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Managing Information in Traffic Networks

The annual costs of traffic congestion in the United States have recently surpassed $100 billion, which has motivated countless governmental and private entities to invest in technologies that can effectively reduce congestion. New horizon is the use of GPS-based devices to inform drivers about available routes to their destination, with the hope of reducing traveling time (at least for these users). In "Informational Braess' Paradox: The Effect of Information on Traffic Congestion," D. Acemoglu, A. Makhdoumi, A. Malekian, and A. Ozdaglar construct a framework to study traffic networks in which drivers have different information regarding the existence of available roads. They show that blindly expanding the information set of some group of drivers can make them worse off, in the sense of increasing the level of congestion they suffer in equilibrium. They further characterize the network topologies that create such inefficiencies, which in turn establishes guidelines for the design of information-sharing infrastructures in order to avoid these inefficiencies.

A New Tool for Studying Kidney Exchange

A pool of patients paired with incompatible donors form a kidney exchange. Exchanging kidneys among pairs create cycles of donation. Altruistic donors, willing to donate to any patient in need, create chains of donation. Existing research has explored the relative importance of cycles versus chains using asymptotic analysis that applies to large graphs (approaching infinite in size). In "A Nonasymptotic Approach to Analyzing Kidney Exchange Graphs," Y. Ding, D. Ge, S. He, and C. T. Ryan propose an algorithm that can, in contrast, be analyzed by the small- and medium-sized graphs seen in practice. This approach initially assigns chains as a random walk among hard-to-match patients followed by assignment through cycles. This approach is used to quantify the relative importance of chains and cycles nonasymptotically. The numerical performance of the algorithm is also surprisingly robust. The random assignment of chains, as opposed to an optimal assignment, does not myopically erode the structure of the exchange to transplant via cycles.

Risk Sharing via Quantiles: Implications for Value-at-Risk vs. Expected Shortfall

Since the financial crisis, the discussion on the use of internal models for capital adequacy in banking and insurance has intensified. Important aspects of this discussion concern which regulatory risk measure should be used and what relevant properties are to be compared and contrasted. In "Quantile-Based Risk Sharing," P. Embrechts, H. Liu, and R. Wang establish a framework of risk sharing via a two-parameter family of quantile-based risk measures. New tools for nonconvex analysis are obtained, and they lead to novel results on risk sharing and market equilibria that are different from the classical expected utility world. New insights concerning regulatory arbitrage, model uncertainty, robustness, and moral hazard are thereby revealed, and these findings present further compelling evidence for advantages of expected shortfall over value-at-risk.

The Attrition Dynamics of Multilateral War

What is the natural outcome of a multilateral war? In "The Attrition Dynamics of Multilateral War," M. Kress, K. Lin, and N. MacKay set up a many-sided attritional fight using Lanchester's aimed fire model. There is no analogue of the "square law" from the bilateral model, so they use an objective function, which maximizes one's own remaining force and minimizes opponents', at the end of the fight. They then use a mix of linear algebra and simple game theory to show that, unless one force can beat all of the others put together, the inevitable outcome is mutual annihilation. If these dynamics apply in the Syrian civil war, the various opposing factions will continue killing each other endlessly unless external interventions make one side dominant. Russia's intervention, supporting the Assad regime, seems to be that external force.

You Can't Hide: Finding Extremists in Online Social Networks

How can we find extremists in online social networks and prevent them from spreading hateful propaganda and inciting terror attacks? In "Finding Extremists in Online Social Networks," J. Klausen, C. E. Marks, and T. Zaman present a new set of operational capabilities to deal with this threat. They use thousands of Twitter accounts related to the extremist group ISIS (the Islamic State in Iraq and Syria) to develop behavioral models that are used to identify extremist users before they post any content and detect when they create new social media accounts. They combine this model with a variant of the classic Polya's urn setup to develop an algorithm for efficiently monitoring the social network to find extremist users. The method developed is not specific to ISIS and can be applied to many extremist groups that operate social networks.

Crying Wolf About Terrorism

When a government issues a warning about increased risk of a terrorist attack and one does not occur, did the government make a mistake or did the terrorists alter their plans in response? How should a government manage its use of warnings and security efforts when terrorists react strategically to public warnings? Warnings need to be credible to be effective, but the terrorist response to warnings may actually undermine their credibility. This poses a conundrum to governments trying to reduce the damage to society from terrorist attacks. N. Bakshi and E. Pinker address this conundrum

in "Public Warnings in Counterterrorism Operations: Managing the 'Cry-Wolf' Effect When Facing a Strategic Adversary." They demonstrate how the optimal use of warnings by governments can reduce the damage from terrorism yet also lead to many false alarms and reduced credibility to these warnings.

