IMS DISTINGUISHED VISITOR LECTURE SERIES

Nonconvex stochastic programs: deterministic constraints

Jong-Shi Pang

14 December 2022 (Wednesday), 9.30–10.15am, GMT +8 (Singapore Time)

Since its early days, the field of stochastic programming has benefitted from the advances of convex programming, particularly large-scale linear programming. A major drawback of this approach is that for ease of computations and analysis, the models are of the convex kind and are formulated at the expense of simplifications but lacking generality and faithfulness to their source applications. A simple case in point is the classical two-stage linear stochastic program with recourse where the first-stage decision variable appears linearly only in the constraints of the second-stage linear program, resulting in the recourse function being convex and piecewise quadratic. Starting with the linearly bi-parameterized two-stage stochastic program with recourse, the speaker and his co-authors have begun a rigorous study of nonconvex (and typically nondifferentiable) stochastic programs of various kinds that arise from diverse sources. Illustrated with motivating applications, this general talk presents some selected results of our research published in several papers addressing problems in this exciting domain of modern optimization, where the combination of uncertainty, nonconvexity, and nondifferentiability constitutes the key analytical and computational challenges, in addition to the common issue of sampling of the randomness. As the first part of this vast topic, the presentation is restricted to the case where the constraints are deterministic and the randomness occurs only in the objective function of the optimization problem. Models, theory, and algorithms are sketchily covered that together are the central elements of a new chapter of stochastic optimization where the surface has barely been scratched.

The bulk of the presented materials is drawn from joint work with Drs. Ying Cui (University of Minnesota), Junyi Liu (Tsinghua University), and Suvrajeet Sen (University of Southern California).

Nonconvex stochastic programs: chance constraints

Jong-Shi Pang

14 December 2022 (Wednesday), 10.45–11.30am, GMT +8 (Singapore Time)

Chance-constrained programs (CCPs) constitute a difficult class of stochastic programs (SPs) due to its possible nondifferentiability and nonconvexity even with simple linear random functionals. Existing approaches for solving the CCPs mainly deal with convex random functionals within the probability function. This work considers two generalizations of the class of chance constraints commonly studied in the literature; one generalization involves probabilities of disjunctive nonconvex functional events and the other generalization involves mixed-signed affine combinations of the resulting probabilities; together, we coin the term affine chance constraint (ACC) system for these generalized chance constraints. The treatment of such an ACC system involves the fusion of several individually known ideas: (a) parameterized upper and lower approximations of the indicator function in the expectation formulation of probability; (b) external (i.e., fixed) versus internal (i.e., sequential) sampling-based approximation of the expectation operator; (c) constraint penalization as relaxations of feasibility; and (d) convexification of nonconvexity and nondifferentiability via surrogation. These ideas lead to several algorithmic strategies with various degrees of practicality and computational efforts for the nonconvex ACC-SP. In an external sampling scheme, a given sample batch (presumably large) is applied to a penalty formulation of a fixed-accuracy approximation of the chance constraints of the problem via their expectation formulation. This results in a sample average approximation scheme, whose almost-sure convergence under a directional derivative condition to a Clarke stationary solution of the expectation constrained-SP as the sample sizes tend to infinity is established. In contrast, sequential sampling, along with surrogation leads to a sequential convex programming based algorithm whose asymptotic convergence for fixed- and diminishing-accuracy approximations of the indicator function can be established under prescribed increments of the sample sizes.

This work is joint with Drs. Ying Cui (University of Minnesota) and Junyi Liu (Tsinghua University).

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Elected a member of the National Academy of Engineering in 2021, Professor Jong-Shi Pang is currently the Epstein Family Chair and Professor of Industrial and Systems Engineering at the University of Southern California. He was the Caterpillar Professor and Head of the Department of Industrial and Enterprise Systems Engineering at the University of Illinois at Urbana-Champagne from 2007 to 2013. Prior to that, he was the Margaret B. Darrin Professor of Applied Mathematics at Rennselaer Polytechnic University from 2003 to 2007. Professor Pang received the John von Neumann Theory Prize (2019) and the Frederick W. Lanchester Prize (1994) both awarded by the Institute for Operations Research and Management Science (INFORMS), and the George B. Dantzig Prize (2013) awarded jointly by the Society of Industrial and Applied Mathematics (SIAM) and the Mathematical Optimization Society. Professor Pang is a member of the inaugural class (2009) of Fellows of SIAM and elected a Fellow of INFORMS in 2019. His research interests include the mathematical modeling and analysis of optimization problems, game-theoretic problems, and, equilibrium programs and their many applications in diverse disciplines.

The talks are part of the program on
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Program webpage
https://tinyurl.com/OptimizationNov2022

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https://tinyurl.com/IMSOptimizeReg

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