industry, Tokyo, Japan, Derek W Bunn, Yuji Yamada
Motivated by the increasing need for retailers to hedge the volatility of the day-ahead electricity price, this study analyses a flexible hedging product, day-ahead cap futures. For pricing, we forecast the density of day-ahead prices using the parametric multifactor skew-t density, estimated with the Generalized Additive Model for Location, Scale and Shape (GAMLSS). Weather forecasts and calendar information are used as explanatory variables. We find that this higher-order model is superior to several lower-order models such as the normal distribution in terms of fairness in pricing, underwriting risk of the risk taker, as well as reducing the variance risk for the hedger.

4 - Health Disparities and COVID-19
Fiona Shafer, Rutgers University, New Brunswick, NJ, United States, Christie Nelson, Karen Bemis
As the COVID-19 pandemic progresses across the nation and the world, data suggests the virus disproportionately impacts marginalized communities (KKF, 2020). Specifically, disparities exist in infection rates and disease outcomes by race and ethnicity in the United States. However, it is unknown to what degree these differences have impacted specific communities across the country. During this research project, I researched various avenues related to COVID-19 including but not limited to long term care facilities and education systems.

5 - Injuries In Israeli Schools: An Advanced Retrospective Nationwide Six-year Analysis For Policymakers
Michael Khalemsky, Head of Management Information Studies, Hadassah Academic College, Jerusalem, Israel, Eli Jaffe, Anna Khalemsky
Child injury is a global public health problem. A nationwide dataset of 36,002 school injury events in Israel between 2013 and 2019 was analyzed. Exploratory research based on cluster analysis combined with advanced statistical tools revealed injury patterns. Games were identified as the prevailing cause of school injuries in Israel. Gender and age differences, and seasonal and circadian trends were observed. Comparison to international data is provided. Understanding the patterns and the trends of school injuries can enable the development of effective prevention policies on the national, municipal, and local levels, focusing the efforts on the key factors affecting injury incidence.

6 - Mathematical Models For Estimating Hiv Incidence In Turkey
Emine Yayali, Assistant Professor, Istanbul Technical University, Istanbul, Turkey, Zikriye M. Erdogan
The number of HIV patients has been decreasing in the world, however HIV incidence has been significantly increasing in Turkey in the last decade. We developed mathematical models to analyze the spread of HIV in Turkey. First, we utilized a Bernoulli model and estimated annual incidence for high risk groups. Then, we developed a dynamic compartmental model of HIV transmission and progression in Turkey to estimate HIV incidence from 2019 to 2030 and to determine the continuum of care which represents diagnosed and treated persons. Our results suggested that both incidence and HIV-related deaths could continue to rise in the next decade, placing a significant burden on the Turkish healthcare system.

7 - Evaluating The Effect Of Flood Insurance Subsidies With An Agent-based Model
Valerie Washington, University of Michigan, Ann Arbor, MI, United States, Seth Guikema, Joi-Lynn Mondisa, Gina Tonn
The National Flood Insurance Program’s plans to move to risk-based rates may increase the financial burden of purchasing flood insurance for some households. In this study, we use an agent-based model to evaluate the effect that income-based flood insurance subsidies have on communities in high-risk flood areas and the flood mitigation strategies employed. We apply this model to the city of Fargo, ND. We compare the effects of insurance subsidies on mitigation decisions, damages incurred, move out rates, and the number of active flood insurance policies held. These results may help us to evaluate the value of flood insurance and insurance subsidies for communities.
4 - Improving Neonatal Transportation Process Through Multi-Method Simulation

Tiffany Yam, University of Washington, Seattle, WA, United States, tiffanyc.yam@gmail.com, William Zhao, Christopher Lo, Ye-Eun Kim, Rachel Umoren, Prashanth Rajivan

Transporting critically ill newborns from one hospital to another with a higher level of care has to be quick and safe. However, this transportation process is complex, risky, resource-constrained, and involves coordination among stakeholders in different hospitals. Using a multi-method simulation approach, we modeled the coordination and transportation process in a regional hospital network in Northwest America. The model was developed by analyzing the current workflow processes and using historical transportation records. The model will be used to redesign the current process with a focus on efficiency and safety, which may be used by similar facilities regionally and globally.

5 - A Hybrid Simulation Study For Assessing Lean Manufacturing Techniques In A Lego Car Manufacturing Facility

Michail Katsigiannis, Auburn University, Auburn, AL, United States, Minas Pantelidakis, Konstantinos Mykoniatis

Modeling and simulation is primarily used as a decision support tool to analyze, understand, and assess the behavior of complex systems. This work investigates a hybrid simulation approach to model a Lego car automotive assembly line. We developed a hybrid discrete-event and agent-based simulation model of the production line to analyze the system’s performance. The simulation experiments involved two scenarios (i.e., Mass Production and Just-in-time with Heijunka) to assess their impact on production line performance metrics. The Just-in-time and Heijunka techniques significantly improved the overall system’s performance in terms of throughput and reduced total time in the system.

4 - Optimal Price Subsidy For Plant-based Meat Toward A Differential Game Model

Jie Qu, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, Chenzhang Bao, Dursun Delen

Dealing with environment and food crisis, popularize the fake meat is a possible solution. However, the high production cost made fake meat lack of competitiveness. High cost will be overcome by technology advancement and economics of scale if it, in early market, received subsidy and help from government to become economically competitive. This paper deals with the determination of optimal pricing policy for the firm and optimal subsidy for the government in the monopoly and oligopoly market using differential game.

5 - HIT Spillovers And Sustained Cooperation

Ankita Srivastava, Oklahoma State University, Tulsa, OK, United States, Chenzhang Bao, Dursun Delen

Based on the proposed referral network model we study IT spillover effects from ambulatory facilities to hospitals. Using a panel of 13 years with 2,768 US hospitals matched with approximately 30,000 ambulatory facilities, we find a 1% increase in the average EMR adoption of the regional ambulatory clinics can reduce the inpatient cost of the focal hospital by 0.031% (savings of $51,000) in one year and by 0.059% (savings of $98,000) in four years. Our model is robust to endogeneity issues. We also find support for mechanisms where spillover effects are expected to be stronger. The referral network model and empirical evidence can propagate a culture of sustained cooperation among healthcare providers.

6 - Digital Borders, Spatial Trade Spillovers, And Development

Gabriel Bahr, Oklahoma State University, Stillwater, OK, United States, Bryan Hammer, Andy Luse

The purpose of this paper is to expand ICT4D literature by investigating the associations between international trade of technology merchandise and development across countries. Using a spatial autoregression model and data on 45 upper-middle and high income countries from 2009 to 2018, we examine the effects of imports and exports of technology driven trade on two measures of development (GDP and HDI). Additionally, we define spatial borders through a trade partner network and discover spillover effects of trade-development on neighboring countries.

VWC51 Virtual Room 51

Economic Modeling I

Contributed Session

Chair: Gabriel Bahr, Stillwater, 74074, United States

1 - Analysis Of Platformer Economy With Network Externalities - Theoretical Pathway To Sharing Economy

Katsuya Hihara, Tokyo Metropolitan University / University of Tokyo, Tokyo, Japan,

Thanks partly to the network externalities, platformers attract vast amount of users with huge profit, hence causing a number of public policy debates. Despite platformers’ high profile, we found very limited number of rigorous researches specifying exact content of externalities and other market elements involving platformers. We use simple Cobb-Douglas type externality model and derive the exact conditions for optima with concrete results about the impact of platformer’s capacity or profit level on social welfare. Also, analytical results show concrete linkages to sharing economies, involving Airbnb or Uber, from our platformer externality modelling.


Ying-Chin Chen, University of Washington-Seattle, Seattle, WA, United States, Qifan Huang, Chen Zhuang

We study the causal effect of dynamic competition on product variety in a live streaming platform, where anchors can sell products to the audience. Our data has about 2 million products. We use a mean-max attention autoencoder neural network to get the embedding of the anchor’s daily sales record. Competition index is defined as the summation of inner products of embedding vectors. The attention mechanism allows us to capture (1) implicit substitution or complementary relationship across product categories (2) time dependency of daily sales. We leverage a natural experiment to identify treatment effect: some top anchors with strong market power quit the platform by accident

3 - Establishing Material Recovery Facility: Quantitative Cost-Benefit Analysis

Joon-Youl Oh, Texas A&M University-Kingsville, Kingsville, TX, United States, Isaac Teye Nuetey

Recycling retrieves wastes into usable materials and catalyzes economic security by reducing wasted resources and creating new jobs. Many small-sized cities have no recycling process facility, hence there is no recycling collection program. This research aims to perform economic analysis for setting up a material recovery facility for small-sized cities. This research, first, estimates the costs associated with building and operating the facility. This research also estimates the generated benefits such as hiring employees, generating products, etc. The results show that building a new recycling facility will add an economic value of more than $500,000 a year with a recovery rate of 30%.

VWC52 Virtual Room 52

Novel Behavioral Models in Social Networks

Sponsored: Social Media Analytics

Sponsored Session

Chair: Tauhid Zaman, Yale University, New Haven, CT, United States

1 - The Categorical Imperative in Networked Collective Intelligence

Douglas Guilbeault, University of California-Berkeley, Berkeley, CA, United States

In this talk, I argue that collective intelligence dynamics differ qualitatively based on whether people exchange numeric or categorical information. I discuss a third study which shows that the social exchange of category systems can promote coherence and consensus in novel task environments that preclude the exchange of numeric judgments. Implications for organizational decision making and cultural evolution are considered.

2 - Social Media Sentiment And Cryptocurrencies

Khizar Qureshi, MIT, Cambridge, MA United States

We conduct a study of social media activity surrounding cryptocurrencies. We collect tweets from Twitter for multiple cryptocurrencies. We also construct measures to quantify the sentiment of the tweets using transformer neural networks. We model social media interactions surrounding tweets of the coin and then fit a Poisson Regression to this data and use the estimated model parameters to construct features that quantify the virality of the coin and its long-term potential for growth. Finally, we attempt to predict which coins have massive future price movements using these virality features.
3 - Online Communication Shifts In The Midst Of The Covid-19 Pandemic: A Case Study On Snapchat
Qi Yang, Massachusetts Institute of Technology, Cambridge, MA, 02139-4204, United States

We study research questions around the impact of Covid-19 on online public and private sharing propensity, its influence on online communication homophily, and correlations between online communication and offline case severity in the United States. To do so, we study the usage patterns of 79 million US-based users on Snapchat. Our findings suggest that Covid-19 has increased propensity to privately communicate with friends, while decreasing propensity to publicly share content when users are out-and-about. Moreover, online communications have observed a marked decrease in baseline homophily across locations, ages and genders. Finally, we observe that increased offline positive Covid-19 case severity is associated with widening gaps across- and within-state communication increases after the onset of Covid-19.

4 - The Impact of Bots in the (First) Impeachment of Donald Trump
Michael J Rossetti, Adjunct Professor, Georgetown University, Washington, DC, United States
Michael J Rossetti, Adjunct Professor, New York University, New York, NY, United States, Taudhid Zaman

We study manipulation of the social media discussion surrounding the first impeachment of U.S. President Donald Trump by automated accounts, known as bots. Our dataset includes 50 million posts from 2.7 million Twitter users covering a 60 day period from impeachment to acquittal. We identify 24,000 bots using an algorithm based on the Ising model from statistical physics. Analysis shows the bots are 100 times more active than normal users, and their follower network structure is polarized along political lines. Language analysis shows pro-Trump bots using terms related to the Qanon conspiracy theory. After quantifying bot impact using a network centrality measure we developed known as generalized harmonic influence centrality, we find that although pro-Trump bots are more numerous and active than anti-Trump bots, the anti-Trump bots have a larger daily impact.

5 - Understanding and Reducing the Spread of Misinformation Online
Mohsen Mosleh, University of Exeter Business School, New York, NY, 07093, United States

Why do people share misinformation, and how can social media platforms reduce the sharing of misinformation? Here, we address these questions. First, we find that the veracity of headlines has little effect on sharing intentions, despite having a large effect on judgments of accuracy. This dissociation suggests that sharing does not necessarily indicate belief. However, most participants say it is important to share only accurate news. To shed light on this apparent contradiction, we carried out four survey experiments and a field experiment on Twitter; the results show that subtly shifting attention to accuracy increases the quality of news that people subsequently share. This indicates that people often share fake news because their attention is focused on factors other than accuracy—and therefore they fail to implement a strongly held preference for accurate sharing.

3 - Efficient Carpooling And Toll Pricing For Autonomous Transportation
Manxi Wu, Massachusetts Institute of Technology, Cambridge, MA, United States

How can autonomous transportation technology be utilized to reduce road congestion? We analyze a carpooling market, where a transportation authority sets tolls on road segments, and riders are incentivized to organize autonomous carpooled trips and split toll prices. We characterize sufficient conditions on the network topology and riders' heterogeneous utilities, under which the market equilibrium implements a socially optimal trip assignment. We also propose an algorithm for computing the market equilibrium. These results enable efficient implementation of market-based autonomous carpooling services.

4 - Scarcity And Waste In Allocation Mechanisms
Juinxiong Yin, University of Southern California, Los Angeles, CA, United States, Peng Shi

Variants of wait-lists are used to allocate scarce resources such as cadaver kidneys. However, around 20% of successfully procured cadaver kidneys are discarded. In this paper, we study the wastage problem from a theoretical perspective with a focus on the wait-list with choice, which is an approximation to the current mechanism for cadaver kidney allocation. We find that 1) it is not always possible to Pareto improve upon the wait-list with choice even when there is waste; and 2) it is impossible to Pareto improve upon the wait-list with choice using a mistake-tolerant mechanism. The findings suggest that reducing waste requires hard discussions among stakeholders.

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1 - Multi-objective Community Resilience Optimization With CGE Modeling For Memphis Metropolitan Statistical Area
Rafia Bushra, University of Oklahoma, Norman, OK, United States
Natural hazards have the potential to cause billions of dollars of damage, create major disruptions in key elements of communities worldwide, and drive complex outcomes such as population dislocation, unemployment rates, threats to household income, etc. In this presentation, we consider the Memphis Metropolitan Statistical Area lying within the New Madrid seismic zone. We implement a community resilience multi-objective optimization model that leverages a reversed engineered computable general equilibrium model derived information to capture system-wide impacts to enhance decision-making.

2 - Disaster Relief Distribution Location-allocation With Discrete-time Planning Periods And Beneficiaries’ Choice
Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY, United States
Previous research on disaster relief distribution in post-disaster environments has assumed that demand at Points of Distribution (PODs) can be assigned purely based on distance. This research focuses on optimal location-allocation decisions under a discrete multi-period planning horizon, incorporating the beneficiaries’ choices of PODs. Such choice depends on POD’s attractiveness, based on metrics such as POD’s capacity, inventory level, travel time, and crowd density. Furthermore, the problem’s objective is to minimize social costs, i.e., logistic and deprivation costs.

3 - Escaped Wildfire Response Planning
Brittany Segundo, Texas A&M University, College Station, TX, United States, Lewis Ntaimo
In this work we allocate resources to an escaped wildfire that is in the extended attacking phase. Because the time until containment is unknown, we approximate multistage stochastic decision-making using a rolling horizon framework. The aim of this program is to contain the wildfire through the construction of discrete firelines. We incorporate endogenous uncertainty by modeling the interaction between constructed firelines and growing firefronts. Our results will demonstrate the impact of dynamic resource allocation, endogenous and exogenous uncertainty, and a rolling horizon framework on the containment of an extreme wildfire.

4 - Rapid Product And Production Adaptation In A Social Emergency: Does It Pay Off?
Wei Sun, City University of Hong Kong, Hong Kong, Hong Kong, Maggie Chuoyan Dong, Bin Yang, Jack Cadeaux
This study focused on an emerging phenomenon amid the COVID pandemic—COVID-relieving product adaptation (CRPA), where manufacturers adapted production facilities to produce medical supplies that were essential for addressing the crisis and in short supply. We use an event study to examine whether CRPA actually improved manufacturers’ financial performance. The results revealed that under severe pandemic circumstances, CRPA significantly boosted stock returns, and this effect was stronger for firms with low political connectedness, low media coverage, and high operational uniqueness. An experiment offers further insights into the underlying mechanisms through which CRPA helps or hurts.

1 - The Impact Of Online Product Reviews On Retailer’s Pricing And Return Policy Decisions
Mehmet Sekip Altug, Associate Professor, George Mason University, University Dr, VA, United States
Customers feel increasingly more comfortable with posting and using online product reviews. In a two-period setting, we explore the impact of product reviews on customer’s valuation uncertainty for an experience-type product and how that in turn affects a monopolist retailer’s pricing and refund decisions. Surprisingly, we find that the retailer makes its return policy even more lenient. In a duopolistic competition, the overall sentiment of the on-line reviews are influenced by the refund and pricing decisions of both retailers. Interestingly, we show that the retailers make their returns more lenient compared to the monopolist case when they collectively determine the review sentiment

2 - Store Network Design For Omnichannel Retailing
Mert Cetin, IESE Business School, Barcelona, Spain, Victor Martinez de Albeniz, Laura Wagner
Using customer level data, we seek to explore the effect of store network on sales for omnichannel retailers. We geolocate customers and consider the stores within close proximity, including covariates of point of sales, assortment, service level, and characteristics of the closest store. We model purchase propensity, basket size and average price per product through channel-specific online, storeNear-buying from a store nearby, and storeFar-a further away one. We draw conclusions for each channel and present a counterfactual analysis to demonstrate how store network effects the revenue.

1 - Delegating Production And Customization To Retail Stores: Influence Of Channel Structure And Buzz Effect On In-store 3d Printing
Nagarajan Sethuraman, Assistant Professor, University of Kansas, Lawrence, KS, United States, Ali Kemal Parlakturk, Jayashankar M. Swaminathan
We study the trade-offs involved in decentralized customization enabled by 3D printing at retail stores. We develop an analytical model that considers in-store 3D printing as a component of the firm’s broader product line strategy. Managerial insights from our model can guide the adoption of 3D printing at retail stores.

2 - Contingent Stimulus In Crowdfunding
Jiahua Wu, Imperial College Business School, Office London, E17 8PG, United Kingdom,Longyuan Du, Ming Hu
Reward-based crowdfunding is a form of innovative financing that allows project creators to raise funds from potential backers to start their ventures. A crowdfunding project is successfully funded if and only if the predetermined funding goal is achieved within a given time. We characterize the dynamics of the project’s pledging process, and show that there exists a cascade effect on backers’ pledging, which is mainly driven by the all-or-nothing nature of crowdfunding projects. According to our data collected from the most popular online crowdfunding platform, Kickstarter, the majority of projects fail to achieve their goals. To address this issue, we propose three contingent stimulus policies, namely, seeding, feature upgrade, and limited-time offer.

