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Editorial

Guest editorial to the featured cluster “Advances in stochastic optimization”

Stochastic optimization involves mathematical methods for making effective decisions in the presence of different forms of uncertainty. Its importance is demonstrated by the ever-growing number of applications, spanning energy, health, transportation and logistics, business analytics, finance, education, agriculture, public sector analytics, supply chain management, and the internet. Additional applications arise in laboratory settings to help with drug discovery or materials science, design of computer simulations, field experimentation and implementation, covering strategic, tactical and real-time problems.

The application settings are so broad that multiple disciplines have evolved to respond to different problem characteristics and research questions. Fields have developed with names such as stochastic programming, dynamic programming (including Markov decision processes, approximate/adaptive dynamic programming, and reinforcement learning), stochastic control, stochastic search, robust optimization, online computation, and stochastic equilibrium. Just as important are fields that evolved around learning unknown functions, including global optimization, ranking and selection, and the multi-armed bandit problem. Increasingly important are careful modeling of stochastic processes, the close relationship between stochastic optimization and machine learning, and creating bridges to the field of uncertainty quantification.

The aim of this Featured Cluster of the European Journal of Operational Research is to collect papers spanning the different flavors of stochastic optimization, so that different communities can learn from each other.

The submission process was organized in two phases: in the first (optional) phase the authors had the possibility to submit an extended abstract, while the second phase was dedicated to full paper submission. About one hundred different abstract/papers were submitted. The reviewing process involved leading experts in various fields of Stochastic Optimization, and resulted in a set of eighteen high-quality papers, which covers many areas of Stochastic Optimization.

It is difficult to classify the papers included in the featured cluster given the variety of topics and methodologies presented, ranging from challenging application areas to new concepts in modeling and solution approaches. From the point of view of the application areas considered, we can roughly distinguish four groups of papers.

A first group of three papers addresses applications in the energy sector.

The paper by Szabo et al. proposes a new market framework in which the owner of an electricity storage facility is able to sell options in an optimal way and to trade on electricity markets in order to add flexibility for the system operator at different times of the day. Using a stochastic model, the authors calculate the real value of the optimal trading strategy for the storage operator together with the balancing cost of this resource and compare it with a target cost for the system operator. The paper by Fleten et al. estimates the costs associated with mothballing, restarting, abandoning and maintaining peaking power plants. The authors propose a real options model to explain switching and maintenance behavior of plant managers. They incorporate non-parametric dynamics for the expectations of the plant managers regarding future profitability in their constrained optimization approach to estimate crucial costs.

The article by Laur et al. considers a market context wherein a proactive energy distribution company is willing to purchase reserve capacity for overload management, using a two-part tariff. The authors model the problem as a three-stage stochastic market including Day-Ahead, Intra-Day and Real-Time, with uncertainty on both demand and generation. Authors address the impact of risk-aversion at each stage adopting an objective based on conditional value at risk and show that, under different operative conditions, risk-aversion close to Real-Time becomes the main driver for decision makers, and that early hedging strategies can lead to sub-optimal solutions.

A second group of seven papers addresses problems in investment management and finance.

The article by Topaloglou et al. proposes a study on scenario-based stochastic programming models for hedging the risks of international portfolios using options. The models consider different levels of integration in managing market and foreign exchange risks, starting with single-stage cases and extending the investigation to multi-stage settings. Zhu et al. investigate strategic decision making on dividend distribution policies of insurance companies and adopt a realistic way for discounting based on some recent developments in behavioral economics, i.e., stochastic quasi-hyperbolic discounting. A game theoretic approach using subgame perfect Markov equilibrium strategies is used to determine economic equilibrium results. Ling et al. proposes a robust multi-period portfolio selection model based on downside risk with asymmetrically distributed uncertainty set, in which the downside losses of a portfolio are controlled by the lower partial

