Report on Jakub Kůdela's doctoral dissertation entitled

"Advanced Decomposition Methods in Stochastic Convex Optimization"

Reviewer: Csaba I. Fábián, John von Neumann University, Kecskemét, Hungary

The dissertation consists of five chapters. Chapter 1 is an introduction to stochastic programming (SP) problems and solution methods. After raising general modelling questions, special features of two-stage problems and chance constraints are discussed. The chapter is concluded by an overview of decomposition methods.

Chapter 2 is based on the paper Kůdela and Popela (2017), referred to as [57] in the dissertation. The Authors formulate two-stage SP problems with nonlinear convex objective and constraint functions, and adapt Geoffrion's Generalized Benders Decomposition to these. I find the construction interesting. Moreover, the generation of a special cut is also proposed in the paper, the inclusion of a bound on the objective value. The bound is based on the expected value problem. – The expected value solution is traditionally used as a starting solution for two-stage problems, but the objective cut is a new idea. – Scenario bunching and multicut techniques are also extended to nonlinear convex setting. All the mentioned methods and techniques are compared in a computational study. The new objective cut conclusively and significantly improves performance. Other findings are in line with the experience observed in the linear case.

Chapter 3 is based on the paper Kůdela, Šomplák, Nevrlý, Lipovský (2018), [60]. It discusses a decision problem concerning waste management infrastructure in the Czech Republic. The problem was formulated in a two-stage setting. The strategic question was, where to construct waste transfer stations and of what capacities. The infrastructure must be used in a volatile environment of undecided EU support that was modelled by random processing costs. The operational question was, how many waste should be transferred on the different edges of the grid. The problem was solved with real-life data and a thorough computational study was conducted. I highly appreciate that beyond averages, histograms are also presented.

Chapter 4 contains results that have not been published yet. I find them most interesting, agreeing with the Candidate's remark in the preface. The results are based on the randomized approach of Campi and associates, referred to as scenario design in the dissertation. The chapter begins with an introduction derived from the paper Campi and Garatti (2011), [21].

The Pool & Discard Algorithm proposed by the Candidate is a way of solving the scenario design problems. The pooling part, as described in section 4.3.1, is an extension of the cutting plane method, using convex nonlinear cuts instead of linear ones. The linearized modification of the pooling procedure, described in section 4.3.3, is actually a cutting plane method. – This observation does not decrease the merit of the Candidate. Quite the contrary, I view it as a preliminary justification of the pooling procedure, because cutting plane methods perform well in practice. – The discarding part is an adaptation of the greedy constraint removal procedure of Pagnoncelli, Reich, Campi (2012), [88].

The Candidate implemented the procedure and performed a thorough and systematic computational study. Experiments with a linear test problem convincingly demonstrate the efficiency of the Pool & Discard Algorithm, and the usability of the sampling-and-discarding approach in general. A comparison with the Bernstein approximation is also presented, with additional justification of the Pool & Discard Algorithm. Test results with a nonlinear test problem compare favorably with results reported in the literature.

Chapter 5 discusses a beam design problem, formulated as a convex problem with probabilistic constraints. It is based on the paper Kůdela and Popela (2018), [58]. The problem is to design a beam of minimal weight that can hold a specified load. This is an optimization problem with constraints derived from ordinary differential equations. Using finite element approximation and ingenious transformations, the problem was formulated with two variables and a single nonlinear constraint that is convex. This formulation allowed the Authors to introduce a new variable, characterizing the quality of the beam material. More importantly, the load was allowed to be random, and the resulting stochastic problem was formulated with two chance constraints. To solve this problem, the Authors applied the approach presented in the previous chapter. The size and the structure of the problem allowed a detailed presentation of the trade-off between reliability and optimality.

The dissertation contains interesting and original results and demonstrates up-to-date knowledge of the Candidate in a wide range of areas. Moreover, he has a knack for explaining difficult topics in a simple way. The described procedures have been implemented and thoroughly tested. The results reported in the computational studies are very interesting and instructive in my opinion. The implemented software tools have been successfully applied in the solution of real-life problems in the areas of waste management and shape optimization.

Summing up my opinion on the dissertation, the Candidate has a thorough theoretical knowledge and possesses a capacity to apply it to real-life problems.

Concerning publications, the Scopus database references 18 papers of the Candidate, and reports 29 citations to them. Most importantly, he co-authored 4 freshly published papers in the topic of waste management planning. All these appeared in academic journals of good standing, some of them in leading journals.

I've been acquainted with Jakub's works for years as he presented or co-authored talks I attended at different conferences. Last time we met at the VOCAL conference at Esztergom, where he was co-author of 3 talks on waste management, controller design, and the solution of quadratic assignment problems.

I think his high-quality research and development activities completely justify the awarding of the doctoral degree to Jakub Kůdela. My recommendation is strongly positive.

Budapest, 1 September 2019

Csaba I. Fábián

Questions to the Candidate

Chapter 2.
The bunching technique is often implemented to work with conditional expected value problems. It means that the parameter realizations ξ_k belonging to the bunch B_l are accumulated in their barycenter $\underline{\xi}_l$ and subproblem (2.5.1) is solved with substituting the same $\underline{\xi}_l$ for each ξ_k $(k \in B_l)$. Please discuss this option in the present setting.

Chapter 4.
The discarding part of the Pool & Discard Algorithm yields a greedy approximation of the optimal constraint removal algorithm. As I understand, it is a heuristic approach. It performed excellently in the computational study. Though in case of larger problems with unknown optima, we may need a statistical estimate of near-optimality. Could you propose such estimate?