3 - Is Kindness The Magical Spell? The Role Of Information And Reciprocity In Revenue-sharing Crowdfunding
Behrooz Pourghannad, University of Minnesota, Rochester, MN, 55901-4841, United States, Guangwen (Crystal) Kong, Laurens G. Debo
We consider an entrepreneur funding his project from investors through a revenue-sharing crowdfunding campaign. The early investor (insider) has a social tie with the entrepreneur and is informed about the future revenue of the entrepreneur's project. We investigate the effects of information asymmetry and reciprocity on various outcomes.

4 - Designing Rewards-based Crowdfunding Campaigns For Strategic (but Distracted) Contributors
Souadipa Chakraborty, University of Kansas, Lawrence, KS, 66045, United States, Robert Swinney, Anyi.Ma
We study a model of rewards-based crowdfunding with the all or nothing funding mechanism. The creator of a campaign solicits pledges from contributors, and if total pledges exceed a predetermined threshold, the campaign is successful, the creator receives all pledges and each contributor receives a non-monetary reward. Otherwise, the campaign fails and contributors are refunded their pledges. We determine how a creator should design her campaign when the uncertainty of receiving the reward makes contributors strategically decide whether and when to pledge.
Transportation-Planning I

Contributed Session

Chair: Navjyoth Sarma

1 - A Novel Method In Assigning New York City Taxicabs Using Machine Learning And Optimization Algorithms
Zeinab Vosooghi, McMaster University, Hamilton, ON, Canada

With the increase in urban commuting, the efficient assignment of taxis to the demand areas becomes challenging. To tackle this problem, a machine learning based optimization framework for taxi assignment is proposed in this paper. Main contributions of this framework are location-based clustering of the trips, their fare amount prediction, drivers’ revenue as well as passengers’ demand coverage maximization, and service level equity. To demonstrate the effectiveness of the model, the experiments are conducted using NYC-Taxi dataset, which outperform the baseline state-of-the-art studies.

2 - An Efficient Algorithm For Continuous Bi-criteria Traffic Assignment
Qianni Wang, School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, China, Jun Xie, Yu (Marco) Nie

This paper proposes a formulation and an efficient algorithm for the continuous bi-criteria traffic assignment problem. The formulation employs the value-of-time (VOT) boundaries as the main solution variables and replaces the conventional flow conservation conditions with simple box constraints. Thanks to these characteristics of the formulation, an efficient path-based algorithm that can simultaneously adjust path flows and VOT boundaries in the equilibration procedure is proposed. Numerical experiments indicate that the proposed algorithm converges much better and faster than the known alternative.

3 - Detecting Accident Prone Zones For Bicycles Using Machine Learning
Isil Koyuncu, Assistant Professor of Management Science, The University of Texas at San Antonio, San Antonio, TX, United States, Meseret Kidane

Using real-life bicycle accident data from various cities in the United States and image recognition techniques over the Google Maps street images we aim to shed light on accident-prone zones and recommend possible improvements to make roads safer for two-wheelers.

4 - Planning For Alternative Fuel Vehicles Evacuation Using Spanning Trees
Denissa Sari Darmawi Purba, Graduate Student, University of Illinois at Urbana-Champaign, Champaign, IL, United States, dpurba2@illinois.edu, Eleftheria Kontou, Chrysafis Vogiatzis

For alternative fuel vehicle types, the evacuation route of conventional vehicles could be infeasible due to limited driving range and sparse refueling infrastructure. Thus, emerging vehicle technology travelers are more vulnerable during hazardous events. In this study, we formulate an evacuation routing problem using k-minimum spanning trees (every tree is rooted to the shelter) with hop constraints to model the refueling needs of each k vehicle fuel type on their way to reach a shelter. We develop a column generation method to solve the problem exactly and seek a minimum spanning tree that minimizes the evacuation time and satisfies the hop constraints.

5 - A Column Generation Approach With Cutting Planes For Location-allocation Of Respondent Vehicles Under Incident Severity Levels
Aysa Atil, North Carolina State University, Raleigh, NC, United States, Leila Hajibabal

This study investigates optimal incident response planning in terms of the location of respondents and the availability considering the frequency and severity of incidents. A mixed-integer linear model is formulated to maximize the total expected demand covered and minimize the total travel time. A column-generation technique with cutting planes is proposed to solve the problem. A benchmark approach is proposed that integrates the Benders decomposition with a demand clustering technique. The algorithms are assessed using real-world incident data in Raleigh, North Carolina. The preliminary results suggest that the proposed algorithm solves the problem efficiently.

6 - Quantifying Shareability Potential In A Transportation Network: Introducing The Maximum Network Flow Overlap Problem
Navjyoth Sarma, University of California, Irvine, Irvine, CA, United States, Michael Hyland

The structure of transport networks and spatial distribution of demand vary across and within cities, affecting the viability of shared mobility modes ranging from fixed-route transit to on-demand ride-pooling. To inform the viability of shared mobility modes, this study proposes a modeling framework to quantify shareability potential within a city. The study introduces the ‘flow overlap’ metric to measure the number of trips sharing a path between an O-D pair. This concept is used to formulate the Maximum Network Flow Overlap Problem to assign person flows to paths that maximize shareability. The model output provides unique insights to support design of multi-modal shared mobility systems.

Game Theory I

Contributed Session

Chair: Thuy Bui, Newark, 07105, United States

1 - On the PTAS for Maximin Shares in an Indivisible Mixed Manna
Ruchita Kulkarni, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Ruta Mehta, S etareh Taki

We study fair allocation of indivisible items, both goods and chores, under the popular fairness notion of maximin share (MMS). The problem is well-studied when there are only goods (or chores), where a PTAS to compute the MMS values of agents is well-known. In contrast, for the mixed wanna, a recent result showed that finding even an approximate MMS value of an agent up to any approximation factor in (0,1] is NP-hard for general instances. In this paper, we complement the hardness result by obtaining a PTAS to compute the MMS value, when its absolute value is at least 1/p times either the total value of all the goods or total cost of all the chores, for some constant p valued at least 1.

2 - Social Welfare Maximization And Conformism Via Information Design In Linear-quadratic-gaussian Games
Furkan Sezer, PhD Student, Texas A&M University- College Station, College Station, TX, United States, Hossein Khazaei, Ceyhun Eksin

We consider linear-quadratic-gaussian (LQG) games in which players have quadratic payoffs that depend on the players’ actions and an unknown payoff-relevant state, and signals on the state that follow a Gaussian distribution conditional on the state realization. An information designer decides the fidelity of information revealed to the players in order to maximize the social welfare of the players or reduce the disagreement among players’ actions. Leveraging the semi-definiteness of the information design problem, we derive analytical solutions for these objectives under specific LQG games.

3 - Illegal Fishing In Congested Maritime Environments
Michael M. Perry, George Mason University Volgenau School of Information Technology and Engineering, Fairfax, VA, United States

A maritime environment is modeled where two countries in close proximity must delineate fishing rights. Countries issue fishing quotas and its shown one can benefit significantly from issuing excessive quotas, inducing illegal fishing in the other’s legal waters. The costs imposed by patrol craft serve as a way of deterring this behavior, but patrols can be offset by employing, for example, assets onboard fishing vessels, a phenomenon of increasing regularity. The cost-effectiveness of each of these measures is assessed. The paper concludes that even if the countries can agree to cooperative combat illegal fishing, the potentiality of illegal fishing will significantly alter the terms of such a deal.

4 - A Proof Of The Optimality Of The E-patrolling Strategy For The Continuous Patrolling Game
Thuy Bui, Rutgers Business School, Newark, NJ, United States, Thomas Lidbetter

We consider the continuous patrolling game introduced in Alpern et al. (2016). This is a zero-sum game between an Attacker, who attacks a network at a particular time and place, and a Patroller, who patrols the network with the aim of intercepting the attack. Recently, Alpern et al. (2020) conjectured that a patrolling strategy called the E-patrolling strategy is optimal for all tree networks, and they proved this to be true in some special cases. In this paper, we settle the conjecture by providing □-optimal strategies for the Attacker. We also give precisely optimal Attacker strategies for some previously unsolved star networks.
We show case the SymbolicWedderburn.jl package and its diagonalize semidefinite constraints, which considerably decreases the complexity primarily geared towards smooth unconstrained settings. In this paper, we study approximation algorithms. Our results may be helpful for practitioners deciding technique. We demonstrate a speedup of several orders of magnitude. Using stochastic gradient descent.

Applying the Burer-Monteiro method to a sampled version of the problem, where semidefinite constraints due to algorithmic complexity and the numerical simulation, we show how the excess risks of personalized federated learning with a smooth, strongly convex loss depend on data heterogeneity from a minimax point of view. Our analysis reveals a surprising theorem of the alternative for personalized federated learning: there exists a threshold such that (a) if a certain measure of data heterogeneity is below this threshold, the FedAvg algorithm [McMahan et al., 2017] is minimax optimal; (b) when the measure of heterogeneity is above this threshold, then doing pure local training (i.e., clients solve empirical risk minimization problems on their local datasets without any communication) is minimax optimal.

We develop a general algorithmic framework called FedLin to tackle some of the key challenges intrinsic to federated learning, namely statistical heterogeneity, systems heterogeneity, and infrequent and imprecise communication. Notably, FedLin exploits past gradients, client-specific learning rates, and error feedback. For smooth and strongly convex losses, we show that FedLin guarantees linear convergence to the global minimum, despite arbitrary objective and systems heterogeneity. We then establish matching upper and lower bounds on the convergence rate of FedLin. Finally, we show that FedLin preserves linear convergence rates under aggressive gradient sparsification. Our work is the first to provide tight linear convergence rate guarantees along with a comprehensive analysis of gradient sparsification in a federated setting.

Linear regression is a fundamental modeling tool in statistics and related fields. In this paper, we study a simple formulation to simultaneously learn the regression coefficients and the permutation corresponding to the mismatches. The combinatorial structure of the problem leads to computational challenges. In this paper, we study a simple greedy local search algorithm. We prove that under a suitable scaling of the number of mismatched pairs compared to the number of samples and features, and certain assumptions on the covariates; our algorithm converges to a solution with residue bounded by a constant multiple of the noise. In particular, in the noiseless case, our algorithm converges to the global optimal solution with a linear convergence rate.

Theoretical Guarantees

Haoxue Wang, Massachusetts Institute of Technology, Cambridge, MA, United States, Rahul Mazumder

Linear regression is a fundamental modeling tool in statistics and related fields. In this paper, we study an important variant of linear regression in which the predictor-response pairs are partially mismatched. We use an optimization formulation to simultaneously learn the regression coefficients and the permutation corresponding to the mismatches. The combinatorial structure of the problem leads to computational challenges. In this paper, we study a simple greedy local search algorithm. We prove that under a suitable scaling of the number of mismatched pairs compared to the number of samples and features, and certain assumptions on the covariates; our algorithm converges to a solution with residue bounded by a constant multiple of the noise. In particular, in the noiseless case, our algorithm converges to the global optimal solution with a linear convergence rate.
3 - A Numerical Analysis Approach To Convex Optimization
Rasmus Kyng, Assistant Professor, ETH Zurich, Zurich, Switzerland
In convex optimization, we can usually obtain O(1)-approximate solutions much faster than high accuracy (1+poly(n))-approximate solutions. One major exception is L2-regression, where low accuracy algorithms can be converted into high-accuracy ones via iterative refinement. I will present generalizations of iterative refinement to p-norms, which lead to high-accuracy algorithms based on crudely solving only a polylogarithmic number of residual problems. I will also discuss several results that build on this new approach, including p-norm regression using \( m^{1/3} \) linear system solves, and p-norm flow in undirected unweighted graphs in almost-linear time. Finally, I’ll mention how our solvers have been used to build faster algorithms for finding directed maximum flows in unit capacity networks.

4 - Revisiting Priority K-center: Fairness and Outliers
Maryam Negahbani, Dartmouth College, Hanover, NH, United States
Samir Khuller, University of Maryland, College Park, MD, United States
Yuanhan Hu, Rutgers Business School, United States
Claire Mathieu, Harvard University, Cambridge, MA, United States
Claire Mathieu is the co-chair of this session
We propose a general heuristic that is orders of magnitude faster than existing regression using \( m^{1/3} \) linear system solves, and p-norm flow in undirected general graphs, we propose a new spectral graph sparsification approach, which can be used to understand existing simple algorithms for the DSP. In this talk, we focus on the k-center objective: Given a set of points in the metric space and a parameter k, cover the points using k balls with minimum radius. We discuss two definitions of fair k-center, individual fairness (introduced by Jung et al. FORC ’20) and the lottery model (introduced by Harris et. al. NeurIPS ’18) and show how they are connected to a previously studied problem called the priority k-center problem (Plesnik ’87). Our main contribution is approximating priority k-center with outliers and providing a framework for approximating the problem with general constraints on the set of solution centers.

5 - Electrical Flows Over Spanning Trees
Hassan Mortagy, Georgia Institute of Technology, Atlanta, GA, 30308-1007, United States
Swati Gupta, Ali Khodabakhsh, Evdokia Velinova Nikolova
We study the effect of the injected noise on the dynamics of SGD. We show this effect induces an asymmetric heavy-tailed noise on SGD gradient updates. To model this dynamics, we first propose a Langevin-like stochastic differential equation driven by asymmetric heavy-tailed noise. We then formally prove and quantify an “implicit effect” of GNIs, which varies depending on the heaviness of the tails and the level of the asymmetry. Empirical results confirm the “implicit effect” of GNIs induces an “implicit bias” that degrades networks performances.

6 - Leveraging Continuous Relaxations To Solve Densest Subgraph Problems
Manuel R. Torres, University of Illinois, Urbana-Champaign, Urbana, IL, United States
Chandra Chekuri, Kent Quanrud
The denest subgraph problem (DSP) is a canonical problem in the field of graph mining. Although the problem can easily be solved in polynomial time, given the proliferation of data, there is a desire for simple algorithms with near-linear running times. We discuss ongoing work where we consider a generalization of the DSP based on supermodular functions. The insights gained from the generalization can be used to understand existing simple algorithms for the DSP. We also give a fast algorithm to solve the generalization, which leads to fast algorithms for all the natural variations captured by the generalization including the k-clique DSP.

### VWC66

**Virtual Room 66**

A session on discrete-continents optimization
Sponsored: OPT/Network Optimization
Sponsored Session

### VWC67

**Virtual Room 67**

Algorithms for Deep Learning
Sponsored: OPT/Nonlinear Optimization
Sponsored Session

Co-Chair: Yuanhan Hu, Rutgers Business School, United States

#### 1 - Asymmetric Heavy Tails And Implicit Bias In Gaussian Noise Injections

Xiaoyu Wang, Florida State University, Tallahassee, FL, United States
Alexander Cannelle, Linglong Zhu, Chris Holmes, Mert Gurbuzbalaban, Umut Simsekli
Gaussian noise injections (GNIs) are widely used to train neural networks, where one injects Guassian noise to the network activation at every iteration of the optimization procedure, which is traditionally called stochastic gradient descent (SGD). In this work, we focus on the so-called “implicit effect” of GNIs, which is the effect of the injected noise on the dynamics of SGD. We show this effect induces an asymmetric heavy-tailed noise on SGD gradient updates. To model this dynamics, we first propose a Langevin-like stochastic differential equation driven by asymmetric heavy-tailed noise. We then formally prove and quantify an “implicit effect” of GNIs induced by GNIs, which varies depending on the heaviness of the tails and the level of the asymmetry. Empirical results confirm the “implicit effect” of GNIs induces an “implicit bias” that degrades networks performances.

### VWC68

**Virtual Room 68**

Accelerated solutions in convex/non-convex optimization
Sponsored: OPT/Nonlinear Optimization
Sponsored Session

Chair: Anastasios Kyrillidis, Rice University, Houston, TX, 77005-1827, United States
Co-Chair: Ioannis Mislidakis, University of Montreal, University of Toronto, Montreal, QC, H2S 2P4, Canada

#### 1 - Accelerated Linear Convergence of Stochastic Momentum Methods in Wasserstein Distances

Buraka Can, Rutgers University, Piscataway, NJ, United States
Mert Gurbuzbalaban
Momentum methods such as Polyak’s heavy ball (HB) method, Nesterov’s accelerated gradient (AG) as well as accelerated projected gradient (APG) method have been commonly used in machine learning practice, but their performance is quite sensitive to noise in the gradients. We study these methods under a first-order stochastic oracle model where noisy estimates of the gradients are available. We obtain several state-of-the-art convergence guarantees for these methods in Wasserstein distances that shed light into their performance and shortcomings.
2 - Average-case Acceleration And Universal Asymptotic Average-case Optimality Of Polyak Momentum

Damien Scieur, Samsung - SAIT AI Lab, Montreal, QC, Canada, Fabian Pedregosa

We develop a framework for the average-case analysis of random quadratic problems and derive algorithms that are optimal under this analysis. This yields a new class of methods that achieve acceleration given a model of the Hessian’s eigenvalue distribution. These methods have a simple momentum-like update, in which each update only makes use of the current gradient and the previous two iterates. Moreover, we establish a novel link between the Polyak Heavy-ball algorithm and the average-case analysis. Our contribution is to prove that any optimal average-case method converges in the number of iterations to Polyak Heavy-ball, under mild assumptions. This brings a new perspective on this classical method, showing that Polyak heavy-ball is asymptotically both worst-case and average-case optimal.

3 - Stochastic Polyak Stepsize with a Moving Target

Robert Mansel Gower, Telecom, Edinburgh, EH10 4SB, United Kingdom

We propose a new stochastic gradient method that uses recorded past loss values to reduce the variance. Our method can be interpreted as a new stochastic variant of the Polyak Stepsize that converges globally without assuming interpolation. Our method introduces auxiliary variables, one for each data point, that track the loss value for each data point. We provide a global convergence theory for our method by showing that it can be interpreted as a special variant of online SGD. The new method only stores a single scalar per data point, opening up new applications for variance reduction where memory is the bottleneck.

4 - Multiagent Assortment Optimization In Sequential Matching Markets

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

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

5 - Adaptive Bin Packing With Overflow

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

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

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When the available information is noisy zero-order (ZO) oracle, stochastic approximation methods are popular for estimating the root of the multivariate gradient equation. Inspired by the Stein’s identity, this work establishes a novel Hessian approximation scheme. We compare it alongside second-order simultaneous perturbation stochastic approximation (2SPSA). On the basis of the almost sure convergence and the same convergence rate, 2SPSA requires four ZO queries, while ours requires three ZO queries. Moreover, 2SPSA requires two statistically independent perturbations and two differencing stepizes, while ours requires generating one perturbation vector and tuning one differencing stepsize only. Besides, the weighting mechanism for the Hessian estimate is generalized and the smoothness restriction on the loss function is relaxed compared to 2SPSA.