Optimizing Assortments Under the Mixed Multinomial Logit Model

Assortment optimization involves the selection of products that a firm offers to its customers in order to maximize the firm's revenue. One of the most general models that can be used to represent consumer choice in this context is the mixed multinomial logit (MMNL) model. In fact, any model that is based on random utility maximization can be approximated to any desired level of accuracy using the MMNL model. The assortment optimization problem under the MMNL model, however, is NP-hard. In "A Conic Integer Programming Approach to Constrained Assortment Optimization Under the Mixed Multinomial Logit Model," A. Şen, A. Atamtürk, and P. Kaminsky develop a novel conic quadratic mixed-integer programming formulation for this problem. Together with valid inequalities they obtain, this new formulation is significantly stronger than the standard linear formulation and enables the solution of industrial-size instances using standard commercial solvers.

To Succeed with Prefabrication and Modularization: Management of Module Inventory and Order-Delivery Time Quotations

There are many business environments where customers value the contractor's short and reliable order-delivery times, such as online outsourcing of home/building improvement projects, on-demand fleet maintenance, and prefabrication and modularization in the construction industry. In such environments, managing inventory of the prefabricated modules in sync with the contractor's delivery time quotation is critical. In "Inventory Control and Delivery Time Quotation for Assembly Supply Chains," S. Chen and K. Moinzadeh study an assembly system of a contractor and module suppliers facing customers with heterogeneous waiting tolerance, where customers' decisions on whether to wait or leave depend on the delivery quotations. They consider two quotation policies, uniform and adaptive, together with two stocking/replenishment policies, namely, independent S-inventory and modified S-inventory policies. An efficient simulation algorithm for the independent S-policy and a dynamic-programming–based heuristic for the modified S-policy are devised. For decentralized systems, the authors propose an incentive mechanism to coordinate the channel.

Supply Networks and the Amplification of Disruption Risk

Multisourcing is a standard practice for mitigating risk in complex supply networks. Typically, firms do not coordinate their sourcing strategies but optimize their risk profiles in isolation. In "Multisourcing and Miscoordination in Supply Chain Networks," K. Bimpikis, D. Fearing, and A. Tahbaz-Salehi highlight that focusing on optimizing sourcing decisions in each tier in isolation may not be sufficient for mitigating risks at an aggregate level. Instead, they establish that multisourcing may increase the overlap in firms' procurement channels and exacerbate the ripple effects of a disruptive event.

Toward Tractable Assemble-to-Order Inventory Systems via State Aggregation

Assemble-to-order (ATO) production is a popular strategy in many industries where rapid delivery of customized products or multi-item orders is crucial. Optimization of ATO inventory systems is often challenging, however, both analytically and computationally. In "The Benefits of State Aggregation with Extreme-Point Weighting for Assemble-to-Order Systems," E. Nadar, A. Akcay, M. Akan, and A. Scheller-Wolf propose a new state aggregation method for a Markov decision process formulation of a very general ATO system. Their aggregation not only drastically reduces computational burden without sacrificing much accuracy but also facilitates analytical treatment of the problem so that the optimal policy structure can be identified and used to further accelerate computation. Numerical experiments on the original problem indicate that the value iteration algorithm initialized with the aggregate solution converges faster than the standard algorithm.

In Facility Location Duopolies on Graphs, Both Competitors Usually Locate Their Facilities in the Median

Facility location problems study how to best locate facilities, anticipating that consumers will be attracted by the facility that is most convenient to them. Such problems relate to application domains that go beyond physical locations, such as rumor dissemination, seeding in social networks, and product design. In "The Competitive Facility Location Problem in a Duopoly: Advances Beyond Trees," Y. Gur, D. Saban, and N. Stier-Moses consider a two-player facility location game, establishing new connections between spatial competition and centralized optimization for various classes of practical topologies. In structures such as median, quasi-median, and Helly graphs, as well as grids and lattices, they establish that an equilibrium can only be located in a 1-median: a vertex that maximizes consumer surplus in the sense of minimizing the weighted distance to all vertices. For the broad class of strongly chordal graphs, which include trees, interval, and block graphs, they further establish that a solution where both players select a 1-median must be an equilibrium.

