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A Safer Blood Supply under Prevalence Rate Uncertainty

Blood products are essential components of any healthcare system, and their safety, in terms of being free of transfusion-transmittable infections, is crucial. While the Food and Drug Administration (FDA) in the United States requires all blood donations to be tested for certain infections, it does not dictate which particular tests should be used by blood centers. Multiple FDA-licensed blood screening tests are available for each infection, and screening tests are imperfectly reliable and have different costs. In addition, infection prevalence rates within the donor population are uncertain, both for emerging and established infections. In "Robust Post-donation Blood Screening under Prevalence Rate Uncertainty," H. El-Amine, E. Bish, and D. Bish develop mathematical models for designing a robust testing scheme for donated blood under prevalence rate uncertainty; their case study indicates that the proposed robust testing scheme outperforms current practices and expectation-based testing schemes. This paper is part of a multiyear research project funded by the National Science Foundation, and was a finalist for the 2015 INFORMS Pierskalla Award for the Best Paper in Healthcare.

Engineer-to-Order Protein Manufacturing

In "Performance Guarantees and Optimal Purification Decisions for Engineered Proteins," T. Martagan, A. Krishnamurthy, P. A. Leland, and C. T. Maravelias model and analyze the protein purification operations conducted by contract biomanufacturers. In this setting, each customer order represents an engineer-to-order protein, and is constrained by predetermined yield and purity requirements specific to the end user. However, protein purification operations involve unique trade-offs leading to high risk of failure in achieving these production requirements. To address this challenge, the authors develop a stochastic dynamic program that aims to reduce the production costs and lead times of protein purification operations. Based on the structural analysis, the state space is partitioned into subsets called the "decision zones." These decision zones are used to characterize the performance guarantees and optimal purification policies for engineered proteins. The developed models are validated and implemented at Aldevron, a contract biomanufacturer specializing in protein services.

Optimization, Satisficing, and Perception

An economic, or (perfectly) rational, person needs to have a clear system of preferences and knowledge of the decision environment. This rationality assumption has been widely used in many decision-making process modeling contexts. Due to various reasons, people often make decisions that cannot be justified by the rationality assumption, but bounded rationality. The main two sources of boundedness of rationality may be: (1) satisficing rather than optimizing, and (2) errors in each individual's perception of the decision environment. Satisficing decision makers choose an alternative whose reward is above a certain threshold, called an aspiration level, or close enough to the best possible reward. In the context of path finding in transportation networks, L. Sun, M. Karwan, and C. Kwon in "Generalized Bounded Rationality and Robust Multicommodity Network Design," show that satisficing under accurate perception is equivalent to optimizing under inaccurate perception; hence the two sources may be modeled in a unified framework.

Deterministic Control for an Inventory Problem

Multiperiod inventory problem is typically difficult to solve. To make things worse, accurate estimates of demand distribution are often not available, and this forces firms to make inventory decision using a point estimate of demand (e.g., using average demand). In "Analysis of Deterministic Control and Its Improvements for an Inventory Problem with Multiproduct Batch Differentiation," H.-S. Ahn, S. Jasin, P. Kaminsky, and Y. Wang study the performance of a deterministic control in the context of a joint production and allocation problem in biopharmaceutical industry. They show that although deterministic control can perform poorly, a simple re-optimization of the control significantly improves performance. Still, there is a limit to what re-optimization can do. The authors analyze two sophisticated improvements of deterministic control that utilize more demand distribution information and more decision dynamics. The result is surprising: the lack of accuracy in demand estimation does not justify the lack sophistication in the inventory planning.

Stochastic Linearity for Supply and Demand Functions

Supply chain and operations management is centering on matching uncertain supply and demand. The modeling of supply and demand is often restricted by the requirement of analytical tractability, which limits the applicability of the models and results. In "Supply and Demand Functions in Inventory Models," Q. Feng and G. Shanthikumar develop a new notion of linearity, termed stochastic linearity in mid-point. The authors show that when the supply and demand are stochastically linear in mid-point, the associated decision problems can be easily analyzed using the conventional concave analysis approach. In fact, almost all of the supply and demand functions in the existing studies satisfy this linearity definition, which can be easily verified analytically and empirically. Various applications are presented to

demonstrate the power of this new notion of linearity in modeling and analyzing inventory and supply chain management problems.

Bargaining in Sequential Trades

Bargaining is common in buyer–seller interactions. In most of the business-to-business transactions, deals are reached after rounds of negotiation between the trading parties. In consumer markets, bargaining is also prevalent for large ticket items. Studies on revenue management, however, focuses heavily on sellers' pricing decisions. In "Posted Pricing versus Bargaining in Sequential Selling Process," Q. Feng and G. Shanthikumar explore a seller's choice between bargaining and pricing in sequential selling processes. The authors introduce a new stochastic order, called the scaled pricing order. The monotonicity of potential buyers' valuation distribution in the scaled pricing order determines the seller's decision between posting a price and bargaining. Applications of the scaled pricing order are demonstrated in several contexts of dynamic revenue management.

