CIRM Interface course on *Data, Uncertainty and Optimization*

Données, incertitudes et optimisation

November 28 to 30, 2017

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Abstract

Data is abundant: energy demand, transport and mobility demand, environmental indicators, meteorological conditions are a few examples where data is available. How can decision-makers incorporate such data when they have to address investment strategies (network extension, new technologies)? How can engineers manage operations — transport network control, smart grid regulation — taking advantage of the available information? How can risk be handled? These are the type of questions addressed in the CIRM Interface course *Data, Uncertainty and Optimization* (`http://conferences.cirm-math.fr/interfacesession1.html`).

The CIRM Interface course will be hosted by the *Centre International de Rencontres Mathḿatiques* (CIRM `http://www.cirm-math.fr/`) at Marseille (South of France) from November 28 to 30, 2017.

The 3-day school alternates courses, case studies and computer sessions. It is aimed at an industrial audience, but can interest academics. The academic organizers are ENSTA ParisTech and École des Ponts ParisTech. The CIRM Interface course is part of the *CIRM Interface Program* (`http://www.fr-cirm-math.fr/booking-interface-program.html`) and part of the SESO series of events on *Smart Energy and Stochastic Optimization* (`http://cermics.enpc.fr/~delara/SESO/SESO/`).

Keywords: scenario trees, stochastic optimization, risk

Link: `http://cermics.enpc.fr/~delara/SESO/courseSESO2017/courseSESO2017/`

Contents

1 Organizing committee, speakers and participants

1.1 Organizing committee

The organizing committee is made of the following French researchers

- Pierre Carpentier (ENSTA ParisTech)
  `http://uma.ensta-paristech.fr/~pcarpent`
- Jean-Philippe Chancelier (ENPC ParisTech)
  `http://cermics.enpc.fr/~jpc/`
- Michel De Lara (ENPC ParisTech)
  `http://cermics.enpc.fr/~delara/`
- Vincent Leclère (ENPC ParisTech)
  `http://cermics.enpc.fr/~leclerev/`

1.2 Scientific committee

- R. Tyrrell Rockafellar (University of Washington, Seattle, USA)
  `http://www.math.washington.edu/~rtr/mypage.html`
- Alexander Shapiro (Georgia Tech, USA)
  `http://www2.isye.gatech.edu/~ashapiro/`
- Roger Wets (UC Davis, USA)
  `https://www.math.ucdavis.edu/~rjbw/mypage/Home.html`

1.3 Speakers

In addition to the lectures and computer sessions provided by the French researchers above, we invite the following international speaker to give lectures

- David Woodruff (UC Davis, USA)
  `http://gsm.ucdavis.edu/faculty/david-woodruff`

2 Course Program

2.1 / Tuesday 28 November (8h-12h). Two-Stage Stochastic Programming. Risk

Opening (8h00-8h15)

Roundtable: presentation of the lecturers and of the participants.

Lecture (8h15-10h00). Michel De Lara

In a deterministic optimization problem, the values of all parameters are supposed known. What happens when this is no longer the case? And when some values are revealed during the stages of decision? We present stochastic optimization as a frame to formulate decision problems under uncertainty. After the analysis of two toy problems, we present two-stage stochastic programming (and the resolution on scenario tree or by scenarios).

An alternative approach to stochastic optimization, for problems with uncertain data, is robust optimization. Where stochastic optimization relies on the knowledge of a probability distribution for the uncertainties, robust optimization only requires to be given an uncertainty set. Stochastic ambiguity lies in-between stochastic and robust optimization: there is more than one probability distribution that possibly drives the uncertainties, and the decision-maker forms expectations before taking the worst case with respect the family of probabilities. More generally, risk measures offer mathematical ways of expressing a large spectrum of risk attitudes. In two-stage stochastic programming, we show how risk can be handled thanks to the Tail Value-at-Risk metrics.