Virtual Profit, Cost, and Revenue Efficiency and Euclidean Distances in Data Envelopment Analysis

The ranking of inefficient firms is an important outcome in a productivity analysis based on data envelopment analysis (DEA). The ranking is in the directional distance function approach determined by the choice of direction, which in turn has been made on an ad hoc basis. In "Directional Distance Functions in DEA with Optimal Endogenous Directions," N. Petersen establishes a scientific foundation for the choice of direction in the directional distance function in the sense that the direction that minimizes the Euclidean distance between the firm under evaluation and the efficient frontier is shown to maximize profit efficiency of the firm with virtual prices. Similarly, the direction that minimizes the Euclidean distance between the firm and the associated input (output) possibility set is shown to maximize virtual cost (revenue) efficiency in difference form. It follows that an alignment of the ratio and the directional distance function approach in DEA is established, because the input (output)–oriented ratio approach involves a maximization of virtual cost (revenue) efficiency in ratio form.

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A Simple Solution Method for Adjustable Robust Optimization

Adjustable robust optimization (ARO) is a methodology to help decision makers make robust and resilient decisions that extend well into the future. The solutions obtained by existing methods for ARO models are often suboptimal because the iterative procedure may not converge to optimality or the imposed simple decision rules are incapable of modeling the complexity of the optimal decision rules. In "Adjustable Robust Optimization via Fourier-Motzkin Elimination," J. Zhen, D. den Hertog, and M. Sim provide a systematic solution scheme and establish guaranteed optimality in a finite number of steps. This generic approach is used to enhance the existing methods and characterize the structures of the optimal decision rules for a broad class of ARO models. In addition, this approach integrates well with the existing theory on distributionally robust optimization and allows the decision makers to make a trade-off between the solution quality and computational effort for solving ARO models.

Monotone Contracts in Moral Hazard Problems

Moral hazard, a classical problem in contract theory, studies a principal (she) who hires an agent (he) to undertake a task but can only offer him a function of a noisy outcome of his effort. In "Monotonicity of Optimal Contracts Without the First-Order Approach," R. Ke and C. T. Ryan provide weak conditions that guarantee that there exists an optimal contract that is nondecreasing (monotone) in the outcome, an empirically observed, nearly universal property of contracts in practice. These weak conditions do not guarantee the validity of the first-order approach (FOA) that assumes the agent's problem can be sufficiently described by first-order conditions, which was previously the only known method of analysis for proving monotonicity results. Going beyond the FOA, Ke and Ryan derive necessary optimality conditions using nonstandard penalty function and variational arguments that make additional contributions to the theory of bilevel optimization.

Alleviating the Artificial Scarcity of Spectrum via Sharing

Until recently, spectrum regulatory bodies have always allocated radio spectrum bands exclusively to certain service providers whose users are referred to as licensed users. Such static allocation creates artificial scarcity of spectrum; that is, certain bands of spectrum are almost fully utilized while most of the others are at low utilization. A natural approach to alleviate the issue is to allow opportunistic use of temporarily idle channels by unlicensed users. However, allowing unlicensed users access may cause interference to existing licensed users, which leads to a trade-off between spectrum utilization and service quality. In "Management of a Shared Spectrum Network in Wireless Communications," S. Wu, J. Zhang, and R. Q. Zhang study whether and how to share a spectrum network by characterizing the optimal operational decisions, including the sensing frequency and the length of service sessions assigned to unlicensed users. They find that it is possible to improve spectrum utilization while guaranteeing the very high service level expected by licensed users. Spectrum sharing can potentially be a socially optimal solution to alleviating spectrum scarcity.

When and How to Use Passive Learning Policies

Due to their remarkable simplicity and ease of computation, passive learning policies, which put no emphasis on forced exploration, are commonly used in dynamic learning problems. In their study "On Incomplete Learning and Certainty-Equivalence Control," N. B. Keskin and A. Zeevi show that passive learning policies exhibit an extreme form of asymptotic inaccuracy in both static and boundedly changing environments: the estimates generated under these policies converge to an uninformative fixed point with positive probability. On the other hand, they also show that these policies can have better asymptotic accuracy in unboundedly changing environments. Interestingly, limiting the estimation memory of passive learning policies improves their accuracy in a wide variety of static and changing environments, without relying on forced exploration.

Beyond Heavy-Traffic Regimes: Universal Bounds and Controls for the Single-Server Queue

Brownian approximations provide tractability in the analysis of queues. Their stationary distributions are used as proxies for those of the original queues, and the convergence of suitably scaled primitives and processes provides mathematical support for the use of these Brownian models. From a heuristic viewpoint, however, there is an immediate Brownian analogue of the queueing model that is derived directly from the primitives. For the $M/GI/1+GI$ system, in "Beyond Heavy-Traffic Regimes: Universal Bounds and Controls for the Single-Server Queue," I. Gurvich and J. Huang prove that this direct (limitless approach) works: the Brownian models are universally accurate. The limitless approach maintains the tractability and appeal of the limit approximations while avoiding many of the assumptions that facilitate them.