moment (LPM). The paper illustrates a computationally tractable approximation approach based on second-order cone optimization used for solving the proposed model. The study by Wong et al. formulates the deposit insurance valuation problem as a zero-sum optimal stopping game using Israeli options with bankruptcy cost. Specifically, it frames the closure of a bank as a game between the insured bank and the deposit insurer, in which a bank with financial difficulties is choosing an optimal self-closure point to maximize its benefits from the deposit insurance scheme; and the deposit insurer is choosing an optimal regulatory closure point minimizing their cost of offering the insurance. Ekblom and Blomvall propose an approach to construct an analytical approximation of the zero-variance importance sampling distribution. They show how this can be designed for the classic intertemporal portfolio choice problem with proportional transaction costs and constant relative risk aversion preferences. Oliveira and Perkowski investigate the problem of making managerial decisions for subsidized investment projects, which turns in an infinite-horizon optimal stopping problem of a switching diffusion driven by either a homogeneous or an inhomogeneous continuous-time Markov chain. The paper characterizes the value function and the optimal strategy of the optimal stopping problem. The paper by Maier et al. introduces an approach for valuing portfolios of interdependent real options under both exogenous and endogenous sources of uncertainty. In particular, a study on a large portfolio of options (i.e., deferment, staging, mothballing, abandonment) under conditions of four underlying uncertainties is reported. Authors propose both modeling and algorithmic approaches showing their applicability by valuing an urban infrastructure investment.

A third group of four papers refer to routing and optimal path problems.

The paper by Guillot and Stauffer offers a new framework for the stochastic shortest path problem in finite state and action spaces generalizing some previous approaches. Authors investigate conditions under which the problem is well-defined and (weakly) polynomial. These conditions generalize the standard assumptions for the deterministic shortest path problem. In this new setting, authors study different policies illustrating their properties. The article by Manseur et al. proposes an adaptive algorithm for optimal and robust guidance for the users of the road networks. This algorithm is based on the Stochastic On Time Arrival (SOTA) family of routing algorithms, which is appropriate for taking into account the variability of travel times through the networks. It takes into account both the reliability of itinerary travel times and the itinerary robustness. Florio et al. present a model for the single-vehicle routing problem with stochastic demands (SVRPSD) with optimal restocking. The model is derived from a characterization of the SVRPSD as a Markov decision process (MDP) controlled by a certain class of policies, and is valid for general discrete demand probability distributions. An algorithmic approach is proposed and computationally tested showing its effectiveness in different scenarios. The paper by Ulmer and Thomas considers the capacitated customer acceptance problem with stochastic requests (CAPSR), a problem in which a company seeks to maximize expected revenue by accepting or rejecting requests. Each accepted request generates revenue while consuming resources. To solve the problem, authors introduce and computationally test a novel method of value function approximation (VFA), the meso-parametric value function approximation (M-VFA).

A last group of papers deal with other applications, such as personnel scheduling problems, risk measures, software testing optimization, and inventory and queuing in production contexts.

The paper by Legrain et al. deals with a multistage personalized nurse scheduling problem under uncertainty. At each stage, the proposed algorithm considers the staffing demand and nurses preferences for the current period and finds a schedule for all nurses without knowledge of future inputs. To obtain a feasible and near-optimal schedule at the end of the horizon authors propose an approach which combines an online optimization method and the sample average approximation.

Cao et al. offer a study on the joint selection of test cases and release problem for a software under test with predetermined classes of test cases and release time deadline. The software test manager can adopt different alternative choices dynamically during software testing progress before the deadline, with the objective of minimizing the cumulative testing cost plus penalty cost after releasing or scrapping the software. Authors formulate the problem as a continuous time stochastic control model and study its mathematical properties showing conditions for which the optimal release policy has a threshold structure. The article by Pichler and Schlotter extends and generalizes the Entropic Value-at-Risk by involving Rényi entropies. Authors provide explicit relations among different entropic risk measures, then elaborate their dual representations and present their relations explicitly. The paper by Hanukov et al. investigates on the performance improvement of a service system via stocking perishable preliminary services. The typical fast food service system can be conceptualized as a queueing system of customers combined with an inventory of perishable products. A potentially effective means of improving the efficiency of such systems consists in applying time management policies and inventory management techniques simultaneously. This paper proposes such an approach, based on a combined queueing and inventory model, in which each customer's service comprises two independent stages.

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