Extending decomposition-coordination methods to stochastic optimization under risk

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.

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

There are three classes of decomposition-coordination methods in optimization: decomposition by prices, decomposition by quantities, decomposition by prediction. The direct application of price decomposition to a risk-neutral stochastic problem raises measurability issues that render subproblems impossible to solve numerically. The DADP (*Dual Approximate Dynamic Programming*) algorithm [1, 4, 5] proposes a coordination by prices that are an approximation of a stochastic multiplier process, solving a relaxed version of the original problem. Can we extend price decomposition and relaxation outside the risk-neutral setting? Which risk measures are compatible with decomposition[2]? If so, what is the risk structure that subproblems inherit?

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 the price decomposition-coordination method in the deterministic framework, then understanding how DADP works and its interpretations. The student will then have to propose how to adapt the DADP approach outside the risk-neutral setting [3].

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] M. De Lara and V. Leclère. Building up time-consistency for risk measures and dynamic optimization. *European Journal of Operations Research*, 249(1):177–187, 2016.

[3] H. Föllmer and A. Schied. *Stochastic Finance. An Introduction in Discrete Time.* Walter de Gruyter, Berlin, 2002.

[4] 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.*

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