Introduction to Stochastic Optimization. Application to Energy Management
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Link: `https://cermics.enpc.fr/~delara/TEACHING/Curso_GUANE_2021/`

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1 Program

1.1 Introduction to Stochastic Optimization

The course starts with basics in stochastic optimization.

- 1h30 — One-stage stochastic programming
- break
- 1h30 — Introduction to risk measures for stochastic optimization

1.2 Stochastic Multistage Optimization

When the problem incorporates several time steps, the stochastic programming approach proposes to build a scenario tree of uncertainties, and to attach one control per node, hence leading to an equivalent deterministic formulation. We present alternative equivalent deterministic formulations.

- 1h30 — Stochastic programming: from one-stage to two-stage (and multistage) problems
- break
- 1h00 — Francis Sourd y Ariel Waserhole (Sun'R Smart Energy)
  Manejo óptimo de una estación de transferencia de energía por bombeo y gestión del riesgo de mercado

1.3 Scenario Decomposition: L-Shaped method, Progressive Hedging Algorithm

When a stochastic optimization is formulated on a large number of scenarios, decomposition techniques can be used in order to solve a collection of subproblems each formulated on a single scenario.

- 1h15 — Progressive Hedging algorithm
- break
- 1h15 — L-Shaped method
- Practical computer session *Two Stage Stochastic Optimization for Fixing Energy Reserves*

1.4 Stochastic Optimal Control and Dynamic Programming

The stochastic optimal control approach looks at the problem from a Markovian point of view, where uncertainties are stagewise independent. We present a generic way of solving this problem by Dynamic Programming.

- Tristan Rigaut (École des Ponts ParisTech e Instituto Efficacity)
  Optimización de energía y control de clima en una micro-red de estación de metro.
- 0h:30 — Management of reservoirs
- 1h00 — Stochastic optimal control. Dynamic Programming approach

- break
- 1h30 — Exercises
- Practical computer session
- Practical computer session
- Practical computer session
- Adrien Le Franc (École des Ponts ParisTech and Efficacity)
  "EMSx: an Energy Management System numerical benchmark"
- Adrien Le Franc (École des Ponts ParisTech and Efficacity)
  "Day-ahead decision making in electricity markets"

1.5 Stochastic Dual Dynamic Programming (SDDP)

In the framework of dynamic programming, the SDDP (Stochastic Dual Dynamic Programming) method allows to push forward the limits of the curse of dimensionality. Taking advantage of linearity and convexity, SDDP builds (lower) approximations of the Bellman value functions in an iterative way.

- 1h30 — Stochastic Dual Dynamic Programming algorithm

1.6 Decomposition Methods

Multistage stochastic optimization problems are, by essence, complex because their solutions are indexed both by stages (time) and by uncertainties (scenarios). Quite often, solutions are also indexed by decision units, like nodes in a graph (space), or agents in a team. Hence, their large scale nature makes decomposition methods appealing. We present, in an unified framework, three main approaches and methods to decompose multistage stochastic optimization problems for numerical resolution: time decomposition (and state-based resolution methods, like Stochastic Dynamic Programming, in Stochastic Optimal Control); scenario decomposition (like Progressive Hedging in Stochastic Programming); spatial decomposition (price or resource decompositions).

- 0h45 — François Pacaud (École des Ponts ParisTech and Efficacity)
  Mixing Dynamic Programming and Spatial Decomposition Methods for the Management of Urban Micro-Grids
- 1h00 — General overview of decomposition methods
- break
- 0h45 — Tristan Rigaut (École des Ponts ParisTech and Efficacity)
  Renewal and operation of a battery: mixing time blocks and price/resource decompositions methods

We will explore different decomposition schemes allowing to split a stochastic optimal control problem — involving a large number of units — so as to obtain several small-scale subproblems. These methods allow to solve the subproblems by Dynamic Programming or SDDP.

- 1h30 — Mixing decomposition techniques and Dynamic Programming

- break
- 1h30 — Dual Approximate Dynamic Programming and related methods
- Practical computer session

References

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[RW91] R.T. Rockafellar and R. J-B. Wets. Scenarios and policy aggregation in optimization under uncertainty. *Mathematics of operations research*, 16(1):119–147, 1991.

[SDR09] A. Shapiro, D. Dentcheva, and A. Ruszczynski. *Lectures on stochastic programming: modeling and theory*. The society for industrial and applied mathematics and the mathematical programming society, Philadelphia, USA, 2009.