The choice of the finite-difference interval for noisy derivative-free optimization is tedious, requiring careful balancing of the truncation and measurement error. In particular, it requires knowledge of both the noise level and bound on the higher-order derivative, which may be unavailable. To address this, we propose a practical finite-difference interval estimation procedure that is robust and generalizable to finite-difference schemes with higher-order accuracy. We integrate this approach into our finite-difference LBFGS method, and propose practical criteria for determining when re-estimation or refinement of the finite-difference interval is necessary. The numerical reliability and efficiency of this approach is demonstrated on a subset of noisy CUTEst problems, and theoretical justification is provided for each component of the algorithm.

## VWC72

**Virtual Room 72**

### SOLA Student Panel

**Sponsored:** Location Analysis

**Chair:** Reem Khrir, Georgia Institute of Technology, Atlanta, GA, United States

**Co-Chair:** Omer Burak Kinay, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

## WB40

**CC - Room 211B**

### In Person: Managing Uncertainty and Scarcity in Energy Systems: Part II

**General Session**

**Chair:** Sebastian Souyris, University of Illinois Urbana-Champaign, Champaign, IL, 61820, United States

**1 - Network Effects and Incentives in Solar Panel Diffusion: A Dynamic Discrete Choice Approach**

Sebastian Souyris, University of Illinois Urbana-Champaign, Urbana, IL, 61801-4860, United States, Anantaram Balakrishnan, Jason Duan, Varun Rai

As the price of residential photovoltaic (PV) solar panels and government incentives decline in tandem, rendering the net cost relatively flat over the years, the annual new solar capacity has been increasing significantly since 1998. In this paper, we study the PV solar panel market in Austin, Texas. We develop a dynamic discrete choice model that explores the neighborhood network effects and the results of various incentive policies on the diffusion of PV systems. We find the network effects are significant, and unobserved household heterogeneity is considerable. We use policy simulations to predict the potential impact of various rebateschedules and optimize rebates according to the policymaker objective.

**Wednesday, 1:30PM - 2:30PM**

## WK01

**CC - Ballroom A /Virtual Theater 1**

### Keynote: Boundary-Expanding OR/OM Research

**Keynote Session**

**1 - Boundary-Expanding OR/OM Research**

Rachel Q. Zhang, The Hong Kong University of Science & Technology, Dept of ISEM, Clear Water Bay, Kowloon, Hong Kong

OR and OM have brought about significant improvements to operations in diverse domains, including military, manufacturing and service, and the knowledge economy. Every technological advance in the modern world has been met with the pursuit of new models by the OR/OM community, often providing fundamental understanding of and significant improvements to its deployment. In this talk, the speaker will share her experience in pursuing research in the boundaries of operations and finance, wireless communications and blockchains, including the inspirations, execution, challenges and lessons learned. Pursuing such projects is not without risk, but is an effective way for a researcher to reinvent him/herself and have a fulfilling career.

## WK02

**CC - Ballroom B /Virtual Theater 2**

### Edelman Reprise: UN World Food Programme

**Keynote Session**

## WK03

**CC - Ballroom C /Virtual Theater 3**

### Keynote: Operational Data Driven Interventions to Decrease Adverse Events Associated with Opioid Overdose

**Keynote Session**

**1 - Operational Data Driven Interventions to Decrease Adverse Events Associated with Opioid Overdose**

Mahesh Nagarajan, University of British Columbia, Sauder School Of Bus. Vancouver, BC, V6T 1Z2, Canada

In this talk, we present a systematic data driven approach to decrease adverse events associated with overdose episodes. We take a three fold approach. First, we examine pathways that result in opioid use and devise protocols to decrease the number of new users. Second, we predict adverse occurrence of adverse episodes among current users and adopt timely interventions that will decrease the likelihood and severity of an event. Third, we focus on the care pathways for existing users and use simple operational techniques to increase the system’s capacity as well as improve outcomes.

## WK04

**CC - Ballroom D /Virtual Theater 4**

### Keynote: Algorithms and Social Service Provisions

**Keynote Session**

**1 - Algorithms and Social Service Provisions**

Rediet Abebe, University of California-Berkeley, Berkeley, CA, 14853, United States

Bio: Rediet Abebe is an Assistant Professor of Computer Science at the University of California, Berkeley and a Junior Fellow at the Harvard Society of Fellows. Abebe holds a Ph.D. in computer science from Cornell University and graduate degrees in mathematics from Harvard University and the University of Cambridge. Her research is broadly in algorithms and artificial intelligence, with a focus on equity and distributive justice concerns. As part of this research agenda, Abebe co-founded and co-organizes the MD4SG initiative and is serving as a Program Co-Chair for the inaugural ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization (EAAMO ’21). Her dissertation received the 2020 ACM SIGKDD Dissertation Award and an honorable mention for the ACM SIGecom Dissertation Award for offering the foundations of this emerging research area. Abebe’s work has informed policy and practice at the National Institute of Health (NIH), the Ethiopian Ministry of Education, and the United Nations Food Systems Summit. Abebe also co-founded Black in AI, a non-profit organization tackling equity issues in AI. Her work is influenced by her upbringing in her hometown of Addis Ababa, Ethiopia.
Wednesday, 2:45PM - 4:15PM

VWD01
Virtual Room 01
Machine Learning for Heterogeneous Data Fusion
Sponsored: Data Mining
Sponsored Session
Chair: Hyunsoo Yoon, SUNY Binghamton University, Binghamton, NY, 13902, United States
1 - A Novel Robust Coupled Tensor Decomposition Method Based On Alternating Direction Method Of Multipliers
Meng Zhao, University of Florida, Gainesville, FL, United States, Mostafa Reisi Gahrooei
Coupled matrix-tensor factorization (CMTF) is a powerful tool to extract a common hidden structure from a tensor and a matrix simultaneously. It has reached a crucial status in the areas of computer vision, signal processing, and neuroscience. However, to the best of our knowledge, most existing coupled canonical polyadic (CP) decomposition methods are sensitive to outliers and lack robustness. This has motivated us to propose a novel ADMM based robust coupled matrix-tensor factorization (RCMTF) method for simultaneously decomposing a pair of matrix and tensor with the presence of outliers. We compare our method with the classical CP decomposition method and the CMTF method. Experiments on both synthetic and real datasets show that the proposed RCMTF method can effectively handle outliers and jointly decompose the coupled matrix and tensor more accurately.

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

3 - Eigen-entropy: A Metric For Sampling Design
Jialing Huang, Arizona State University, Sch Compt Infor & Dec Sys Eng, Tempe Campus, Mail, Tempe, AZ, 85281, United States, Hyunsoo Yoon, Ojas Pradhan, Teresa Wu, M inqiang Li, J in Tian, Xiaoyu Shi, M ingluo Wang, Benjamin Yao, Xiaohu Liu
Sampling is to identify a representative data subset capturing characteristics of the whole dataset. Existing sampling algorithms have some limitations including required assumptions on data distributions or models. In this study, we propose a new metric, termed Eigen-Entropy, based on information entropy for multivariate dataset. The eigenvalue is derived on basis of eigenvalues extracted from correlation coefficient matrix on multivariate data. We prove Eigen-Entropy is a metric to measure the heterogeneity of dataset theoretically, thus it can be used to assist sampling decision. The performance of the proposed method is evaluated using real building case studies. Evaluation results indicate that the proposed method outperforms the method from existing literature in terms of accuracy while maintaining smaller number of samples.

4 - Robust Deep Clustering Guided Adversarial Unsupervised Domain Adaptation
Jun Kataoka, Vestal, NY, 13920, United States
We propose a novel unsupervised domain adaption (UDA) method to predict unlabeled data on the target domain, given labeled data from the source domain. In the current approach, we enhance the features obtained from the target domain using an unsupervised MNASNet, considered as a target model. We then select the features of the target model with the highest performance. In the next stage, we use a combination of these features to train the proposed model. In this study, we formulated a unique business problem previously considered unapproachable, and we propose a novel solution that considers the real-business scenario for the task. In particular, we propose a Transformer model to forecast the firm’s material event series, based on its SEC 8-K current reports. Our proposed model demonstrates forecasting improvements over traditional sequence-to-sequence models and task-specific Markov chain Monte Carlo simulations.

VWD02
Virtual Room 02
Data mining and decision analytics
Sponsored: Data Mining
Sponsored Session
Chair: Sophie Zhai, University of Oklahoma, Oklahoma, OK, 73019-4038, United States
1 - Does When And How Matter? Information Disclosure Strategy In Online Crowdfunding
Yoonseock Son, University of Notre Dame, Notre Dame, IN, United States, Xinxue (Shawn) Qu, Daewon Sun
Crowdfunding has become an important financing model to help project creators get financial support from backers at an early stage. Most of the time, product quality is unknown to the backers, and this information asymmetry issue often leads to the failure of crowdfunding campaigns. To reduce the uncertainty of the backers, project creators can disclose project updates throughout the process. This study examines when and how the information disclosure timing influences the success of the crowdfunding project. Moreover, text analysis is conducted to understand the impact of information richness and content similarity on the funding results.

2 - Multi-modal, Multi-lingual, Multi-locale And Multi-task For Goal Oriented Dialogues
Yunji Wang, Amazon Alexa, Bellevue, WA, United States, Meiguo Wang, Benjamin Yao, Xiaohu Liu
Due to the high demand for conversational AI, goal-oriented dialogue system becomes a popular research topic. Dialogue structure analysis and automated evaluation are the crucial steps in goal-oriented dialogue system. We propose a multi-modal, multi-lingual, multi-task model for major natural language processing (NLP) tasks, such as domain classification, goal boundary detection. In this paper a universal representation is proposed with pre-trained RoBERTa and Wav2vec 2.0. Our multi-task model is a neural architecture consisting of two hierarchically connected transformer networks and it is easy to incorporate the side information at different levels, such as turn and session. We experiment with different setups and datasets, and the proposed model yields state-of-the-art performance on a collection of benchmark datasets from a commercial voice service.

3 - Personalized Recommendation Based On Consumer Price Preferences
Wenhao Guo, Tianjin University, Tianjin, China, wh_guo@tju.edu.cn, Jin Tian, Xiaoyu Shi, Minqiang Li, Haiyang Feng
Recommendation methods usually use consumers’ historical ratings to predict their preferences for products. Moreover, price plays a significant role in consumers’ purchase decisions. We propose a novel recommendation method based on multi-factorization with the consideration of consumers’ price preferences. We determine the consumers’ price preferences from ratings in a framework of matrix factorization. The final predicted ratings are calculated by adding an additional term of price effect into the matrix factorization framework. The experimental results show that the proposed method has superior performance than several existing methods in both rating prediction and Top-K recommendation.

4 - The Power of Behavioral Hings: FOMC Press Conference and Market Expectations
Yanzhen Chen, HKUST, Austin, TX, 78712, United States, Yanzhen Chen, HKUST, Hong Kong, Hong Kong, Ruixue Zhao, Ruixue Zhao
In this study, we focus on the unintended behavioral hints during FOMC press conferences and their market reactions - expectation, surprise, and uncertainty. Using FOMC video recordings from 2000 to 2019, we find that the financial market is responsive to the duration of length that features the chairman of FOMC during press conferences. To be more specific, a longer focus on the chairman and a higher rate of direct eye contact during responses reveal a high expectation of interest rate and uncertainty on the monetary policy. Our paper posits novel machinery for financial investors’ expectation formation process and sheds light on a careful design of information disclosure.

5 - What’s Next? Harnessing AI To Forecast Firm Material Event Sequences
Sophie Zhai, University of Oklahoma, Norman, OK, 73019-4038, United States, Drew Zhang
In this paper, we formulate a unique business problem previously considered unapproachable, and we propose a novel solution that considers the real-business scenario for the task. In particular, we propose a Transformer model to forecast the firm’s material event series, based on its SEC 8-K current reports. Our proposed model demonstrates forecasting improvements over traditional sequence-to-sequence models and task-specific Markov chain Monte Carlo simulations.
1 - Predictability Of Art Auction Price Without Seeing The Art Piece
Jaehyuk Park, Northwestern University, Chicago, IL, 60626, United States,
Jaehyuk Park, School of Public Policy and Management, Korea Development Institute (KDIS), Sejong-si, Korea, Republic of,
Kangsan Lee, Yong-Yeol Ahn

As social media evolves, its usage is no longer restricted to personal purposes of connecting with friends or topics of interest. Organizations are using social media for many different purposes, including branding and customer support. Individuals use social media to share specific information for business or political purposes, which we term as public communication purposes. Examples include highlighting or advertising one’s own music or written works. There are few extant studies on how the communication purposes (personal or public) influence users’ information revealing behaviors and their implications on privacy. In this empirical study, we aim to fill this gap by analyzing users from social media (specifically Twitter) and comparing the privacy behaviors among users who have different communication purposes.

2 - Understanding The Relationship Between Communication Purposes And Privacy Behaviors On Social Media
Yuanxia Li, University of Arizona, Tucson, AZ, United States, Sudha Ram

Cities are the innovation centers of the US economy, but disruptions, including technology, can exclude workers unless policy promotes the jobs and skills that increase worker pay, create employment, and foster economic resilience. In this talk, I model labor market resilience with an ecologically-inspired job network constructed from the similarity of occupations' skill requirements. The economic resilience of cities is universally determined by the connectivity within a city's job network. US cities with greater job connectivity experienced lower unemployment during the Great Recession. Further, cities that increase their job connectivity see increasing wage bills, and workers of embedded occupations enjoy higher wages than their peers elsewhere. Finally, I show how job connectivity may clarify the augmenting and deleterious impact of automation in US cities.

3 - Skill Complexity And The Resilience Of Urban Labor Markets
Morgan Frank, PhD, University of Pittsburgh, Pittsburgh, PA, 15260, United States

We argue that three different types of scientific innovation — combinatorial, exploratory, and transformative — can be distinguished by generative algorithms. A new framework based on a short text model, namely, a graph-based tensor Dirichlet Process Multinomial Mixture model: Trips and passengers are formulated as tensor words and tensor documents respectively to depict the latent passenger flow's spatial dependence. A detection statistic is constructed by using graph community detection, which can be used for further signal selection and noise filter. It can be efficiently solved via a Min-Cut-based method. For the latent passenger flow's spatial dependence, we develop several algorithmic features that we demonstrate to induce coordination among the vehicles. We benchmark our algorithm with baselines in a simulation environment and have designed and run a real-world field experiment with regular drivers on a major ride-hailing platform. We have observed significantly positive results on income rate comparing our method with experienced drivers who performed idle-time repositioning based on their own expertise.

4 - InnoVAE: Patents, Generative Algorithms, and Innovation Frontiers
Zhaoqi Cheng, Carnegie Mellon University, Pittsburgh, PA, 15206-3747, United States

We present a new practical framework based on deep reinforcement learning and decision-time planning for real-world vehicle repositioning on ride-hailing platforms. Our approach learns the spatiotemporal state-value function using a batch training algorithm with deep value networks. The optimal repositioning action is generated on-demand through value-based policy search. For the large-scale problems, we develop several algorithmic features that we demonstrate to induce coordination among the vehicles. We benchmark our algorithm with baselines in a simulation environment and have designed and run a real-world field experiment with regular drivers on a major ride-hailing platform. We have observed significantly positive results on income rate comparing our method with experienced drivers who performed idle-time repositioning based on their own expertise.

5 - RMDGM: A Reinforcement Learning Approach For Multimodal Smart Transportation
Siyuan Feng, The Hong Kong University of Science and Technology, Hong Kong, Hong Kong.

We propose a novel algorithm that establishes a reinforcement learning approach that estimates the long-term expected rewards, and an Integer Linear Programming (ILP) that matches idle drivers and waiting customers in real-time based on both immediate revenue and the estimated long-term rewards. By evaluation on the real-world on-demand data and metro system in Manhattan, the proposed method shows remarkable improvement on the system’s efficiency under different density of supply and demands.
5 - Public Transportation Analysis Via Tensor Decomposition And Spectral Clustering
Nurettin Dorukhan Sergin, Arizona State University, 3705 S. Terrace Rd, Tempe, AZ, 85282-5544, United States, Hao Van
Automated fare collection systems record millions of transactions every day in major cities. These transactions, when analyzed, yield tremendous insight to public transportation decision-makers. We propose a model that undertakes two important analyses: discovering station similarities and detecting rare events in terms of hourly passenger inflow into stations. Our method combines tensor decomposition with spectral clustering and trains on a spatiotemporal tensor. We present our findings on smart card data collected over several months from Hong Kong’s subway system.

- **VWD05**

**Virtual Room 05**

**Optimization Methods for Learning from Data**

_Sponsored: Data Mining_

_Sponsored Session_

Chair: Paul Brooks, Virginia Commonwealth University, Richmond, VA, 23284-4000, United States
Co-Chair: Jose H Dula, University of Alabama, Tuscaloosa, AL, 35487, United States

**1 - Better Fitting Hyperplanes**

John W Chinneck, Carleton University, Systems And Computer Eng, Ottawa, ON, K1S 5B6, Canada, Paul Brooks
Most hyperplane fitting techniques try to optimize some type of distance measure, e.g. minimize the sum of the squared distances to the data points, which often skews the hyperplane towards any outliers and away from the mass of points. This conflicts with the intuitive understanding that the best fitting hyperplane is closer to more points than other hyperplanes. We present the Relative Better Measure and associated algorithm which works towards this cardinality goal and show experimentally that it provides better fits in the face of outliers, especially clusters of outliers. The algorithm has short running times even for large data sets.

**2 - Nearest Convex Hull Classification with Linear Programming**

Jose H. Dula, University of Alabama, School of Business, Tuscaloosa, AL, 35487, United States, Anatoly Nemirok
The multi-class classification problem aims at assigning a test point to one of several classes that partition a data set. Nearest Convex Hull Classification uses the point’s distance to the convex hulls of the class’s data for this assignment. This presents a special challenge when the test point is interior to two or more hulls. We propose a lazy supervised machine learning method based on linear programming that locates internal and external test points and approximates distances. Advantages include that the same formulation is used for interior or exterior points, necessary and sufficient conditions for classification, the absence of user-defined parameters, and excellent scalability. Tests on health care data show the method performs well.

3 - Processing Large Scale DEA: The State-of-the-art

Jose H. Dula, University of Alabama, School of Business, Tuscaloosa, AL, 35487, United States, Dimitris K Despotis, Gregory Koronakov
Dula’s 2012 algorithm, BuildHull, was the fastest way to process DEA when it came out. Since then there has been an interest in analyzing and testing the algorithm’s performance. We report on a study comparing BuildHull with a recent competing approach for DEA using a well-structured data suite which includes massive data sets and allows insights into the effects of dimensionality, cardinality, and extreme-efficient DMU density.

4 - Dynamic L1 Regression

Botan Citil, University of Alabama, Tuscaloosa, AL, United States, Jose Dula
The objective of this project is to apply L1 regression to streaming data. L1 regression is considered to be more robust than ordinary least squares and is indicated when the data contain outliers such demand spikes, etc. We report on results that enhance and accelerate resolving the special LP formulation for this problem. We present numerical results from our tests.