Break (10h00-10h30)

Computer session (10h30-11h45). Pierre Carpentier, Jean-Philippe Chancelier, Michel De Lara, Vincent Leclère

Introduction to the scientific software Scicoslab

The newsvendor problem

Questions and answers session (11h45-12h00)

2.2 / Tuesday 28 November (14h-18h). Examples of Industry Case Studies

Presentation of case studies (14h00-15h30). Pierre Carpentier, Jean-Philippe Chancelier, Michel De Lara, Vincent Leclère

We present three case studies making use of stochastic optimization.

- Work done by Francis Sourd and Ariel Waserhole (Sun'R)
  "Renewable Energy Aggregator: How to Handle Market Risk"

- Work done by Tristan Rigaut (Efficacity and Cermics—École des Ponts ParisTech)
  "Optimization for Energy Efficiency and Climate Control of a Subway Station Microgrid"

- Work done by François Pacaud (Efficacity and Cermics—École des Ponts ParisTech)
  "Optimal Control of a Domestic Microgrid with Battery and Renewable Energy"

Break (15h30-16h00)

Questions and answers session (16h00-18h00)

The industry participants will present problems that they currently address. The teaching staff will analyze and discuss possible methods to tackle such practical issues.

2.3 / Wednesday 29 November (8h-12h). Scenario Generation and Progressive Hedging (Lecture)

Lecture (8h00-10h00). David Woodruff

Stochastic programming seeks good decisions to be implemented "now" by taking into account uncertainty about future data as well as the possibility for decisions that are made in a few time stages in the future. This requires a model of the decision process as well as a characterization of the uncertainty concerning future data, which we do using scenarios. Scenarios can be defined as a set of data for the optimization problem, where each member of the set is a full specification of the data with an attached probability. For multi-stage problems, these data are typically organized into a tree. When planning and scheduling power systems, there are usually forecasts available that can be used to inform the scenario creation process. We will describe methods that we have developed that use historic data about forecasts along with observed data to create high quality scenarios.

Break (10h00-10h30)

Lecture (10h30-11h45). David Woodruff

Once one has the scenarios, Stochastic programming proposes to build a scenario tree of uncertainties, and to attach one decision variable per node, hence leading to an equivalent deterministic formulation. However, the size of the resulting problem can be overwhelming. We advocate a method of solving the problem using methods that are in a family known as Progressive Hedging. The problem is decomposed by scenario and iteratively solved so that only one decision vector corresponds to "now."

Questions and answers session (11h45-12h00)

2.4 / Wednesday 29 November (14h-18h). Scenario Generation and Progressive Hedging (Computer Session)

Computer session (14h00-18h00). Teaching staff

We have open-source software that enables experimentation with this method. We will propose a computer session on the unit commitment problem in energy.

2.5 / Thursday 30 November (8h-12h). Multi-Stage Stochastic Dynamic Programming

Lecture (8h00-10h00).

When moving from two-stage stochastic programs to multi-stage, the scenario tree grows exponentially and so does the size of the optimization problem. By contrast, the optimal control approach looks at the problem from a Markovian view where uncertainties are stagewise independent, making it possible to compress past information in a reduced state. This opens the way for the dynamic programming resolution method that we present. We illustrate the approach on stock management problems.

Break (10h00-10h30)

Computer session (10h30-11h45). Pierre Carpentier, Jean-Philippe Chancelier, Michel De Lara, Vincent Leclère

Code the dynamic programming algorithm.

A Numerical Toy Stochastic Control Problem Solved by Dynamic Programming

Questions and answers session (11h45-12h00)

2.6 / Thursday 30 November (14h-18h). Workshop on Industry Case Studies

Questions and answers session (14h00-16h30)

The industry participants will present problems that they currently address. The teaching staff will analyze and discuss possible methods to tackle such practical issues.

Break (16h30-17h00)

Assessment session (17h00-18h00)

The participants will assess the course and give feedback.