Extending decomposition-coordination methods — by prices, by quantities and by prediction — to multi-stage stochastic optimization

Scientific training period proposal

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1 Organism, supervision and material conditions

Organism

Name: CERMICS, École des Ponts ParisTech

Address: 6 and 8 avenue Blaise Pascal, Cité Descartes, 77455 Marne la Vallée Cedex 2

Name: UMA, ENSTA ParisTech

Address: 828, boulevard des Maréchaux, 91762 Palaiseau Cedex

Supervision and material conditions

Address:
CERMICS, École des Ponts ParisTech,
6 et 8 avenue Blaise Pascal, Cité Descartes, 77455 Marne la Vallée Cedex 2

Supervisors:
Jean-Philippe CHANCELIER (CERMICS, jpc@cermics.enpc.fr, 01 64 15 36 38)
Pierre CARPENTIER (UMA, pierre.carpentier@ensta-paristech.fr, 01 81 87 21 10)
Michel DE LARA (CERMICS, delara@cermics.enpc.fr, 01 64 15 36 21)
Vincent LECLÈRE (CERMICS, leclerev@cermics.enpc.fr)

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. However, a direct application of decomposition to a stochastic problem raises measurability issues that render subproblems impossible to solve numerically. The DADP (*Dual Approximate Dynamic Programming*) algorithm [1, 2, 3] proposes a coordination by prices that are an approximation of a stochastic multiplier process, solving a relaxed version of the original problem. Is such approximation approach possible with other decomposition methods? If so, what would be the interpretation?

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 the three classes of decomposition-coordination methods 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 to other decomposition methods.

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.*