2 - An Expandable Learning-optimization Framework For Sequentially Dependent Decision-making

Dogacan Yilmaz, New Jersey Institute of Technology, Newark, NJ, 07029-2444, United States
Here, we present a deep learning-optimization framework to solve sequentially dependent optimization problems. We utilize an attention-based encoder-decoder neural network architecture to learn from the optimal solutions of the dependent optimization problems. Then, the required level of predictions is optimized to reduce the infeasibility of the predictions generated, which is used with a commercial solver to achieve a substantial solution time reduction. We demonstrate our approach in two different MIP problems: multi-item capacitated lot sizing and multi-dimensional knapsack. Our results show that models trained on shorter instances can be successfully used to predict longer instances. The solution time can be reduced by several orders of magnitude with a small optimality gap. Our framework can be advantageous to solve NP-hard problems quickly.

3 - Retail Analytics for Store-Wide Shelf Space Allocation

We address a store-wide shelf-space allocation problem that seeks to maximize the profit from shoppers’ impulse buying. By analyzing thousands of customer baskets, we build a predictive model for in-store traffic, as a function of the space allocation and the store layout and then embed it in a non-linear mixed-integer programming model. The latter is linearized by using linear equivalent constraints and piecewise linear approximations. This helps prescribe improved store configurations and yields managerial insights for retailers.

4 - Importance Sketching For Fast Low-rank Matrix/tensor Learning: Algorithm And High-order Convergence

Anru Zhang, Duke University, Durham, NC, 23562, United States
We consider the matrix/tensor rank constrained least-squares optimization. This problem covers many specific examples arising from applications, including matrix/tensor regression, completion, PCA/SVD, and phase retrieval. We propose a new algorithm RISRO based on a new sketching framework, recursive importance sketching. Several existing algorithms can be reinterpreted under the new sketching framework and RISRO offers clear advantages over them. RISRO is easy to implement and computationally efficient, where the core procedure in each iteration is only solving a dimension reduced least-squares. We establish a local quadratic rate of convergence for RISRO under mild conditions. We also discover a deep connection of RISRO to Riemannian manifold optimization. The effectiveness of RISRO is demonstrated in applications in machine learning and statistics.
further, our model allows estimating the worst case scenario with a given precedence-related activities.

infinite right tail which puts no limit on how long an activity can be delayed; renewable-resource constraints. As a consequence of the distribution of the completion time for the entire project is Normally distributed. We investigate the conditions under which it can be claimed that ‘delays at the activity level adversely impact average project completion time, while controlling for variability.’ We categorize probability distributions of activity duration for which the expected adverse impact on project completion time is guaranteed to occur or not: we show that distributional asymmetries can warp the expected cause-effect relationship between activity delay and project delay. We also make some remarks on activity slack in PERT networks, and on almost sure bounds for project completion time in large scale project networks.

2 - A Revised PERT Model Using Log-Normal Activity Times
Eric Logan Huggins, Professor of Management, Fort Lewis College, Durango, CO, United States, Ivan G. Guardiola
The standard PERT model assumes that activity times follow Beta distributions and that completion time for the entire project is Normally distributed. We consider several revisions to this model: specifically, we assume that the activity times follow Log-Normal distributions instead which we believe may improve the model. While the Log-Normal can be similarly skewed like the Beta, it has an infinite right tail which puts no limit on how long an activity can be delayed; further, our model allows estimating the worst case scenario with a given confidence level.

5 - Influence Of Pre-Conflict Relationship On Socio-Emotional Reconciliation In Construction Subcontracting: Moderating Role Of Shadow Of The Future
Conghan Wang, Tianjin University, Tianjin, China, Shuibo Zhang, Ying Gao
Once one conflict occurs, the removal of conflict-related negative emotions (i.e., socio-emotional reconciliation) have pragmatic significance in promoting relational resilience in construction subcontracting. This study distinguishes pre-conflict relationship into two types, and investigates their effects on socio-emotional reconciliation and the moderating role of shadow of the future on the effects.

VWD08
Virtual Room 08
Project Management
Contributed Session
Chair: Conghan Wang,
1 - Perturbations In Stochastic Project Networks
Anand Paul, University of Florida, Gainesville, FL, United States,
We investigate the conditions under which it can be claimed that ‘delays at the activity level adversely impact average project completion time, while controlling for variability.’ We categorize probability distributions of activity duration for which the expected adverse impact on project completion time is guaranteed to occur or not: we show that distributional asymmetries can warp the expected cause-effect relationship between activity delay and project delay. We also make some remarks on activity slack in PERT networks, and on almost sure bounds for project completion time in large scale project networks.

2 - Interrelationships Among Project Attributes And Time-phased Resource Patterns In A Project Portfolio
Vishwanath Hegde, Professor, California State University-East Bay, Hayward, CA, United States, Zinovy Radovilsky
We analyze the interrelationships among project attributes, durations, and time-phased resource allocation patterns in a portfolio of engineering projects. We estimate parametric models that capture unique duration/resource usage patterns from a longitudinal dataset spanning eleven years and analyze the link between the patterns and project attributes. Our research enhances the macro estimation of duration and resource requirements for incoming projects.

3 - A Continuous-time Linear Programming Formulation For Resource-constrained Project Scheduling With Multiple Sites
Norbert Trautmann, Full Professor, University of Bern, Bern, Switzerland, Mario Gnaegi
We present a continuous-time mixed-integer linear programming formulation for scheduling the activities of a multi-site project subject to precedence and renewable-resource constraints. As a consequence of the distribution of the renewable-resource units among the multiple sites, transportation times must be considered for moving some mobile resource units or the output of some precedence-related activities.

4 - A Revised PERT Model Using Log-Normal Activity Times
Eric Logan Huggins, Professor of Management, Fort Lewis College, Durango, CO, United States, Ivan G. Guardiola
The standard PERT model assumes that activity times follow Beta distributions and that completion time for the entire project is Normally distributed. We consider several revisions to this model: specifically, we assume that the activity times follow Log-Normal distributions instead which we believe may improve the model. While the Log-Normal can be similarly skewed like the Beta, it has an infinite right tail which puts no limit on how long an activity can be delayed; further, our model allows estimating the worst case scenario with a given confidence level.
Malaria is a mosquito-borne, lethal disease that affects millions and kills hundreds of thousands of people each year, mostly children. In this paper, we couple a susceptible-infected-recovered compartment model for the disease dynamics with an integer linear program to allocate malaria interventions across geographic regions and time, subject to budget constraints, with the aim of minimizing the number of person-days of malaria infection. The model provides a qualitative decision-making tool to weigh alternatives and guide malaria eradication efforts. A one-size-fits-all campaign is found not to be cost-effective; it is better to consider geographic variations and changes in malaria transmission over time when determining intervention strategies.

Chemotherapy drug administration is a complex problem that often requires expensive clinical trials to evaluate potential regimens. In this paper, we develop linear and mixed-integer programming models for combination chemotherapy that incorporate various important operational constraints. We also address uncertainty in the tumor heterogeneity with a chance constraint.

We used a linear programming model to identify the optimal allocation of the Centers for Disease Control and Prevention’s HIV prevention funding for local U.S. jurisdictions. The model maximizes the number of cases averted while allocating a given budget among prevention interventions and populations stratified by gender and risk groups. Inputs to the model include budget and data on the costs and efficacy of HIV prevention programs. Model solutions report the number of new cases prevented and the corresponding funding allocation to each prevention intervention for different subpopulations.

Chemotherapy is one of the primary modalities of cancer treatment. Chemotherapy drug administration is a complex problem that often requires expensive clinical trials to evaluate potential regimens. One way to better inform future trials is to build reliable models that illustrate how a patient may react to specified drugs and doses. Previous chemotherapy optimization models have relied on optimal control, which does not lend itself to discrete considerations such as doses via pills and rest periods. In this paper, we develop mixed-integer linear programming models for combination chemotherapy that incorporate various important operational constraints. We also address uncertainty in the tumor heterogeneity with a chance constraint.

Hosseinian

We applied DELPHI across >200 regions since early April 2020 with consistent high predictive power. DELPHI compares favorably with other models and predicted large-scale epidemics in areas such as South Africa and Russia weeks before realization. Furthermore, using DELPHI, we can quantify the impact of interventions and provide insights on future virus incidence under different policies. We illustrate how Janssen effectively accelerated the Phase III trial of the first single-dose vaccine Ad26.Cov2.S by selecting optimal locations using such analysis.
would result in lower patient welfare than the previous Share 35 policy. We conclude that the current acuity circles policy change across geographies in lesser sick patients. Collectively, not all geographies process and decisions for medical devices. Selective in accepting organs, however there was heterogeneity in behavior on patients’ welfare. We find that Share 35 policy helped in reducing the tim e in confinement for each population group.

3 - COVID-19 Vaccine Allocation Optimization By Age And Risk Groups
Narzian Arslan, Northwestern University, Evanston, IL, United States, Ozge Surer, David Morton, Lauren Meyers
Vaccines are the primary means for mitigating a pandemic, but mass vaccination does not typically begin until a pandemic is well underway. As various types of COVID-19 vaccines become available in the US, it is crucial to decide on a vaccine prioritization strategy. We present an age and risk structured epidemiological model that incorporates vaccine allocation. We apply a derivative-free optimization algorithm as well as a greedy heuristic into our SEIR-type simulation model to determine an optimal vaccine rollout to minimize an objective, which can incorporate expected mortality, infections, and hospitalizations, accounting for both general ward and ICU beds.

4 - Quantifying The Benefits Of Targeting For Pandemic Response
Dan Andrei Iancu, Stanford University, Stanford, CA, 94305-7216, United States, Sergio Camelio-Gomez, Florin Ciocan, Xavier Warness, Spyros Zournoupolou
The social-distancing measures implemented in response to COVID-19 have involved targeting specific groups or activities for confinement. Such targeting can be contentious, so rigorously quantifying its health and economic benefits is critical for designing effective and equitable policies. We propose a framework for computing interventions targeted by population group characteristics as well as the activities that individuals engage in, and showcase a full implementation using publicly available data. We find that optimized dual-targeted policies have a simple and explainable structure, and lead to substantial complementarities and Pareto improvements, reducing the overall number of deaths and the economic losses, and also reducing the time in confinement for each population group.

1 - Intertemporal Content Variation With Customer Learning
Robert Swinney, Duke University, Durham, NC, 27708-9972, United States, Fernando Bernstein, Souidipta Chakraborty
We study a firm that sells repeatedly to a customer population over time. Motivated by new business models like streaming services, we assume that the price is the same in every period, but the firm varies the content available over time. Customers learn their utility on purchasing and decide whether to purchase again in subsequent periods. The firm faces a budget for the total amount of content available during a finite planning horizon, and allocates content to maximize revenue. We show that the optimal allocation policy is monotone: content value increases if customer heterogeneity is low and decrease otherwise. Furthermore, for the case of T = 2 periods, we show how two critical factors—the fraction of “new” versus “repeat” customers, and the size of the content budget— affect the optimal allocation policy and the importance of varying content value over time.

2 - The Role Of Dealer Demonstration In The Adoption Of Electric Vehicles
Ioannis Bellos, George Mason University, Fairfax, VA, 22030-4422, United States, Vishal Agrawal, Hang Ren
To date, electric vehicles represent a very small fraction of the total vehicle sales. One reason often cited as contributing to customers’ hesitation to adopt electric vehicles is the uncertainty around their achievable range which depends on idiosyncratic factors that can be fully experienced only post-purchase. In this paper, we consider the role that car dealers can play in offering customers as close to a post-purchase experience as possible by providing demonstration services such as extended test drives. We study the dealer’s decision whether to sell electric vehicles in addition to conventional ones and if so, whether to provide demonstration services. We characterize both the economic and environmental impact of these decisions.

3 - Implications of Worker Classification in On-Demand Economy
Zhoupeng (Jack) Zhang, Rotman School of Management, University of Toronto, Toronto, ON, M5S 3E6, Canada, Ming Hu, Jianfu Wang
Workers in the gig economy have long been treated as independent contractors, which disqualifies them from employee benefits. We evaluate the impacts of California Assembly Bill 5 (AB5), a statute that requires on-demand platforms to reclassify their workers as employees. We model the service process of such a platform as a queueing system with long-term (LT) and ad hoc (AH) workers. We show that AB5 does not always improve LT workers’ welfare because, in the free market, the presence of AH workers can incentivize the company to pay a high piece-rate wage. While the company’s profit always decreases, transaction volume can either increase or decrease due to AB5, rendering consumer welfare implications ambiguous. We propose a way to refine the current AB5.

4 - All-or-nothing Or Keep-it-all? Campaign Design Choice In Rewards-based Crowdfunding Platforms
Simone Martinesi, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19103-6007, United States, Ekaterina Astakhina
We compare two popular, alternative campaign designs for rewards-based crowdfunding, Fixed Funding and Flexible Funding. In contrast to prior literature, which argues that Fixed Funding is superior to Flexible Funding, we show that each campaign mode can outperform the other, depending on the characteristics of the project, and we provide recommendations for how to choose between the two.
2 - The Mallows Model Of Discrete Choice In Operational Contexts
Gustavo J. Vulcano, Universidad Torcuato di Tella, Buenos Aires, 1428, Argentina, Srikanth Jagabathula

We study the Mallows discrete choice model, which is relatively novel in the OM community and provides a fairly parsimonious representation of a rank-based model of choice. We illustrate how this model can be used to estimate price behavior in retail settings where only transaction and product availability data are available. Then, we show how to extend the model to a setting where customers are described by partial orders, and the firm has access to individual panel data. Our numerical experiments on real-world panel data show that the model leads to competitively accurate, fine-grained predictions for individual purchase behavior compared to state-of-the-art alternative methods.

3 - Discrete Choice Via Sequential Search
Aydin Alptekinoglu, Pennsylvania State University, University Park, PA, 16802-3603, United States, Natalia Kosilova

This work considers the sequential search process of the consumer and derives the resulting choice probabilities. While the optimal search strategy was characterized by Weitzman (1979), to the best of our knowledge there is no work deriving the choice probabilities that result from the optimal search strategy.

5 - Online Nash Social Welfare Maximization Via Promised Utilities
Billy Jin, PhD Student, Cornell University, Ithaca, NY, United States, Siddhartha Banerjee, Vasilis Gkatzelis, Artur Gorokh

We consider the problem of allocating a set of divisible goods to N agents in an online manner over T periods, with adversarially-chosen normalized valuations in each period. Our goal is to maximize the Nash social welfare, a widely studied objective which provides a balance between fairness and efficiency. On the positive side, we provide an online algorithm that achieves a competitive ratio of O((log N)^2) and O((log T)^2), and also a stronger competitive ratio of O(log k) in settings where the value of an agent in any period is no more than k times her average value. We complement this by showing this bound is essentially tight: no online algorithm can achieve a competitive ratio of O((log N)^2(1-Δ)) or O((log T)^2(1-Δ)) for any constant Δ > 0.
2 - Courier Sharing in Food Delivery
Arseniy Gorbushin, ON, Canada
The food delivery market is migrating to platforms. One of the platform’s advantages is optimized routing by sharing couriers (SC) among many restaurants. We ask two questions: how SC reduces delivery costs and how it affects the market equilibrium. We consider a spatial queuing model in which couriers are the servers. We show that SC is preferable if restaurants maximize throughput in a big market. However, if they maximize profit then SC intensifies price competition and may decrease profit.

3 - Spatial Elasticity
Bobby Nyotta, UCLA Anderson School of Management, Los Angeles, CA, 91355-3203, United States, Fernanda Bravo, Keith Chen
Using transactions data from a popular downtown neighborhood in a large metropolitan city’s mobile phone application for parking payments, we analyze customer behavior from a natural pricing experiment to estimate the “spatial elasticity,” a measure of how individuals quantify the cost of walking an additional mile, in an urban mobility setting. We find that customers require approximately $81 to walk an additional mile to their intended destination. The results are robust against several varying assumptions and when considering factors such as weather and time of day. Our estimates can be used in ride-sharing, bike-sharing, e-scooter-sharing settings to incentivize users to end their trips at key locations to either ensure future availability or reduce congestion.

4 - Autonomous Vehicles For Ride-Hailing
Xiaotang Yang, University of Minnesota, Minneapolis, MN, 55442-4516, United States, Saei Benjaafar, Zicheng Wang
We consider a setting where a ride-hailing platform can operate with both autonomous vehicles (AVs) and conventional vehicles (CVs or drivers) over a spatial network. An important distinction between AVs and CVs is in the associated cost structure (drivers are paid only when they fulfill demand while AVs are purchased ahead of time and incur a fixed cost) and in the repositioning of vehicles upon the completion of service. The repositioning of AVs is under the control of the platform. In contrast, the repositioning of CVs is in the hands of the drivers who act strategically. We study the effect of introducing AVs to the ride-hailing market, including repositioning strategy, driver welfare, admission control and vehicle assignment policy.

4 - The Impact Of Uncertainty On A Broker’s Optimal Bidding Decisions In B2B Markets
Ozden Engin Cakici, American University, Washington, DC, United States
We study a broker’s problem of matching a buyer with stochastic suppliers. The broker bids at each supplier. After the suppliers evaluate the bids, the broker learns the procurement quantity and then ships the items from each supplier to the buyer. When there is a single supplier the problem reduces to a new type of newsvendor problem. We study the impact of uncertainty on the optimal bids. We prove that the broker may or may not increase the bid when faced with uncertainty compared to a case with no uncertainty. We provide conditions under which it is optimal for the broker to bid at multiple suppliers. We numerically find that the broker’s expected profit decreases in the correlation between suppliers.

5 - Assortment Optimization For Online Multiplayer Video Games
Fan You, PhD Candidate, University of Colorado-Boulder, Boulder, CO, United States, Thomas Vossen
We consider the assortment optimization problem for a class of online multiplayer video games, where the in-game store has a unique structure with two sections, Featured and Just For You (JFY). All customers are offered the same featured assortment whereas JFY is used for personalized recommendations. We model the choice of customers under the constrained mixture of nested logit model, and design a MILP formulation, as well as a FPTAS. We also propose a Lagrangian upper bound and a fast heuristic. We prove the finite integer relaxations of the MILP formulation, the FPTAS as well as the heuristic algorithm. Numerical experiments show that our approaches perform well across a variety of settings.
platform by interpreting the solution to the equivalent workload formulation in numerical and a dynamic control policy for the ride-hailing demand and uncertainty, advance selling only scheme is optimal; when the advance and upgrade to fast-track tickets on the spot. We find that when there is uncertainty, advance selling or fast-track tickets suffers the demand uncertainty later when they consume the service. At the park gate, customers can observe the demand and decide whether to purchase the regular or fast-track tickets. They can also purchase regular tickets in at the park gate, customers can observe the demand and decide whether to purchase the regular or fast-track tickets. They can also purchase regular tickets in

1 - Operational Linkages Between Covid-19 Testing Strategies And Patient Infections
Debjit Roy, Indian Institute of Management-Ahmedabad, Ahmedabad, India, Akash Gupta, Anand Nair, J. C. W. Van Ommeren
To limit transmission of virus and control outbreaks during pandemics such as COVID-19, rapid diagnostic testing is touted as an effective strategy. While health authorities have developed testing protocols, including testing priorities for vulnerable population, the effect of protocols on the volume of infections and the effective usage of swab analysis capacity at a public lab versus a private lab for testing mild and severe patient groups is unclear. Using stylized queueing models, we address the decision of appropriately allocating patient swab batches among analysis sites to minimize the spread of infections.