Online Scheduling with Job Cancellations

In many service systems including healthcare scheduling, make-to-order manufacturing systems and server applications, a finite amount of service capacity must be allocated to a stream of jobs of different priorities arriving randomly over time. Jobs incur costs and may also cancel while waiting for service. In "Multipriority Online Scheduling with Cancellations," X. Wang and V. Truong propose a simple online algorithm for such resource-allocation models. The competitive ratio is 1/2 and is tight in the worst scenario. The authors also provide extensive numerical experiments to show that the proposed online algorithm has robust empirical performance and outperforms common heuristics in most settings.

A New Approach to Optimizing Inventory in Multiproduct Newsvendor Settings under General Customer Choice Behavior

Matching expensive supply to uncertain demand is a central problem facing retailers, manufacturers, and agriculture biotech firms. In "The Multiproduct Newsvendor Problem with Customer Choice," A. Farahat and J. Lee develop a new methodology that firms can use to improve inventory decisions under general, nonparametric, models of customer purchase behavior. These choice models can capture various complex assortment and inventory effects on customer choice as well as other behavioral patterns. The new methodology, called Approximate Similarity Transformation, is rooted in ideas from matrix theory. It yields stocking solutions and profit upper bounds. One specialization results in a decomposition by customer into a sequence of assortment optimization problems, yielding stocking solutions and profit upper bounds that typically outperform existing benchmarks.

Statistical Theory for Aggregate Efficiency

In "Central Limit Theorems for Aggregate Efficiency," L. Simar and V. Zelenyuk develop statistical theory (central limit theorems in particular) for measures of aggregate frontier-type efficiency, which are used in operations research, economics and business for analyzing efficiency of industries, organizations, countries, etc. It first considers the case when the individual true efficiency scores being aggregated are observed and then considers more realistic case when they are unobserved and estimated via DEA or FDH, as is usually done in practice. The developed theory opens a path for more accurate and theoretically better grounded statistical inference (e.g., estimation of confidence intervals and conducting statistical tests) on aggregate efficiency estimates such as industry efficiency, etc.

Structure in Queueing Control Problems

Many interesting queueing and inventory control problems are modeled by multidimensional stochastic dynamic programs. For these problems, researchers have been interested in the following issues. First, whether the structure of the optimal policy can be characterized in an insightful manner and second how the optimal policy changes as the problem input parameters change. For instance, in an inventory rationing problem, one questions whether the optimal allocation policies are determined by simple thresholds and if so, how a change in holding costs or demand/production rates affects the optimal thresholds. In "Effects of system parameters on the optimal cost and policy in a class of multidimensional queueing control problems," S. Vercraene, J.-P. Gayon, and F. Karaesmen propose a methodology to explore such problems in some generality using a few general dynamic programming operators and systematically investigating their properties.

Incorporating Customers' Abandonment Decisions into a Queueing System

The traditional approach to study a queueing system with abandonments assumes that the abandonment time distribution is given exogenously. However, in many service systems, customers behave strategically, giving rise to the endogenous customer behavior. In "An Equilibrium Analysis of a Multiclass Queue with Endogenous Abandonments in Heavy Traffic," B. Ata and X. Peng propose a framework to study a multiclass queueing system with endogenous abandonments using an equilibrium approach. The authors prove that for such systems, there exists a unique equilibrium in which the customers' abandonment time and the virtual waiting time for the various classes are consistent in the two models. They also propose a computational scheme for equilibrium calculation and apply the scheme using data from an Israeli bank call center.

The Performance Impact of Dependence in Single-Server Queues

Queueing applications are often complicated by dependence among interarrival times and service times. Such dependence is common in networks of queues, where arrivals are departures from other queues or superpositions of such complicated processes. These complications make realistic stochastic models intractable. In "Using Robust Queueing to Expose the Impact of Dependence in Single-Server Queues," W. Whitt and W. You address this problem. Building on the 2015 paper, "Robust Queueing Theory," by C. Bandi, D. Bertsimas, and N. Youssef in this journal, Whitt and You develop a new functional robust queueing formulation for the steady-state workload, which represents the dependence through the index of dispersion for work, introduced by K. W. Fendick and W. Whitt (1989). They show that the new robust queue-

ing approximation is exact for the steady-state mean in the M/GI/1 model, is asymptotically correct in both heavy traffic and light traffic, and is effective in simulations of networks of queues.

