Combining decomposition methods for multi-stage stochastic optimization problems with SDDP-like algorithm

Scientific training period proposal

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1 Organism, supervision and material conditions

Organism

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Supervision and material conditions

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Number of students: 1

Material conditions: a financial gratification is offered

Dates: to be discussed

2 Proposal

Research domain

Mathematics, stochastic optimization, computer science, energy.

Context

The internship deals with the optimization of dynamical systems in a stochastic setting, that is, in the realm of Stochastic Optimal Control (SOC) problems in discrete time. The standard way to numerically solve such problems is the celebrated Dynamic Programming method, due to Richard Bellman. The main difficulty of the method is the so-called curse of dimensionality: the computational burden exponentially increases with the number of state variables of the dynamical system. Several ways to circumvent this difficulty have been proposed. Among them, decomposition and approximation methods such as Stochastic Dual Dynamic Programming, Progressive Hedging, Dual Approximate Dynamic Programming appear to be effective on large classes of problems.

Subject

The *Dual Approximate Dynamic Programming* (DADP) algorithm [1, 2, 3] allows to solve, by relaxation, a stochastic optimization problem by spatial decomposition in subproblems. In the numerical implementations performed till now, each subproblem is solved by Dynamic Programming, by discretizing the state space. Now, the *Stochastic Dual Dynamic Programming* (SDDP) algorithm [4, 5] is a possible alternative to solve the subproblems, under assumptions of linearity for the dynamics and of convexity for the costs.

Expected work

The proposals on decomposition-coordination methods in optimization allow for both theoretical and numerical developments, according to the student orientation. The dynamic management of hydropower dams and of spatially distributed energy reserves stand as natural applications.

The work will first consist in absorbing the principles of DADP and SDDP. The student will then have to propose how to integrate SDDP within DADP, and to study the theoretical and numerical consequences of this integration.

References

[1] K. Barty, P. Carpentier and P. Girardeau. Decomposition of large-scale stochastic optimal control problems. *RAIRO Recherche opérationnelle, 44(3), 167-183, 2010.*

[2] P. Girardeau. Résolution de grands problèmes en optimisation stochastique dynamique et synthèse de lois de commande. *PhD dissertation, École des Ponts ParisTech, Université Paris-Est, France, 2010.*

[3] V. Leclère. Contributions to Decomposition Methods in Stochastic Optimization. *PhD dissertation, École des Ponts ParisTech, Université Paris-Est, France, 2014.*

[4] A. Shapiro. Analysis of stochastic dual dynamic programming method. *European Journal of Operational Research*, 209:63–72, 2011.

[5] Alexander Shapiro, Wajdi Tekaya, Joari Paulo da Costa, and Murilo Pereira Soares. Risk neutral and risk averse Stochastic Dual Dynamic Programming method. *European J. Operational Research*, 224:375–391, 2013.