2 - Joint Staffing and Admission Control Problem Under Different Levels of Information
Wei Liu, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, Vidyyadharulkarni, University of North Carolina-Chapel Hill, Chapel Hill, NC, 27599-3260, United States
We consider a joint staffing and admission control problem in a multi-server queueing system under three different levels of information, namely minimal, partial and full information about the state of the queueing system. Our major contribution lies in the combination of the admission control, staffing problem, and information levels. The system earns a reward from serving each customer if her queuing time is no more than a fixed threshold and each server costs a fixed amount per unit time. Under each information case, we derive the optimal admission policy and optimal staffing level by maximizing the profit. We also show the connection between these two criteria in determining the optimal staffing level. Finally, we compare the system performance under different levels of information.

3 - Dynamic Dispatch And Centralized Relocation Of Cars In Ride-hailing Platforms
Nasser Barjesteh, University of Toronto, Toronto, ON, M5S 2E8, Canada, Baris Ata, Sunil Kumar
We consider a ride-hailing platform that seeks to maximize its profit by dynamically dispatching cars to pick up customers and centrally relocating cars from one area to another. We model the platform as a closed stochastic processing network. We use an approximate analysis in the heavy-traffic regime and consider the resulting Brownian control problem. The Brownian control problem is equivalent to a lower-dimensional control problem referred to as the equivalent workload formulation. We propose an algorithm to solve the equivalent workload formulation numerically and a dynamic control policy for the ride-hailing platform by interpreting the solution to the equivalent workload formulation in the context of the original ride-hailing system. We demonstrate the effectiveness of the proposed policy using a simulation study.

4 - Advance Selling And Upgrading In Priority Queues
Yaolei Wang, University of Science and Technology of China, Hebei, China, Ping Cao, Jingui Xie, Dongyuan Zhan
In this paper, we study upgrading in a priority queue setting with advance selling that has emerged in the park industry. Customers who purchase advance fast-track tickets suffer the demand uncertainty later when they consume the service. The park gate, customers can observe the demand and decide whether to purchase the regular or fast-track tickets. They can also purchase regular tickets in advance and upgrade to fast-track tickets on the spot. We find that when there is no demand uncertainty, advance selling only scheme is optimal; when the uncertainty is large, spot selling only scheme is optimal; only when the uncertainty is medium, advance selling with upgrading option scheme is optimal. We also find that allowing the upgrading option is no less profitable than forbidding upgrading option. Finally, we investigate the advance selling with downgrading option scheme.

5 - Engine Failure Forecast Model For Saving The Operating Cost: A Case Of American Airlines
Nicolas Rosal, University College London School of Management, London, United Kingdom, Lina (Dalhye) Song
We quantitatively the impact of applying an engine failure forecast model on the airlines’ maintenance operating cost. We first compare the performances of existing engine failure forecast models and find that: (a) a stacking model with an XGBoost estimator performs best with 99.9% accuracy and 0% no-fault-found rate, and (b) engine pressure ratio (epr) is a key variable for predicting the engine failure. We then use American Airlines as a case study, where we quantify that applying a failure forecasting model can save up to $1.16 billion per year on maintenance expenses.
it. In this study, we bring our monitoring methodology to the experimentation moving slugs inside a tube. Then, a neural network (U-Net) was trained to detect sequence pattern characteristics by utilizing the relative positions of alphabets in (SGT). SGT is a feature extraction technique for sequences. It extracts the limitations usually found in EU-based models. An in-depth analysis that uses statistical and simulation tools is made of the results from a case study. This analysis indicates that the model generates recommendations that are more assertive than other models with regard to prioritizing NGP risks.

**3 - A Sequence Graph Transform Based Method For Monitoring Discrete Sequence Processes**

Meseret Karaca, University of Florida, Gainesville, FL, United States, Chitta Ranjan, Mostafa Reisi-Gahrooei, Michelle M. Alvarado, Panayote (Panos) M. Pardalos

A discrete sequence is an ordered series of discrete events. It is becoming customary to monitor the sequence processes for anomaly detection. In this study, we propose a monitoring methodology that uses sequence graph transforms (SGT). SGT is a feature extraction technique for sequences. It extracts the sequence pattern characteristics by utilizing the relative positions of alphabets in it. In this study, we bring our monitoring methodology to the experimentation using simulated and real-life datasets. Finally, we show our results in terms of accuracy and the anomaly detection time compared to existing methods such as Chi-Square monitoring and hidden Markov models.

**4 - Automatically Monitoring Slug-flow Process Of Continuous Crystallization**

Yanjun Qian, Virginia Commonwealth University, Richmond, VA, United States,

In this project, we investigated the slug-flow process of continuous crystallization in pharmaceutical manufacturing. This project consists of three parts. First, we applied the Gaussian mixture model for the foreground extraction to detect moving slugs inside a tube. Then, a neural network (U-Net) was trained to detect the locations of those crystals, and the overlapped crystals were segmented based on the Canny edge detector. At last, we obtained a robust size distribution from the measurement results and monitored the crystallization process.
1 - Mitigating The Negative Effects Of Customer Anxiety Through Access To Human Contact
Michelle A. Shell, Boston University, Dover, MA, 02030-1820, United States
Through a series of lab and field experiments, conducted in the high-anxiety domain of financial services, we document the negative effects of anxiety on customer performance and demonstrate how providing customers with access to human contact can improve customers’ willingness to engage, elevate choice satisfaction and engender trust in companies.

2 - Searching for the Best Yardstick: Cost of Quality Improvements in the U.S. Hospital Industry
Jong Myeong Lim, The Wharton School, Philadelphia, PA, 19104, United States, jongmllim@wharton.upenn.edu, Kenneth Moon, Sergei Savin
The Hospital Value-Based Purchasing (VBP) Program is Medicare’s implementation of yardstick incentives applied to hospitals in the U.S. Under the VBP Program, 2% of all Medicare payments, estimated to be US$1.9B in FY2021, are withheld and redistributed based on relative performance in the quality of delivered care. We develop a dynamic equilibrium model in which hospitals are engaged in a repeated competition under yardstick incentives. Using structural estimation methods, we recover key parameters that govern hospitals’ decisions to invest in quality improvement, including the financial and non-financial costs and uncertain outcomes of investment. Our counterfactual analyses explore the implications for practice managers.

3 - Effect of Workforce Fragmentation on the Erosion of Relational Care Continuity
Harshita Kajaria-Montag, University of Cambridge, Cambridge, CB3 0JE, United Kingdom, Michael Freeman
Primary care is facing a workforce crisis, which poses a critical challenge for primary care managers: how can a shrinking clinical workforce manage the increasing demand for primary care services? Most primary care practices have focused on improving daily throughput, but this has led to a decline in continuity of care (COC) which has the potential to improve clinical productivity and shown to drive better patient health outcomes. However, there is little understanding of the key levers to deliver COC. We fill this gap by empirically examining the workforce factors that explain the decline in COC by using a dataset consisting of all PCP consultations for approximately 10% of UK’s population over 10 years. Using a system GMM approach, we show that workforce fragmentation and diversity can explain almost 40% of the decline in COC. We discuss the implications for practice managers.

4 - Focusing Provider Attention: An Empirical Examination Of Incentives And Feedback In Flu Vaccinations
RJ Niewoehner, UNC Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States, Bradley R. Staats
Influenza imposes heavy societal costs through healthcare expenditures, missed days of work, and numerous hospitalizations each year. Considering these costs, the healthcare and behavioral science literature offers suggestions on increasing patient demand for flu vaccinations. And yet, the adult flu vaccination rate fluctuated between 37% and 46% between 2010 and 2019. In this paper, we investigate how to improve clinic vaccination rates by altering provider behavior. We implement and study a flu vaccine intervention among 145 clinics from 9 different states. We find clinics that received relative performance feedback outperformed all others. Moreover, we also find clinics in this group exhibit rank response behavior, specifically Last-Place Aversion. Overall, we find that clinic-level performance feedback can effectively drive operational improvement.

INFORMS Anaheim 2021
structure and validate our model using real e-commerce orders. We use a matching design to study the effects of proposal evaluation procedures, criteria, and their relative weighting on supplier performance by combining U.S. government data on contract awards with data extracted from the corresponding RFP documents. Our performance measure, reconstructing, captures subjective and difficult to measure aspects of supplier performance. Our results are relevant for policymakers, buyers, and potential suppliers.

2 - Dynamic Retail Network Expansion In A New Market
Hongmiao Fan, Tsinghua University, Beijing, China, Shizhan Gong, Chen Mavis Wang, Zuo-jun Max Shen
Expansion of retail networks in second-tier cities is a new trend, and the store opening strategy should make a trade-off between learning the market structure and maximizing the long-term sales. This task constitutes a dynamic subset selection problem, with the novel feature that once a store location is selected it cannot be removed from the subset. We propose an online learning and optimizing policy for the retail network expansion problem, and conduct regret analysis to ensure efficiency of the proposed policy. We further extend the modeling and algorithm to capture cannibalization effects between nearby stores.

3 - Robust Remanufacturing Planning With Parameter Uncertainty
Zhicheng Zhu, Texas Tech University, Lubbock, TX, United States, Yisha Xiang, Yue Shi, Tong Li
We consider the problem of remanufacturing planning in the presence of statistical estimation errors. We model this problem as a robust Markov decision process, where the true system transition probability is assumed to be unknown but lie in an ambiguity set that consists of all possible realizations. We further establish structural properties of optimal robust policies and insights for two types of ambiguity sets: phi-divergence and Wasserstein distance. A computational study on the NASA turboprop engine shows that our data-driven decision framework consistently yields better worst-case performances and higher reliability of the performance guarantee.

4 - Optimal Level Design in Video Games
Yifu Li, Assistant Professor, Xi’an Jiaotong-Liverpool University, Suzhou, China, Christopher Ryan, Liefeng Sheng
Retention of players is a key of successful video games, which hinges on the quality of the game’s design. An important design question is how to sequence game elements within a level of the game. Each element has two features: reward and difficulty. We study the sequencing problem to maximize the remembered utility of the level subject to accomplishment and stress. We find that the optimal design depends on the reward rate. When the reward rate is high, the optimal design mimics that of passive experiences. When the rate is low, it resembles a game with “warm-ups” and “cool-downs”. Intermediate cases follow the “mini-boss, end-boss” design where one peak is in the middle and another is at the end.

5 - Operation-oriented Generative Model Of E-commerce Orders For Stowage In Mobile Fulfillment Systems
Yike Hu, Tsinghua University, Beijing, China, Chen (Mavis) Wang
The robotic mobile fulfillment system provides operational flexibility for storage of enormous and volatile e-commerce orders. Inspired by the topic modeling in natural language processing, we treat inventory pods carrying SKUs like topics composed of words. We introduce pod capacity constraints to the generative model of e-commerce orders, and show the duality between the pod visit minimization problem and the novel operation-oriented generative model. Furthermore, we design an online algorithm to capture the dynamics in order structure and validate our model using real e-commerce orders.

Chair: Yike Hu, United States

1 - Proposal Evaluation Approaches And Supplier Performance
Beverly Osborn, PhD Candidate, The Ohio State University, Columbus, OH, United States, osborn.259@osu.edu, John V. Gray
We use a matching design to study the effects of proposal evaluation procedures, criteria, and their relative weighting on supplier performance by combining U.S. government data on contract awards with data extracted from the corresponding RFP documents. Our performance measure, reconstructing, captures subjective and difficult to measure aspects of supplier performance. Our results are relevant for policymakers, buyers, and potential suppliers.

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Expansion of retail networks in second-tier cities is a new trend, and the store opening strategy should make a trade-off between learning the market structure and maximizing the long-term sales. This task constitutes a dynamic subset selection problem, with the novel feature that once a store location is selected it cannot be removed from the subset. We propose an online learning and optimizing policy for the retail network expansion problem, and conduct regret analysis to ensure efficiency of the proposed policy. We further extend the modeling and algorithm to capture cannibalization effects between nearby stores.

3 - Robust Remanufacturing Planning With Parameter Uncertainty
Zhicheng Zhu, Texas Tech University, Lubbock, TX, United States, Yisha Xiang, Yue Shi, Tong Li
We consider the problem of remanufacturing planning in the presence of statistical estimation errors. We model this problem as a robust Markov decision process, where the true system transition probability is assumed to be unknown but lie in an ambiguity set that consists of all possible realizations. We further establish structural properties of optimal robust policies and insights for two types of ambiguity sets: phi-divergence and Wasserstein distance. A computational study on the NASA turboprop engine shows that our data-driven decision framework consistently yields better worst-case performances and higher reliability of the performance guarantee.

4 - Optimal Level Design in Video Games
Yifu Li, Assistant Professor, Xi’an Jiaotong-Liverpool University, Suzhou, China, Christopher Ryan, Liefeng Sheng
Retention of players is a key of successful video games, which hinges on the quality of the game’s design. An important design question is how to sequence game elements within a level of the game. Each element has two features: reward and difficulty. We study the sequencing problem to maximize the remembered utility of the level subject to accomplishment and stress. We find that the optimal design depends on the reward rate. When the reward rate is high, the optimal design mimics that of passive experiences. When the rate is low, it resembles a game with “warm-ups” and “cool-downs”. Intermediate cases follow the “mini-boss, end-boss” design where one peak is in the middle and another is at the end.

5 - Operation-oriented Generative Model Of E-commerce Orders For Stowage In Mobile Fulfillment Systems
Yike Hu, Tsinghua University, Beijing, China, Chen (Mavis) Wang
The robotic mobile fulfillment system provides operational flexibility for storage of enormous and volatile e-commerce orders. Inspired by the topic modeling in natural language processing, we treat inventory pods carrying SKUs like topics composed of words. We introduce pod capacity constraints to the generative model of e-commerce orders, and show the duality between the pod visit minimization problem and the novel operation-oriented generative model. Furthermore, we design an online algorithm to capture the dynamics in order structure and validate our model using real e-commerce orders.
of their optimal LOS. Capacity constraints limit the ability of hospitals to keep patients for the entirety where our designs are especially beneficial.

Surrogate outcomes have long been used in clinical trials when the true outcome of interest is expensive, time consuming, or otherwise difficult to measure. In this work we propose optimal adaptive clinical trial designs that integrate surrogate and true outcomes, and we analytically and empirically characterize regimes where our designs are especially beneficial.

We consider the problem of determining the number of staffed beds in emergency departments (EDs) in different points in time, to minimize average waiting times of patients for a fixed budget. The system is modelled as a time-inhomogeneous multi-server queueing system (G/G/nt) with multiple patient classes with non preemptive priority. We develop a new queuing approximation which enables us to model the staffing problem as a sample-based linear program, by the means of sample average approximation and discrete approximations. We demonstrate the performance of our approach via extensive numerical experiments where parameters of the models are estimated from a real ED data, and comparing with two other simulation-based optimization techniques. Our algorithm results in consistent near-optimal solutions for reasonably small computational times in all test scenarios.
5 - Data-driven Robust Optimization For Closed-loop Supply Chain Under Time-dependent Uncertain Carbon Tax Rate
Yun Geon Kim, Yonsei University, Seoul, Korea; Republic of, Byung Do Chung

Most robust optimization studies for closed-loop supply chain design (CLSC) considering uncertain carbon tax are based on the premise that uncertain carbon tax is time-independent. This study proposes a novel uncertainty set that reflects time series pattern of uncertain parameter when uncertain carbon tax follows time-dependent autoregressive process. Tractable robust counterpart is derived and the performance of the proposed method is evaluated with a multi-period CLSC design problem.

■ VWD32
Virtual Room 32
Supply Chain & Operational Risk Management
Sponsored: MSOM/Supply Chain
Sponsored Session
Chair: Youngsoo Kim, University of Alabama, Tuscaloosa, AL, 35487, United States
1 - Presenter
Vadim Glnsky, Kellogg School of Management, Evanston, IL, 60201-4428, United States, Sunil Chopra, Florian Lucker

In many industries, future demand is driven by past sales, and the inability to sell today can decrease future market size. While the dependence of demand on sales has been addressed in several streams of Operations literature, such a setting has not been studied in the disruptions literature. We find that risk mitigation strategies become quite different from those presented in the existing disruptions literature. For example, there may exist distinct values of probability of disruption, at which the order quantity from an unreliable supplier increases in probability of disruption, when the OEM either single or even dual sources from the unreliable and reliable suppliers. Our study is particularly relevant nowadays as many industries where future demand is driven by sales (i.e. consumer electronics) frequently experience supply disruptions.

2 - The Role Of Real-time Event Monitoring In Dynamic Response To Disruptions
Shailesh Divyey, Rensselaer Polytechnic Institute, Troy, NY, 12180-2075, United States, Mert Hakan Hekimoglu, T. Ravichandran

This study examines the benefits of real-time monitoring of disruption events and how such monitoring capabilities influence the optimal response strategies to disruptions. Prior research sheds light on the benefits of disruption mitigation where mitigation is typically characterized in the form of either reduced likelihood of a disruption occurring or shorter time-to-recovery following a disruption. However, in practice, it may not be always possible to proactively dodge a disruption or resolve it quickly. Furthermore, it is challenging to predict from the get-go how long a disruption will last, and a firm's initial belief can become significantly off while the event unfolds. Using a two-stage stochastic program, we show the benefits of real-time monitoring capabilities coupled with dynamic response strategies.

3 - Concurrent Sourcing Under Supply And Demand Uncertainty
Bryant Cassidy, University of Alabama, Tuscaloosa, AL, United States, Nicholas K Freeman, Sharif Melouk

A central question in the supply chain strategy literature related to Supply Chain Risk Management (SCRM) asks how a firm should delineate its boundary with respect to goods composing a product or service it offers. We investigate the setting in which a firm may choose to make and buy components used to manufacture finished goods (concurrent sourcing), and determine the optimal decision strategy under uncertain supply and demand. For simplicity, we assume supply is uncertain in an all-or-nothing manner: either the supply is totally disrupted or not. We show that the optimal strategy follows a threshold structure defined by problem parameters. We also investigate the effect of concerns about concurrent sourcing on the supplier's optimal pricing strategy. Our analysis highlights the conditions under which a manufacturer and a supply chain system benefit the most from concurrent sourcing.