A New Methodology for the Optimization of Queueing Systems with General Impatience

Existing applications of Markov decision processes fail in addressing the dynamic control questions for queueing models with abandonments. One reason is that the available approaches require uniformization, while in the considered queueing models, the jump rates are generally unbounded functions of actions and states. In "A Uniformization Approach for the Dynamic Control of Queueing Systems with Abandonments," B. Legros, O. Jouini, and G. Koole propose a nonstandard definition for the system states that leads to a natural uniformized system with no rate modification, or state truncation. They explicitly model the waiting of the first customer in line in the system state, instead of the traditional modeling using the number of customers. The proposed method can be also used to solve various queueing optimization problems where the objectives and/or constraints involve the distributions of the performance measures, not only their expected values.

Arriving on Time in Stochastic Road Networks

Routing vehicles in transportation networks is particularly challenging when it is critical for the end users to arrive by a deadline. To provide meaningful directions, one has to assess the travel-time uncertainty associated with any given itinerary, but it is typically difficult to get an accurate description of the uncertainty for lack of data about random fluctuations in traffic congestion (e.g. caused by traffic incidents, variability of travel demand) at the time of planning. In the paper "Robust Adaptive Routing Under Uncertainty," A. Flajolet, S. Blandin, and P. Jaillet develop an efficient solution methodology for computing a history-dependent routing strategy, as opposed to an a priori path, minimizing a risk function of the lateness under distributional ambiguity, when the arc travel times are only known through confidence intervals on some statistics (e.g. mean, absolute mean deviation, and quantiles).

An Information-Directed Method for Exploration in Online Optimization

In "Learning to Optimize via Information-Directed Sampling," D. Russo and B. Van Roy propose a new approach to online optimization problems in which a decision-maker must balance between exploration and exploitation while learning from partial feedback. Each action is sampled in a manner that minimizes the ratio between squared expected single-period regret and a measure of information gain: the mutual information between the optimal action and the next observation. They establish an expected regret bound for information-directed sampling that applies across a very general class of models and scales with the entropy of the optimal action distribution. Simple analytic examples illustrate how information-directed sampling accounts for kinds of information that alternative approaches do not adequately address and that this can lead to dramatic performance gains. For the widely studied Bernoulli, Gaussian, and linear bandit problems, the paper demonstrates state-of-the-art simulation performance.

Experimental Designs with a Guaranty of Quality

The Maximin Latin Hypercube Designs (Maximin LHDs) play an important role in computer simulations. They are used to sample complex systems, where experiments are costly, in order to build models. Their space-filling and noncollapsing properties (due to the Maximin and Latin constraints) ensure good accuracy of models produced. The complexity of the Maximin LHD construction problem is undetermined. The only techniques of Maximin LHD generation used until now were heuristic algorithms (with certain rare exceptions) on the results of which a performance bound cannot be given. In "The First Approximation Algorithm for the Maximin Latin Hypercube Design Problem," J. Tomasik, A. Rimmel, M.-A. Weisser, and K. Le Guiban propose a polynomial-time algorithm which produces Maximin LHDs with guaranteed quality. The approximation ratio of the separation distance maximum is computed thanks to the upper bounds the authors discovered. The experiments conducted identify a wide family of Maximin LHDs for which their algorithm outperforms Simulated Annealing.

Flocking for Distributed Stochastic Optimization

In recent years, the paradigm of cloud computing has emerged as an architecture for computing that makes use of distributed (networked) computing resources. In "A Flocking-Based Approach for Distributed Stochastic Optimization," S. Pu and A. Garcia consider a bio-inspired distributed computing scheme for stochastic optimization which relies on modest communication requirements among processors and most importantly, does not require synchronization. Specifically, they analyze a scheme with $N > 1$ independent threads implementing each a stochastic gradient algorithm. The threads are coupled via a perturbation of the gradient (with attractive and repulsive forces) in a similar manner to mathematical models of flocking, swarming and other group formations found in nature. In the presence of overhead caused by synchronization, the flocking-like implementation has shown to outperform a centralized stochastic gradient algorithm based upon the average of N gradient samples at each step.

Modeling Production with Several Component Processes

Traditional nonparametric methods of efficiency and productivity analysis implicitly assume that firms and other organisations employ a single production process, in which all types of inputs and resources are simultaneously used to produce all outputs. In practice, however, there are many situations in which organisations are involved in several different production processes. In "Nonparametric Production Technologies with Multiple Component Processes," V. V. Podinovski. O. B. Olesen, and C. S. Sarrico develop a new model of production technology with several component processes characterized by both process-specific and shared inputs and outputs. They derive their model formally, from a set of stated production axioms that are flexible enough to include a variety of possible assumptions about the production process. The authors demonstrate that the new model outperforms conventional nonparametric models, by considering an application involving secondary schools with several programs of study, and also by using simulated data.