4 - Impact Of Ransomware Attacks On Healthcare Systems
Youngsoo Kim, University of Alabama, Tuscaloosa, AL, 35487, United States, Ming Zhao, Nickolas K Freeman

Advances in health IT systems have helped healthcare organizations to pave the way for more effective patient treatment. However, such IT developments have also made the healthcare industry more vulnerable to cyber attacks called ransomware. Utilizing a unique dataset that captures two ransomware attacks experienced by large U.S. hospitals, we employ a difference-in-differences regression design to examine the causal impact of ransomware on ambulance performance measures. Furthermore, we investigate the effectiveness of mitigation strategies that may alleviate operational disruptions in healthcare systems caused by ransomware breach. Overall, our findings can help healthcare policymakers and administrators (e.g., government health officers, EMS directors, and hospital executives) to make informed decisions about cyber security risks.

■ VWD34
Virtual Room 34
Volunteer management policies
Sponsored: MSOM/Sustainable Operations
Sponsored Session
Chair: Mariana Escallon, Chicago, IL, 60657, United States
1 - Nonprofit Operations: Managing Volunteers And Paid Workers
Lei Li, Purdue University, West Lafayette, IN, United States, Gemma Berenguer, William Haskell

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

2 - Efficiently Combining Centralized Scheduling Workforce And Self-scheduling Workforce
Mariana Escallon-Barrrios, Northwestern University, Evanston, IL, 60657, United States, marianaeccion2023@u.northwestern.edu, Karen Smilowitz, Reut Noham

We present a model to efficiently combine two workforces, one that self-schedule (SSW) and one that is scheduled by a centralized planner (CSW), in order to meet organizational objectives and maintain reliable, engaged and motivated staff. We investigate a two-stage stochastic approach first assigns CSW to the schedule, leaving ample slots available for SSW to choose from. We incorporate behavioral components such as preferences, satisfaction, and SSW reactions to unavailable time slots (i.e. spillover effects, which were analyzed via a choice exercise). We present a case study based on five years of operation data from an emergency response organization. We analyze the importance of incorporating behavioral components and how it can change the model solution.

3 - Attraction And Compromise Effects With Environmental Information
Miriel Yavuz, University of California-Los Angeles, Los Angeles, CA, United States, Gaia Bianchi, Charles J Corbett, Taylor Bergstrom, Aimée Drolet, Timothy F. Malloy, Deepak Rajagopal, Rakesh K. Sarin, Francesca Testa

Although several tools have been developed to collect environmental and social information, there is currently minimal guidance on how to make decisions based on such information and accompanying trade-offs. Decision-makers are known to be subject to a wide range of biases and heuristics in other decision contexts. This experimental study aims to explore whether a selection of well-documented biases, namely the attraction and compromise effects, occur in the context of sustainability-related decision-making.

■ VWD35
Virtual Room 35
Electrical Markets II
Contributed Session
Chair: Santiago Maiz, CIUDAD REAL, 13071, Spain
1 - Computation Of Convex Hull Prices Using Dantzig-wolfe Decomposition
Panagiotis Andrianezis, Boston University, Brookline, MA, United States, Dimitris Bertsimas, Michael C. Caramanis, William W. Hogan

Several US ISOs have recently considered Extended Locational Marginal Prices as approximation to Convex Hull (CH) prices, mainly because determining exact CH prices is computationally challenging, while providing little intuition about the price formation rationale. We describe the CH price estimation problem by relying on Dantzig-Wolfe decomposition and Column Generation as a tractable, highly parallelizable, and exact method, with finite convergence, which provides intuition on the underlying price formation rationale. We provide several stylized examples and realistic ISO-scale datasets to support scalability and validate proof-of-concept.
We address the expansion planning problem of a virtual power plant (VPP) considering the possibility of building new assets such as conventional, renewable, and storage units. The VPP is modeled as a price-maker player that participates in energy and reserve markets altering the prices of these markets to its own benefit. Uncertainties in production levels of renewable units and up/down reserve deployment requests are addressed using a stochastic programming approach. Numerical results show the influence of the behavior of the VPP in the expansion decisions.

### VWD36

**Virtual Room 36**

**Large Scale Optimization**

**Contributed Session**

Chair: Sai Krishna Kanth Hari, 

1 - **A Self-learning Hyper-heuristic Method For Strategic Mine Planning**

Yassine Yaakoubi, McGill University, Montreal, QC, Canada, yassineyaakoubi@outlook.com, Roussos Dimitrapoulos

To address the need for self-managed solution approaches that can tackle the production scheduling of large-scale industrial mining complexes without resorting to aggregation, a new self-learning hyper-heuristic is proposed. The proposed method is a multi-neighborhood simulated annealing algorithm used in conjunction with reinforcement learning (RL), where the selection of a perturbation (low-level heuristic) is made in self-adaptive learning. Several state-of-the-art agents have been implemented and incorporated into the RL framework. Results show the method's effectiveness on real-sized mining complexes reducing the number of iterations by 30-50% and computational time by 30-45%.

2 - **Learn To Decompose: Enhancing Interdependent Infrastructures Resilience**

Shima Mohebbi, George Mason University, Fairfax, VA, United States, smohebbi@gmu.edu, Babak Aslani

Providing timely resource allocation plans for disrupted interdependent infrastructures can expedite the recovery phase and enhance the systems resilience. This study aims to develop a hybrid approach based on the Gaussian Process (GP) and multi-objective evolutionary algorithm based on decomposition to design restoration plans for large-scale interdependent networks which are governed by several sectors. The GP module iteratively extracts valuable information from the current Pareto frontier to guide the search mechanism. We apply the framework to water-transportation networks in Tampa, FL. We also design a simulation analysis to evaluate the performance for different problems.

3 - **An ODHCPlex Python Primer**

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

This short tutorial shows participants how to build a basic model using the DOCPlex API in Python. This session includes setting the Python environment, reading data from a CSV or spreadsheet, creating variables, objective functions, constraints, solving the model, and returning the results. Additionally, this session points the participants to further reading so that they may expand their capabilities. Furthermore, we will present the brand new ODHCPLEX API for Python, which improves solution times for large models.

4 - **Linear Relaxations For Mixed Integer Nonlinear Programs In Natural Gas Transportation Networks**

Sai Krishna Kanth Hari, Los Alamos National Laboratory, Los Alamos, NM, United States

Efficient and profitable transportation of natural gas along pipeline networks requires solving challenging Mixed Integer Nonlinear Programs (MINLPs) as the gas flow is governed by nonlinear, non-convex physics. Obtaining tight bounds on the objective value of these MINLPs using convex relaxations is of significant interest in the research community. Here, we utilize the recent advancements in the literature of polyhedral relaxations for univariate and bilinear functions to develop Linear Programming and Mixed Integer Linear Programming relaxations for the MINLP.

### VWD38

**Virtual Room 38**

**Energy Policy and Planning II**

**Contributed Session**

Chair: Do-Hyeon Ryu, Postech, Pohang, Korea, Republic of 

1 - **Dynamic Adaptation Of Data-driven Uncertainty Sets For The Two-stage Robust Unit Commitment Problem Via Reinforcement Learning**

Diego Jiménez, Master student, Universidad Técnica Federico Santa María, Valparaíso, Chile

Robust optimization models for the unit commitment problem are widely used on power systems scheduling since increasing penetration levels of renewable energy. Classical uncertainty sets define the robustness of the method as part of the preprocessing. This work proposes a solution scheme based on data-driven uncertainty sets, where adaptation parameters are dynamically calculated as a function of previous operation results. Reinforcement learning is used to achieve closed-loop operation. Experiments show the effectiveness of the proposed methodology against well-known non-adaptive strategies.

2 - **Stochastic Unit Commitment Problem, An Analytical Approach**

Carlos Olivos, Auburn University, Auburn, AL, United States, Carlos.Olivos@auburn.edu, Antolagasta, Chile, Jorge F. Valenzuela

The stochastic unit commitment problem has been modeled using different approaches such as scenario generation, chance-constrained, and robust optimization. These methods tend to provide conservative solutions resulting in higher dispatching and commitment costs. We propose an analytical formulation of the expected dispatch and commitment costs resulting from the probability distribution function of the random load. The model is linearized through a piece-wise linear approximation and solved as a Mixed Integer Linear Program (MILP). The solution is verified by simulating and computing analytically the expected cost. Results, algorithms, and conclusions will be presented.

3 - **Valuation Of An Option To Expand Generation And Transmission Capacities Under Demand Uncertainty**

K. Jo Min, Iowa State University, Ames, IA, United States, Jay Ghodke, Nazia Nur, Cameron MacKenzie

Under the framework of real options, given that the demand follows a geometric Brownian process (GBM), we show how to value an option to add a generation unit in the network based on the optimal power flow and the locational marginal price. Utilizing the demand lattice discretized from the GBM process, we derive the economic consequences of costs to a bus with and without an additional power plant/transmission line. These in turn will lead to the computation of the value of an option to add a power plant/transmission line. How to utilize this value of the option for the electric power planning will be illustrated via numerical examples.

4 - **A Study On The Effects Of Information Privacy Concerns And Electricity Usage Habits On The Acceptance Of Advanced Metering Infrastructure**

Do-Hyeon Ryu, Postech, Pohang, Korea, Republic of, Kwang-Jae Kim

Advanced metering infrastructure (AMI) is a system to measure electricity usage in real time. Despite the benefits of AMI, its acceptance is being delayed due to some obstacles. First, the AMI could cause privacy invasion because it collects electricity usage information that may disclose the life pattern of the household. Second, consumers who regularly use a small amount of electricity would not need AMI. This study examines the effects of information privacy concerns and electricity usage habits on the acceptance of AMI using the structural equation modeling technique. The results would be useful for electric power companies to establish strategies for the AMI penetration in households.
In this research we use simulation to examine the performance of several priority scheduling rules in both total utility (value) created and make span for a flow shop where customer balking is allowed in response to shop congestion. In addition to developing two new priority scheduling rules based on marginal cost pricing, we also imbed a random choice utility model into the simulation model to more accurately mirror the customer's decision to use the flow shop or an alternative. We find that the optimal priority scheduling rule depends on the perspective of the decision maker.

2 - An Extended Supporting Hyperplane Algorithm Based On Monte Carlo Simulation For Flow-shop Scheduling Problem In Human-robot Collaboration With Joint Chance Constraints
Duo Wang, Tsinghua University, Beijing, China,

In this paper, we proposed an integrated optimization model combining resource allocation with flow-shop scheduling problem in uncertain environment of human-robot collaboration. We develops an extended supporting hyperplane (ESH) algorithm based on Monte Carlo simulation that provides an exact solution of CVAR reformulation without closed mathematical form and it is proven to be superior under various specific parameters to well-known popular approaches: individual chance constraint programming, Bonferroni approximation and scenario-based approach. The experimental results show that our method has better efficiency, stability and reliability than other mentioned methods.

3 - A Simulation Study On Optimal Production Planning With A Profit Risk Measure
Guangrui Xie, PROS, Houston, TX, United States,

In modern markets, the market prices of products are usually volatile and can pose risks of losing profit on manufacturers’ production plans. We enhanced a traditional profit maximization model for production planning by considering the profit risk caused by product price uncertainty. We introduced a profit risk measure into the objective function through linearized profit variance calculation, hence the model maximizes profit at different risk aversion levels. We then simulated product prices using the Monte Carlo method based on real-world data and evaluated the enhanced profit maximization model. The enhanced model effectively reduced profit risk as compared to the traditional model.

4 - Bidding Mechanisms And Incentive Analysis For Temporally-coupled Electricity Markets
Pengcheng You, Johns Hopkins University, Baltimore, MD, United States, Rajni K Bansal, Dennice Gayme, Enrique Malalda

This work studies competition among heterogeneous participants in temporarily coupled markets. We first characterize the cross-time coupled incentives that each group of participants experience and develop bidding mechanisms that accurately convey preference, without revealing private information. We then characterize the strategic behavior of individual participants and investigate their joint impact on market conditions. Our analysis unveils the opportunities for participants to manipulate prices and exercise market power. Further, we evaluate the inter-group market power shift and identify cases where a particular group of participants has an edge over others in competition. This study highlights the importance of accounting for the interplay among heterogeneous participants and their extra flexibility endowed by market participation across time.

5 - Efficient Active Search For Combinatorial Optimization Problems
Andrew Liu, Associate Professor, Purdue University, West Lafayette, IN, United States, Chen Feng, Zibo Zhao

While distributed energy resources (DERs), such as rooftop solar panels, are key to improve sustainability and resilience, they also present significant challenges to utilize them in a coordinated fashion. Peer-to-peer (P2P) energy trading within a distribution network to match supply (from DERs) and demand is one idea to better utilize DERs, and the trading can be realized via double auctions. Instead, we propose an alternative supply-demand ratio based matching mechanism and discuss its convergence to a mean-field equilibrium with multi-agent.

6 - Global-tep: A New Global Solver For AC Transmission Expansion Planning
Mahdi Mehrtash, University of British Columbia, Vancouver, BC, Canada, Yanikai Cao

In this research, we propose a new global solver, named Global-TEP, for the transmission expansion planning problem with AC network representation (ACTEP), which is a mixed-integer nonlinear programming problem. The proposed solver is based on second-order cone relaxation, enhanced relaxation tightening constraints, and optimization-based/feasibility-based bound tightening techniques. As illustrated by numerical case studies, Global-TEP, which can solve the ACTEP efficiently with a guaranteed optimality gap, is more scalable, more flexible, and much faster than the available global solvers.

3 - Optimal Capacity Payment And Expansion Under Demand-side Risk
Xinyue Song, Johns Hopkins University, Baltimore, MD, 21210, United States, Maxim Bichuch, Benjamin Field Hobbs

The construction of capacity markets is important in maintaining grid stability and market efficiency. We propose a leader-follower game on optimal capacity and subsidy decision in a competitive market. The market faces a load consisting of heterogeneous stochastic individual demand. To promote extra capacity, the system operator grants a payment to energy suppliers for each unit of capacity added, aiming at that the suppliers voluntarily choose a utility-maximizing capacity such that the total outage probability is controlled and total market utility is maximized. We show equilibrium results of this hierarchical game and illustrative numerical examples calibrated to real-world data.

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3 - Scaling Up Exact Neural Network Compression
By ReLU Stability
Thiago Serra, Bucknell University, Lewisburg, PA, 17837-2005, United States, Abhinav Kumar, Srikumar Ramalingam, Srikumar Ramalingam
We can compress a neural network while exactly preserving its underlying functionality with respect to a given input domain if some of its neurons are stable. However, current approaches to determine the stability of neurons in networks trained with Rectified Linear Unit (ReLU) activations require solving or finding a good approximation to multiple discrete optimization problems. In this work, we introduce an algorithm based on solving a single optimization problem to identify all stable neurons. Our approach is on median 21 times faster than the state-of-the-art method, which allows us to explore exact compression on deeper (5 x 100) and wider (2 x 800) networks within minutes. For classifiers trained under an amount of L1 regularization that does not worsen accuracy, we can remove up to 40% of the connections.

4 - Discrete Black-box Optimization Using Mixed Integer Programming
Christian Tjandraatmadja, Google, Cambridge, MA, United States, j98
Theodore P. Papalexopoulos, Ross Anderson, Juan Pablo Vielma, David Belanger
Model-based Black-box Optimization (MBO) maximizes an expensive black-box function by iteratively refining a surrogate regression model, where the next point to query is selected by optimizing an acquisition function based on the surrogate model. This inner acquisition problem may itself be a challenging optimization problem, particularly when the domain is discrete and combinatorially constrained. In practice, Mixed-Integer Linear Programming (MILP) solvers are not only able to efficiently search over such domains, but can also globally optimize piecewise-linear acquisition functions. We propose a general framework for discrete MBO that combines MILP with neural networks as surrogate models. We test our approach on a range of unconstrained and constrained discrete problems, including DNA binding and the NAS-Bench-101 neural architecture search benchmark.

Virtual Room 42
New Product Development
Contributed Session
Chair: Weihan Jia, Trinity College Dublin, Dublin, Ireland, Yufei Huang
1 - AI-assisted Multimodal Evaluation System For Design Assessment
Chenxi Yuan, Northeastern University, Boston, MA, United States, 80309-5002, United States, Law rence M. Ausubel
Design concept evaluation is a key process in new product development with a significant impact on the product’s success. In view of limited and biased concept evaluation caused by subjective judgment of designers, we propose a deep multimodal regression model as a potentially disruptive way to bridge this gap. Specifically, we develop a deep neural network enabling accurate and scalable prediction of overall and the attribute-level performance ratings of design concepts from product images and descriptions. We test and validate the model through experiments on a large footwear dataset with low MSE loss and high accuracy.

2 - Optimal Product Introduction Strategies Under Price Signals Of Quality
Yalan Zhu, Northwestern Polytechnical University, Xi’an, China, Gongqian Liang, Yufei Huang
Product introduction strategies plays an important role when a firm introduces successive generation of product. When the firm introduces a product with unobservable quality, price can act as an effective tool to signal product quality. This paper studies the firm’s decision on product introduction strategy in the presence of strategic consumers considering price signaling product quality. We consider four product introduction strategies: single rollover strategy, skipping, shelving and trade-in program. We find that, in the presence of price signal, single rollover strategy is optimal even though no consumer purchases the old version.

3 - Impact Of Consumer Complaints On Time To Recall: Empirical Investigation Of The Automobile Industry
Weihan Jia, Trinity College Dublin, Dublin, Ireland, Yufei Huang, Jingjie Wei
We obtain a car recall dataset with almost 80 variables and 26 million observations by merging three data files from National Highway Traffic Safety Administration in the USA. To apply a neural network model, we identify 10 defect signals from description of component and measures consumer complaints as the similarity of the occurrences of defect signals between consumer complaints and recall with cosine similarity and Euclidean distance, and then perceives time to recall as both categorical and continuous variable. After that, we investigate the effect of consumer complaints on the manufacturer’s recall timing decision via pooled regression and multinomial logistic regression.

Virtual Room 43
Advances in Auction Design
Sponsored: Auctions and Market Design
Sponsored Session
Chair: Benjamin Lubin, Boston University, Boston, MA, 2215, United States
Co-Chair: Sven Seuken, University of Zurich, Switzerland
1 - Revenue-Incentive Tradeoffs In Dynamic Reserve Pricing
Sebastien Lahaye, Google Research, New York, NY, 06830-5228, United States
Online advertisements are primarily sold via repeated auctions with reserve prices. We study how to set reserves to boost revenue based on the historical bids of strategic buyers, while controlling the impact of such a policy on the incentive compatibility of the repeated auctions. Adopting an incentive compatibility metric which quantifies the incentives to shade bids, we propose a novel class of dynamic reserve pricing policies and provide analytical tradeoffs between their revenue performance and bid-shading incentives. The policies are inspired by the exponential mechanism from the literature on differential privacy, but our study uncovers mechanisms with significantly better revenue-incentive tradeoffs than this mechanism in practice. We empirically evaluate the tradeoffs on synthetic data as well as real ad auction data from a major ad exchange.

2 - VCG, The Core, And Assignment Stages In Auctions
Oleg V. Baranov, University of Colorado-Boulder, Boulder, CO, 80309-5002, United States, Lawrence M. Ausubel
The VCG mechanism is one of the most compelling constructs in mechanism design, but complementarities create the possibility of non-core outcomes. In this article, we develop a theory of complementarities in assignment stages of spectrum auctions. The contingency restriction—the standard rule guaranteeing contiguous spectrum to each bidder—is shown to enable a new type of bidder complementarity, creating a setting with endemic bidder complementarities. When the VCG mechanism is used, non-core outcomes, together with all of the known anomalies, must be expected. We provide an empirical case study of these issues by examining a conspicuous spectrum auction. For the FCC’s Incentive Auction, we find many non-core outcomes, establish a potential for non-core outcomes in the majority of the sample, and provide the first empirical documentation of zero-revenue outcomes.

3 - Fourier Analysis-based Iterative Combinatorial Auctions
Jakob Weisteiner, University of Zurich, Zurich, 8045, Switzerland
Recent advances in Fourier analysis have brought new tools to efficiently learn set functions. We bring the power of Fourier analysis to the design of CAs. The key idea is to approximate bidders’ values using Fourier-sparse set functions, which can be computed via value queries. Since the number of queries is too large for real-world CAs, we propose a new hybrid design: first use NNs to learn bidders’ values and then Fourier transform these learned representations. We formulate a Fourier transform-based WDP and derive its MIP formulation. We then devise an iterative CA that asks Fourier-based queries. We experimentally show that the hybrid CAs improve on the performance of the original CAs, which are used in the FCC’s Incentive Auction.

4 - Electricity Markets In Transition
Peter Cramton, Professor of Economics, University of Cologne, University of Maryland, Cologne, 20816, Germany, Emmanuel Robbio, David Malec, Pacharassit Suja\"i\"tama\"n\"ota
Electricity markets are changing the way electricity is generated and consumed. The transition depends critically on climate policy and market design. We model the markets to evaluate the impact of alternative policies on electricity market outcomes over decades, including costs, profits, social welfare, risks, and reliability. Each year, investors decide which resources enter and exit given forward-looking consistent expectations about energy prices. We model decisions at the unit level based on precisely calculated profits from energy, reserves, and capacity markets. Profits depend critically on the resource structure, which changes each year. New elements of electricity markets, such as battery storage and demand response are fully integrated. The model provides insights into how policies such as carbon pricing impact the transition to renewable energy.
1 - Determining Diagnostic Priorities For Machines In Serial-parallel Multistage Manufacturing Process
Young-Gwan Kim, Pohang University of Science and Technology, Pohang, Korea, Republic of, Seung-Hyun Choi, Ju-Yeong Kim, Dong-Hee Lee, Young-Mok Bae, Young-Chan Oh, Jong-Bum Park, Kwang-Jae Kim
In a serial-parallel multistage manufacturing process (SP-MMPI), each stage has several alternative machines among which one machine is assigned to an individual product. In SP-MMPIs where products are produced in batch units, the products in the same batch tend to move collectively through the same process path (i.e., the same set of machines in several stages). This property makes it difficult to diagnose faulty machines that result in a high defective rate. This study develops a method to derive diagnostic priorities for a set of machines considering the collective movement of products. The proposed method is applied to the semiconductor manufacturing process to demonstrate its effectiveness.

2 - Crisis Of Plastic: Business Implications From Data Analytics
Nesreen El-Rayes, New Jersey Institute of Technology, Newark, NJ, United States, Junmin Shi
The crisis of plastic is an intriguing problem. A global move toward the urgency of taking actions as plastic pollution has imposed a detrimental impact on biodiversity loss, climate change, among other forms. The main contributions of our work are about providing an extensive data-based analysis on the status and implications of plastic pollution using machine learning and visualizations through three lenses of different levels: (1) global-level view, (2) industry-level view in the United States, and (3) consumer-level view based on social media platform data (i.e., Twitter). This study sheds light on the prevailing crisis of plastic with rich insights derived from real-world data for each level.

3 - The Analytics Of A Hybrid Workforce
Edward Tuorinsky, Managing Principal, DTS, Arlington, VA, United States
Missions haven’t changed, but day-to-day operations have. The pandemic is driving a modernization of the government workforce, introducing a truly hybrid platform. In this study, we will draw on our experience with the U.S. Fish and Wildlife Service to make data actionable, and leveraging human data analytics.

2 - Optimization Of Missing Value Imputation For Neural Networks
Jongmin Han, Sungkyunkwan University, Suwon, Korea, Republic of, Seokhoo Kang
For predictive modeling of a neural network with missing values, several imputation methods that have different competences are available. Existing studies have selected a single method or manually combined them. In this study, we propose a method to optimize missing value imputation for a neural network. Using various imputation methods, we obtain different imputations for each instance. The convex combination of the imputations is used as an input of a neural network. The neural network and the weights of the combination are simultaneously trained toward improving the performance. We verified the effectiveness of the proposed method on benchmark datasets with various missing rates.

3 - A Bayesian Methodology For Portfolio Optimization
Chang Yuan Li, UC Santa Barbara, Santa Barbara, CA, United States, Alexander Shkolnik, Lisa R. Goldberg, Jeffrey R. Bohn
Factor analysis of security returns aims to decompose a return covariance matrix into systematic and specific risk components. Traditional statistical approaches like PCA and MLE suffer from drawbacks, including a lack of robustness, strict assumptions on the underlying model, and insensitivity to narrow factors such as industries and currencies. We propose a 2-step convex optimization procedure to decompose a security return covariance into its low rank and sparse parts. The low-rank component includes the broad factors that affect most securities. The sparse component includes narrow factors and security-specific effects. We illustrate with simulated and empirical data examples.

3 - Bayesian Methodology For Portfolio Optimization
Yan Wang, Graduate student, The University of Hong Kong, Hong Kong, Hong Kong, Peng-Chu Chen
We developed a Bayesian method to optimize the portfolio in the stock market. We use the enhanced data set of stock historical return and Markov chain Monte Carlo method to obtain the posterior distribution of the stock average return. We show that if the extended data set size is infinite, the posterior distribution is consistent. We provide the credible interval for the out-of-sample return realized by the portfolio constructed from the posterior average return. In addition, we compared it with the out-of-sample return realized by the portfolio based on the maximum likelihood average return. In most cases, the Bayesian posterior average return outperforms the maximum likelihood average return.

Orur Alintas, Boston University-Questrom School of Business, Boston, MA, United States

With the help of digitization, the sophisticated decision support systems have become more and more popular in many industries. Even though, the stand-alone effectiveness of these systems is well proven, how they are used in a business setting is still a conundrum. With this study, we aim to investigate how individuals make decisions with the presence of these systems in a complex business setting. The results of the study will be presented.

2 - The Data Acquisition Scheduling Problem For A Constellation Of Satellites

Mônica Maria De Marchi, IEAv/DCTA, Sao Jose dos Campos, Brazil, Maria Jose Pinto, Ana Claudia Hayashi

This work addresses the scheduling problem of imagery collection for a constellation of satellites to monitor targets with different priorities for a planning horizon. The mathematical model ensures that target observations would take place within the available observation time-windows as well as the processing time capacities. It also explicitly models the revisit time (the time between successive observations of the same target), the due time and the setup time to adjust the sensor between two consecutive acquisitions with different acquisition modes. The methodology will be demonstrated in a deforestation context wherein targets need to be regularly monitored.

3 - Vancomycin Dosing In Critically Ill Patients: A Machine Learning Approach

Mohammad Samir Tootooni, Assistant Professor, Loyola University Chicago, United States, Erin Barreto, Kianoush Kashani, Kalyan Pasupathy

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

4 - Developing a Novel Exact Model of Zoning Optimization for Marine Spatial Planning

Mohadese Basirati, IMT Atlantique, Lab-STICC, Brest F-29238, France, Brest, France, Patrick Meyer, Romain Billot

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

5 - Priority Queueing On Ride-hailing Platforms

Thomas De Munck, PhD Researcher, UCLouvain, Louvain-la-Neuve, Belgium, Philippe Chevalier, Jean-Sebastien Tancrèz

Several ride-hailing platforms have started experiencing priority mechanisms for riders during peak hours. Given their limited capacity, how to allocate drivers between high-priority and regular riders is not a trivial question. To investigate it, we design a continuous-time Markov decision process. In this model, riders may be rejected or may abandon the queue with respective penalty costs associated. In this setting, we find the optimal admission policy for riders. We also evaluate the implications of this policy for the classes of riders through several performance measures such as the expected waiting time, service level, or the probability of abandonment before getting service.
1 - Is Sharing Really Caring? The Negative Impact of Promoting Online Donation Campaigns On Social Media

Yashar Dehdashti, Texas Wesleyan University, Fort Worth, TX, 76102, United States, Aidin Namin, Brian T. Ratchford, Larry Chonko

Online donation through crowdfunding has become increasing popular in recent years. These campaigns need to raise awareness about their existence. Social media are the perfect vehicle to inform people about the need for help and raise awareness as they can reach a large audience in a short time. However, users might merely like and/or share these campaigns without making a meaningful contribution (e.g., giving money to a donation seeking campaign); known as slacktivism. We investigate the underlying mechanism through which liking and sharing these campaigns on the social media affect their success. Our data come from a major crowdfunding website over a significant period of time. We show that the overall effect of using social media for online donations is negative. Our research has important managerial implications in that using social media should be done more creatively.

2 - Opinion Leader Identification Associated With Covid-19 In Online Social Networks

Behnam Malmir, Virginia Tech, VA, United States

Safety culture is a collection of beliefs, attitudes, and practices that is focused on improving individual and organizational health and safety. Providing interactions between citizens and governments could elevate this improvement. Social media has been known as one of the most valuable tools to this aim and government agencies eagerly have applied social media applications to enhance citizen engagement in managing crises. However, employing opinion leaders (OLs) to improve the effects of social media on people’s safety culture has been neglected in the literature. This paper provides a framework for OLs identification in the era of pandemic situations called ‘Pandemic OL Finder’. The proposed framework comprises three steps of finding potential OLs on the Twitter platform, determining the characteristics of those OLs, and discovering real OLs.

3 - Extracting ESG Indications From 10-K Documents

Varada Krishnaswamy, Virginia Tech, Blacksburg, VA, United States

Extraction of indications from financial statements, such as 10-K documents, is critical in investment decisions. Manually processing these files is time-consuming and labor-intensive. We present text-mining-based methodologies for retrieving knowledge about Environment, Social, and Corporate Governance (ESG) indicators from 10-K documents in this paper. Since these reports include unstructured formats and a large amount of text, it is a struggle to interpret the text accurately. Until searching for text blocks that reflect ESG indications, we present methods for detecting text blocks in unstructured text. We expect to list the retrieved texts according to their logical similarities to the indicators and their quantitative content.

4 - A Cost Reduction Model In A Fuel Distribution Terminal

André R. Cruz, Universidade de Brasília, Brasília, Brazil, Reinaldo Crispiniano Garcia

This work implements a model for the operations of a fuel distribution terminal. The study comprises the loading of tanker trucks, in order to test the impact of different scenarios in the terminal’s performance indicators and costs. The used input data set includes about 11,600 trucks arriving in the terminal in a four month period. The preliminary results show to be possible to obtain about 11.5% of savings when comparing with actual costs.

5 - Simulation-based Optimization For Convex Functions Over Discrete Sets

Eunji Lim, Adelphi University, Garden City, NY, United States

We propose a new iterative algorithm for finding a minimum point of a real-valued function f* with the domain X, when f* is known to be convex, but only noisy observations of f(x) are available at each point x in X. The proposed algorithm not only estimates the minimum point of f*, but also provides the probability of each point in X being a minimum point of f*, using the fact that f* is convex. Numerical results indicate that the proposed algorithm converges to a minimum point of f* as the number of iterations increases and shows fast convergence especially in the early stage of the iterations.

6 - Extracting ESG Indications From 10-K Documents

Varada Krishnaswamy, Virginia Tech, Blacksburg, VA, United States

Extraction of indications from financial statements, such as 10-K documents, is critical in investment decisions. Manually processing these files is time-consuming and labor-intensive. We present text-mining-based methodologies for retrieving knowledge about Environment, Social, and Corporate Governance (ESG) indicators from 10-K documents in this paper. Since these reports include unstructured formats and a large amount of text, it is a struggle to interpret the text accurately. Until searching for text blocks that reflect ESG indications, we present methods for detecting text blocks in unstructured text. We expect to list the retrieved texts according to their logical similarities to the indicators and their quantitative content.
1 - Fair Allocation Of Vaccines, Ventilators And Antiviral Treatments: Leaving No Ethical Value Behind In Healthcare Rationing
Tayfun Sonmez, Boston College, Department of Economics, Chestnut Hill, MA, 02467, United States, Parag Pathak, Utku Unver, Bumin Yener
COVID-19 has revealed limitations of existing mechanisms for rationing medical resources under emergency scenarios. Many argue that these mechanisms abandon various ethical values such as equity by discriminating against disadvantaged communities. Illustrating that these limitations are aggravated by a restrictive choice of mechanism, we formulate pandemic rationing of medical resources as a new application of market design and propose a reserve system as a resolution. We develop a general theory of reserve design, introduce new concepts such as cutoff equilibria and smart reserves, extend analysis of previously-known ones such as sequential reserve matching, relate these concepts to current debates, and present policy impact.

2 - Application Mistakes And Information Frictions In College Admissions
Tomas Larroucau, Arizona State University, Tempe, AZ, United States, Ignacio Rios, Christopher Nilsson
We analyze application mistakes in a centralized college admissions system. We use data from Chile and exploit institutional features to identify a common type of mistake: applying to programs without meeting all requirements (admissibility mistakes). We find that changes in admission requirements increase admissibility mistakes. However, this effect fades out over time, suggesting that students adapt to changes in requirements but not immediately. In addition, we find that between 2% - 4% of students do not list their top-preference program, even though they face a positive admission probability. We use these insights to design a large-scale information policy. We find that showing personalized information about admission probabilities has a causal effect on improving students' outcomes even in seemingly strategy-proof college admissions systems.

3 - Designing School Choice For Diversity In The San Francisco Unified School District
Katherine L. Mentzer, Stanford University, Stanford, CA, 94305, United States, Irene Yuan Lo, Itai Ashlagi, Maxwell Allman
Prompted by a redesign of the San Francisco Unified School District (SFUSD) school choice system, we explore how choice mechanisms affect tradeoffs between choice, diversity, and other school district goals. We used simulations combining zone optimization with choice to propose new assignment policies. We found that zones must be designed with choice, as choice can lead to regeregation of diverse zones. However, well-designed zones combined with minority reserves could attain SFUSD diversity goals, as well as other district objectives such as predictability and proximity. In SFUSD, traditional school choice tools such as priorities can also attain diversity goals and provide choice, at the expense of predictability and proximity. Based on our findings, we recommended a policy of medium zones and reserves that was approved by the SFUSD Board of Education.

2 - Large-scale Zone-based Evacuation Planning: Generating Convergent And Non-preemptive Evacuation Plans Via Column Generation
Jorge A. Huertas, Georgia Institute of Technology, Atlanta, GA, United States, Pascal Van Hentenryck
In zone-based evacuations, the evacuated region is divided into zones, and vehicles follow the single evacuation path assigned to their corresponding zone. Ideally, these evacuation paths converge at intersections to reduce driver hesitation: and non-preemptive schedules ensure that the evacuation of a zone, once it starts, proceeds without interruptions. We present a macroscopic optimization model to produce convergent and non-preemptive evacuation plans. Furthermore, we decompose our model and use a column-generation algorithm to solve it in real large-scale evacuation scenarios. Finally, we use a microscopic traffic simulator to evaluate the quality of the generated plans.

3 - Nurturing Empirical Research in Operations Management: Key Challenges and Future Directions
Nitin Jain, Indian Institute of Management Udaipur, Udaipur, India,
The operations management (OM) discipline is influenced by diverse fields like economics, engineering, operations research, and organizational theory. Despite this interdisciplinary nature and quantitative rigor’s advancement, OM research is still unable to address practitioners’ issue well. The concerns raised in the extant literature emphasize on the need for more empirical advancement in OM area. Hence, this paper investigates how empirical research can complement the traditional analytical techniques. It also identifies critical themes in OM ranging from sustainability to humanitarian operations wherein empirical investigation can add immense value to make OM research holistic.

4 - Air Route Planning To Minimize The Radiation Dose In Aircraft Operating Under Radioactive Plume Scenarios
Maria Jose Pinto, Dr, IEAV/DCTA, Sao Jose dos Campos, Brazil, Claire Lourenco Antonio Federico, Breno Debela Luna, Monica De Marchi
This work aims to provide an optimized safe route for an aircraft on situations of exposure to ionizing radiation by overflight within radioactive or nuclear plumes in the scope of Chemical, Biological, Radiological and Nuclear defense (CBRN defense) missions. The purpose of the developed methodology to solve the problem is to minimize the radiation accumulated dose along the route, aiming at preserving the health of the crews and minimizing vehicle contamination. The methodology is applied through different random instances and to a simulation of the prognosis of the temporal evolution of the radioactive plume, produced using the ARGOS code for a hypothetical nuclear scenario.

Revenue/ Yield Management I
Contributed Session
Chair: Haobo Yu, Hong Kong
1 - Counterfactual Self-Training
Ruijiang Gao, University of Texas at Austin, Austin, TX, United States, Max R. Biggs, Wei Sun
Unlike traditional supervised learning, in many settings only partial feedback is available. Such settings encompass a wide variety of applications including pricing, online marketing and precision medicine. We approach this task as a domain adaptation problem and propose a self-training algorithm which impu tes outcomes with finite discrete values for finite unseen actions in the observational data to simulate a randomized trial. We offer a theoretical motivation for this approach by providing an upper bound on the generalization error defined on a randomized trial under the self-training objective. We empirically demonstrate the effectiveness of the proposed algorithms.

2 - Lift Estimates And Schedule Optimization For Trade Promotion Planning
Sophia Huang, Senior Data Scientist, Vistex, Inc., Chicago, IL, United States, Maarten Oosten
Trade promotions consist of the multi-level promotional activities of a manufacturer. The manufacturer tries to promote its products to the consumers but since the retailers are the intermediate parties that sell and promote the products they must be incentivized to execute the promotions. After all, if the promotion is not attractive for the retailer, there won’t be a promotion. Therefore, the manufacturer should model the behavior of the consumers as well as that of the retailers: In this presentation we discuss the challenges this poses in both the estimation of the promotion effects as well as the optimization of the promotion schedule and propose models that address these challenges.
Online food channel increases the restaurant’s profit, but worsens offline diners’ experience. Given a fixed commission rate, a restaurant prefers small online orders to large ones due to limited cooking capacity and shorter wait time. However, platform’s preference is opposite due to the fixed delivery cost. In practice, restaurants set a minimum consumption and platform better designs the contract to mitigate the conflict. We consider three components of the contract: commission fee, service fee, and membership fee. We find that membership fee and service fee are important to channel coordination while commission rate’s efficiency varies a lot and depends on the offline diners’ heterogeneity.

**3 - Waiving Commissions for Food Delivery Services**

Haobo Yu, University of Hong Kong, Hong Kong, China, Wei Zhang

Online food channel increases the restaurant’s profit, but worsens offline diners’ experience. Given a fixed commission rate, a restaurant prefers small online orders to large ones due to limited cooking capacity and shorter wait time. However, platform’s preference is opposite due to the fixed delivery cost. In practice, restaurants set a minimum consumption and platform better designs the contract to mitigate the conflict. We consider three components of the contract: commission fee, service fee, and membership fee. We find that membership fee and service fee are important to channel coordination while commission rate’s efficiency varies a lot and depends on the offline diners’ heterogeneity.

**4 - Direct-to-consumer Firm’S Competitive Strategy Against A Dominant Retailer: Opening An Experiential Physical Store Vs. Specializing In An Online Store**

Masaonbu Takeda, Keio University, Yokohama, Japan, Nobuo Matsuyabashi

This study investigates strategic interaction between a monopolistic platform and competing manufacturers, where each manufacturer has three options as its product strategy; joining the platform and developing its product by utilizing consumer data shared among the alliance members, employing a direct-to-consumer model and developing its product by utilizing only its own consumer data, and simply selling its existing product. We show that the platform becomes the most beneficial in equilibrium when the manufacturers are moderately differentiated.

**5 - Live Commerce Retailing With Online Influencers: Two Business Models**

Baolong Liu, Assistant Professor, ShanghaiTech University, Shanghai, China, Weilong Wang

Selling during online influencers livestreaming has become prevalent in the retailing sector. For firms, to keep the business sustainably profitable, key decisions to make include whether it is worth collaborating with influencers and how, as well as the corresponding pricing and inventory decisions. Based on industrial practice, we investigate two business models: the Influencer-oriented Short-window (IOSW) model and the Market-oriented Long-window (MOLW) model, to understand how the models benefit a firm and how decision making affects profit sustainability. To this end, we build stochastic optimization models and derive regarding managerial insights.

**6 - Trade Promotions And Their Consequences**

Ming Jin, University of Oregon, Eugene, OR, United States

Using data from a multi-echelon pharmaceutical supply chain, we study the dynamics between pricing, orders, and inventory at each tier. For example, we study how distributors respond to trade promotions (price discounts by the manufacturer). We quantify the financial impact of trade deals and evaluate their effectiveness.

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**VWD57**

Virtual Room 57

**Operations/ Marketing Interface I**

Contributed Session

Chair: Ming Jin, Haobo Yu, University of Hong Kong, Hong Kong, China, Wei Zhang

**1 - The Effect Of The U.S.-China Trade War And The Covid-19 Pandemic On The Effectiveness Of The Promotion Of U.S. Agricultural Exports.**

Misty Blessley, Associate Professor, Temple University, Philadelphia, PA, United States

U.S. agricultural exports have long been vulnerable to changes in weather, politics, and the global economy. Recently, agricultural exports have been hurt by the U.S.-China trade war and the COVID-19 pandemic. The objective of our project is to improve understanding of the factors that lead to U.S. government’s export promotion of specific agricultural product categories, and the effectiveness of the export promotions. Insights are developed through the analysis of multiple years of agricultural export promotions. The findings are expected to provide important contributions to theory, policy and practice.

**2 - Overage Disutility, User Trading And Tariff Design**

Yanzhi Li, City University of Hong Kong, Kowloon Tong, Hong Kong, Weixiang Huang, Youhua Chen

Popular tariffs in the telecommunications market, such as three-part tariffs and flat-rate plans, specify an allowance below which customers enjoy a free and high-quality service. Some network service providers have recently begun to allow data trading among their subscribers, who can now sell their allowances or buy up to meet their needs. We find that allowing trading among users improves system-wide consumption efficiency and reduces overage disutility at the expense of losing overage revenue. Overall, trading can be beneficial to the firm. Moreover, allowing trading always improves social welfare and can also improve consumer surplus.

**3 - Game-theoretic Analysis Of Alliance Between Platforms And Competing Manufacturers In Sharing Consumer Data For Product Developments**

Hiroshi Matsubaisa, Keio University, Yokohama, Japan, Nobuo Matsuyabashi

This study investigates strategic interaction between a monopolistic platform and competing manufacturers, where each manufacturer has three options as its product strategy: joining the platform and developing its product by utilizing consumer data shared among the alliance members, employing a direct-to-consumer model and developing its product by utilizing only its own consumer data, and simply selling its existing product. We show that the platform becomes the most beneficial in equilibrium when the manufacturers are moderately differentiated.

**4 - Direct-to-consumer Firm’S Competitive Strategy Against A Dominant Retailer: Opening An Experiential Physical Store Vs. Specializing In An Online Store**

Masaonbu Takeda, Keio University, Yokohama, Japan, Nobuo Matsuyabashi

This study provides a game-theoretic analysis to investigate whether a firm employing a direct-to-consumer (DTC) business model should open an “experiential” physical store, or specialize in and enhance its online store, in competition with a dominant retailer that owns both physical and online channels. We show that opening its experiential physical store is likely to be more effective for the DTC firm as its competitive strategy.

**5 - Live Commerce Retailing With Online Influencers: Two Business Models**

Baolong Liu, Assistant Professor, ShanghaiTech University, Shanghai, China, Weilong Wang

Selling during online influencers livestreaming has become prevalent in the retailing sector. For firms, to keep the business sustainably profitable, key decisions to make include whether it is worth collaborating with influencers and how, as well as the corresponding pricing and inventory decisions. Based on
5 - Optimizing Vehicle Allocation For First- And Last-mile Connectivity Using An Agent-based Framework
Saumya Bhatnagar, Senior Project Associate, Indian Institute of Science, Bengaluru, India, Tarun Rambla, Gitakrishnan Ramadurai
The first and last mile of a trip are often inconvenient to transit users. This has led to a decline in the ridership of public transit systems in many cities because of competing ride-hailing services or personal travel modes. To address this problem, we propose an agent-based simulation and optimization approach for resource allocation of first- and last-mile vehicles at different stations of a metro network. Performance measures such as fleet utilization and unserved trip requests are analyzed under different policy frameworks such as zonal restrictions and operational strategies involving matching and routing. A case study involving metro and land-use data from Bangalore, India, is presented.

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VWD60
Virtual Room 60
Game Theory II
Contributed Session
Chair: Tal Alon,
1 - Tripartite Evolutionary Game Research On Government-enterprise Collaborative Innovation In Intelligent Manufacturing
Mengshan Zhu, Tongji University, Shanghai, China, Wenyong Zhou, Chunyan Duan
Intelligent manufacturing has become the main trend in the transformation and upgrading of manufacturing industries among countries in the world. This paper constructs a tripartite evolutionary game model of collaborative innovation between the government, manufacturing companies, and Internet companies, analyzes the three parties' strategic choices in the process of collaborative innovation, and reveals the influencing factors through numerical simulation. Results indicate that evolutionary stability strategies are affected by costs, government support, incentives, penalties, and the initial willingness of all parties to participate.

2 - Consumer-to-consumer Fashion Product Exchange In The Sharing Economy: Good Or Bad For Copycats?
Yingjia Wabg, Hong Kong Polytechnic University, Hong Kong
Hong Kong, 19044791@connect.polyu.hk, Yi-Ning Fung, Suyuan Luo
With the development of digital platforms and mediating technologies, consumer-to-consumer product exchange (C2C-PE) has become very popular in the sharing economy for fashion products. Another noticeable challenge in the fashion industry is copycat trading. In this paper, we construct analytical models to explore how C2C-PE affects copycat products. We theoretically find that the presence of C2C-PE benefits the original brand and their consumers, while harms the copycat brand. To check the robustness of the results, we further consider the cases of strategic quality decision and price dependent C2C-PE utility.

3 - Algorithm For Computing Approximate Nash Equilibrium In Continuous Games With Application To Continuous Blotto
Sam Ganzfried, Ganzfried Research, Miami Beach, FL, United States
Successful algorithms have been developed for computing Nash equilibrium in a variety of finite game classes. However, solving continuous games -- in which the pure strategy space is (potentially uncountably) infinite -- is far more challenging. We present a new algorithm for computing Nash equilibrium strategies in continuous games. We experiment with our algorithm on a continuous imperfect-information Blotto game, in which two players distribute resources over multiple battlefields. Blotto games have frequently been used to model national security scenarios. Experiments show that our algorithm is able to quickly compute close approximations of Nash equilibrium strategies for this game.

4 - Optimization And Game Theory For Coordination In Humanitarian Operations: A Systematic Review
Ayasha Faroog, Kansas State University, Manhattan, KS, United States, Jessica Heier Stamm
Optimally utilizing limited resources while activating coordinated response from multiple participants can lead to more effective and efficient humanitarian operations. Although OR/MS applications in humanitarian logistics have grown rapidly, their contribution to facilitating coordination among stakeholders is unclear. We present results from a systematic literature review that explores the potential for game theory and optimization to facilitate vertical or horizontal coordination between multiple actors engaged in humanitarian operations, highlighting trends and opportunities.

5 - Contracts With Private Cost Per Unit-of-effort
Tal Alon, Technion - Israel Institute of Technology, Haifa, Israel, alinbal Talgam-Cohen, Paul D. Dueting
Economic theory distinguishes between principal-agent settings in which the agent has a private type (e.g. private cost per unit-of-effort) and settings in which the agent takes a hidden action. Many practical problems, however, involve aspects of both. A natural goal is to design an IC contract, which consist of an allocation rule that maps types to actions, and a payment rule that maps types to payments. Our main contribution is an LP-duality based characterization of implementable allocation rules, which applies to both discrete and continuous types. We present several applications, including a polynomial-time algorithm for finding the optimal contract with a constant number of actions.

VWD61
Virtual Room 61
Towards the Future of Air Traffic Flow Management
Sponsored: Aviation Applications
Sponsored Session
Chair: Lu Dai, University of California, Berkeley, University of California, Berkeley
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.
1 - Challenges and Rewards in Practical Optimization

Jakob Błaavand, Head of Business Insight and Analytics at the Danish Crown, Oxford, United Kingdom, ja

In real life, data is messy; decisions are made based on multiple opposing metrics, deadlines are tight, users are reluctant to change and managers want results. Tackling all of these challenges, and more, is essential for optimisation solutions to succeed in real life, and when you do the impact can be large. This talk will discuss the key ideas, tasks and activities required for successful optimisation solutions. The talk will be driven by examples from solutions developed and deployed in the energy, pharmaceuticals and telecommunications sectors.

2 - Catching Fraud And Money Laundering With Machine Learning And Optimisation.

Ruben Menke, Banking Circle, Copenhagen, Denmark, rum@bankingcircle.com

Anti money laundering and fraud detection is a significant challenge for the financial industry. To improve the effectiveness of transaction monitoring, machine learning models are deployed to augment the established rule based models. Selecting which payments to forward for manual analysis is a reinforcement learning problem. Methods to optimally select transactions for screening are investigated and compared. It is demonstrated that careful selection is essential to maintain the performance of the machine learning model. Quantifying and optimising the performance of machine learning models in anti money laundering is necessary for approval by regulators.

3 - Deploying A Hybrid MILP Solution For Highly Complex Semiconductor Scheduling Problems

Senya Elaoud, Flexcition Limited, London, United Kingdom, Dionyssios Xenos, Ioannis Konstantelos

Job scheduling in semiconductor factories is an NP-hard problem. It is a non-identical parallel machines job shop problem with secondary resources. Practical applications typically resort to the use of approximate techniques. Many factors render the use of MILP optimisation challenging: problem complexity, high uncertainty, multiple objectives. We present a novel solution strategy that combines MILP optimisation with heuristic techniques to schedule thousands of wafers. Flexcition has been deployed in semiconductor fabs and shown to outperform existing approaches. Using case studies we showcase how we can accommodate complex problem features and provide high quality schedules.

4 - Practical Optimization: What It Takes To Make Optimization Succeed In Real Life

Thomas Flidner, Kearney, Munich, Germany, Sven Flake

A core property of bringing operations research methods into industrial-size projects is a heterogeneous context of business requirements and technical questions, of very abstract and very detailed topics. In this talk, we showcase a customer project and we use this showcase to highlight core steps of applying OR: (1) How to keep track of the customer’s vision during the project; (2) How to identify, isolate, and tackle mathematical questions that customers cannot be aware of; (3) How to bring a project to life step by step while keeping mathematical complexity at bay.

5 - Tools And Processes For Rapid Prototyping Of Optimization Applications

Richard Oberdieck, Gurobi Optimization, Nordlundsvej 27, Hvidovre, 2650, Denmark

Ideally, projects involving optimization start out with the business problem for which a decision strategy is needed. Based on this, a mathematical model is designed, implemented and validated against a set of test data, before it is encoded in an optimization application which solves the business problem. Unfortunately, most projects do not follow this path, for example due to complicated business logic, stakeholder management and data quality issues. Therefore, it is crucial to be able to iterate through each step quickly in order to quickly identify and resolve any blocking issues. In this talk, we will share some of the tools and processes used inside Gurobi that we have found to work well in these situations. In addition, we will provide recommendations to OR experts, developers and project managers on common pitfalls we see and several strategies on how to mitigate them.

6 - Optimization in Renewables: Focus on Hydrogen

Jens Jakob Sørensen, Ørsted, Skærbaek, Denmark

Ørsted is an energy company concentrating on renewables that uses optimization for decision support in several problems. This talk discusses some of the challenges in developing optimization tools and what steps we have taken to overcome them. As an example, a rolling horizon dispatch model is used to assess how to operate green hydrogen plants and estimate their profitability.
In this talk, we will present two randomized Douglas-Rachford (DR) splitting algorithms for a class of composite finite-sum nonconvex optimization problems widely used in machine learning and federated learning. The first algorithm is a randomized coordinate DR splitting scheme, while the second one is its asynchronous variant. We show that both algorithms achieve state-of-the-art iteration-complexity bounds and allow one to inexactly evaluate the underlying proximal operations. We apply our methods to a well-known federated learning model and numerically compare them with other methods on several numerical experiments of both synthetic and real datasets. Our results show some promising performance. This is a joint work with Nhan H. Pham (UNC), Lam M. Nguyen (IBM), and Dzung T. Phan (IBM).

3 - New Tools for Adversarial learning in Games
Jacob Abernethy, Ann Arbor, MI, 48104, United States
The fields of Machine Learning, Game Theory, and Optimization were originally thought to be quite distinct, but in recent years researchers have found a number of surprising and puzzling connections among the algorithmic tools used in each. In this talk we'll explore a number of emerging results on the unusually strong relationships between no-regret learning, Nash equilibrium computation, multi-player game dynamics, and convex and non-convex optimization; we will also lay out a number of open problems that have remained a challenge in these areas.
1 - A General Framework For Optimal Data-driven Optimization
Tobias Sutter, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, Bart Paul Gerard Van Parys, Daniel Kuhn
We advance a novel framework which allows us to study how to transform data into optimal decisions. We characterize the optimal decision as the least conservative decision that guarantees an exponential decay of its corresponding out-of-sample disappointment, where the out-of-sample disappointment quantifies the probability that the actual expected cost of the proposed decision exceeds its predicted cost. By invoking a large deviation principle, we show that the optimal decision can be constructed via a separation into an estimation and a subsequent robust optimization phase. The corresponding robust optimization scheme relies on an ambiguity set that is induced by the large deviation rate function of the estimator used. The presented framework is the first to attempt rating the zoo of ambiguity sets derived in the recent literature in terms of statistical power.

2 - Distributionally Robust Optimization with Markovian Data
Mengmeng Li, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, Tobias Sutter, Daniel Kuhn
We study a stochastic program where the probability distribution of the uncertain problem parameters is unknown and only indirectly observed via finitely many correlated samples generated by an unknown Markov chain with d states. We propose a data-driven distributionally robust optimization model to estimate the problem’s objective function and the corresponding optimal decision. By leveraging results from large deviations theory, we derive statistical guarantees on the quality of this estimator. The distributionally robust optimization problem is a nonconvex program of size $\mathcal{O}(d^2)$. By exploiting the underlying problem structure we propose a customized Frank-Wolfe algorithm to solve it with simple convex oracle subproblems of size $\mathcal{O}(d)$. Numerical experiments show that our approach statistically outperforms existing methods from the literature.

3 - On Large Deviation Principles In Dynamic Decision Problems
Wouter Jongeneel, PhD student, EPFL Lausanne, Switzerland, Wouter Jongeneel, EPFL Lausanne, Switzerland
Just recently, an optimal formulation of data-driven static optimization has been proposed by appealing to the theory of Large Deviations. The approach displays great flexibility and in this talk we will start the discussion regarding to what extent these ideas can be carried over to the dynamic setting.

4 - Optimal Data-driven Decision-making With Any Desired Out-of-sample Guarantees
Mohammed Amine Bennouna, PhD student, Operations Research Center, MIT, Cambridge, MA, United States, Bart Paul Gerard Van Parys
We study the problem of designing optimal approaches for stochastic optimization problems when only data is available. Most prior works construct estimators of the true unknown expectation using data and derive out-of-sample bounds to guarantee the quality of the estimator. We follow a different route. We formalize what are the desirable properties of estimators used for stochastic optimization problems and seek to find the ‘optimal’ estimator verifying these properties. For any desired out-of-sample guarantee, we construct explicitly a Distributionally Robust (DR) estimator that is uniformly closer to the true cost than any other estimator verifying such guarantee, making it optimal. We exhibit three different regimes depending on the strength of the guarantee for which the optimal DR estimator has uncertainty set all probability simplex, KL ball and ellipsoid.

5 - Optimal Transport In The Face Of Noisy Data
Bart Paul Gerard Van Parys, MIT Sloan School of Management, Cambridge, MA, 02139, United States
Optimal transport distances are popular and theoretically well understood in the context of data-driven prediction. A flurry of recent work has popularized these distances for data-driven decision-making as well although their merits in this context are far less well understood. This in contrast to the more classical entropic distances which are known to enjoy optimal statistical properties. This begs the question when, if ever, optimal transport distances enjoy similar statistical guarantees. Optimal transport methods are shown here to enjoy optimal statistical guarantees for decision problems faced with noisy data.