



Fondation mathématique
FMJH
Jacques Hadamard



J. Hadamard

The Gaspard Monge Program for Optimisation and operational research

Opening Conference
September 18th, 2012

Grégoire Allaire
Sandrine Charousset

Agenda



- ▶ **FMJH and PGMO : organisation, main research topics**
- ▶ **Results of the call for projects**
- ▶ **Working groups and seminars**
- ▶ **Next call for projects**

What is PGMO ?



A joint initiative of EDF and the Jacques Hadamard Mathematical Foundation (FMJH)

◆ A new kind of research partnership :

- ➔ Based on corporate patronage
- ➔ For optimization and operations research
- ➔ Involving academic and industrial researchers

◆ Main objectives :

- ➔ Develop a research community
- ➔ Stimulate joint research projects
- ➔ Support and improve education in optimization
- ➔ Promote job opportunities for students in this field



Bringing together the mathematicians of the Saclay campus in order to form a top research community in pure and applied mathematics and their interfaces with sciences.

Members :

- ➔ **Founding members** : Math departments of the ENS-Cachan (CMLA), Université Paris-Sud (LMO), École Polytechnique (CMAP and CMLS), IHÉS , CNRS
- ➔ **Partners** : UVSQ, ENSTA ParisTech, Télécom ParisTech, CEA (IPhT), INRIA, EDF ...
- ➔ The FMJH is hosted by the Fondation de Coopération Scientifique of the Paris-Saclay campus.



Main objectives :

- Become a worldwide recognized center on the campus, highly visible and competitive for the best graduate students and mathematicians
- Promote openness and exchanges between mathematics and other disciplines and between mathematics and the economic world
- Promote a shared scientific policy, with a reactive governance,
- Develop joint research and training actions
- Contribute to break the frontiers between University, Grandes Écoles and companies
- Develop job opportunities for young mathematicians in companies
- Enhance the mathematical background of engineers
- ...

Organization of PGMO



PGMO is a program of the FMJH

■ A general optimization program (PRMO)

➤ Optimization education

- ★ Scholarships
- ★ Support for optimization classes
- ★ Promote industrial opportunities

➤ Academic research projects

➤ Seminars, workshops, conferences...

■ Optimisation and Energy Research Initiative (IROE)

- Focused on industrial applications in the field of energy
- Created at the instigation of EDF

PRMO and IROE projects



- Projects are open to any academic researchers in France and abroad
- IROE projects involve EDF and academic researchers
- Due to the non-profit character of EDF patronage, all results of PGMO projects are made freely available to the community
- Other industrial partners are welcome to join in sponsoring new dedicated initiatives
- PGMO is not yet another funding agency ! Collaboration and networking is strongly encouraged
- Projects can be of various sizes

Organization of PGMO



Gaspard Monge Program for Optimization and operations research

Coordinator : Grégoire Allaire

« Mathematical Research
on Optimisation » (PRMO)

Education
Research projects
Seminars and Conferences

Research Initiative « Optimization
and Energy » (IROE)

Managing Officer : Sandrine Charousset

Joint research projects

Other Future
Research Initiatives

Master classes,
training,
scholarships

Seminars,
conferences, Web
site

Academic research projects,
publications, Joint applied research
projects, Optimization algorithms and
open software, ...

Governance



Steering Committee

- ★ Florian de Vuyst (ENS Cachan)
- ★ Stéphane Gaubert (INRIA)
- ★ Yves Laszlo (FMJH, Paris-Sud)
- ★ Eric Lunéville (ENSTA)
- ★ Bertrand Maury (Paris-Sud)

Executive Board

- ★ Grégoire Allaire (Coordinator of PGMO, Ecole Polytechnique)
- ★ Frédéric Bonnans (INRIA, Ecole Polytechnique)
- ★ Pierre Carpentier (ENSTA)
- ★ Sandrine Charousset (In charge of IROE, EDF R&D)
- ★ Michel Minoux (UPMC)

Scientific Council

- ★ Alexandre d'Aspremont (Ecole Polytechnique)
- ★ Marie-Christine Costa (ENSTA)
- ★ Michel de Lara (Ponts)
- ★ Laurent Dumas (UVSQ)
- ★ Leo Liberti (Ecole Polytechnique)
- ★ Patrice Perny (UPMC)
- ★ Filippo Santambrogio (Paris-Sud)
- ★ Roberto Wolfler Calvo (Paris-Nord)
- ★ FMJH Scientific Council representative

The first call for projects



Topics

- + Research Projects (Optimisation)
- + Teaching projects

Two kinds of projects

A : trainees, material, trips, ...

- Open to all academic teams (international jointly with a french team)

B : PHD, post-doc, invited researchers

- In Saclay laboratories

Criteria for elected projects

- Scientific quality at the highest international level
- Cooperation and networking between different teams
- Projects organising seminars and workshops in Saclay,
- Projects with young researchers,
- Applications to industry

Results of the 2012 call for projects



26 projects submitted, 21 accepted

► On PRMO :

- ◆ 1 project about teaching
- ◆ 2 research network projects
- ◆ 5 research projects

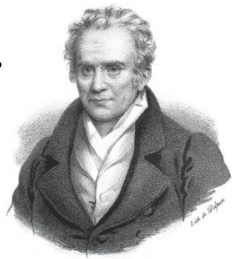
► On IROE

- ◆ 2 project about Unit-Commitment
- ◆ 3 projects dealing with optimisation under uncertainties
- ◆ 3 projects about optimising hydro-valleys
- ◆ 2 projects about scheduling of outages for thermal plants
- ◆ 1 project about economic equilibriums
- ◆ 1 project about asset-liability management
- ◆ 1 project about the design of nuclear cores



PRMO Projects

Web portal and electronic courses for the teaching of stochastic optimization



► **Team :** *P. Carpentier (ENSTA) , JP Chancellier, M. De Lara (CERMICS)*

► **Main features**

◆ **Context:**

- Realizing electronic courses

◆ **Objectives :**

- Broadcast stochastic optimization
- Learn to master the new technologies of communication

Latin America Stochastic Optimization Network (LASON)



► **Team :** *B. Kulnig Pagnoncelli, T. Homem-de-Mello, (Universidad Adolfo Ibáñez), F. Bonnans, L. Pfeiffer (CMAP and INRIA), , P. Carpentier (ENSTA), J-P. Chancelier, M.De Lara, V. Leclère (CERMICS)*

► Main features

- ◆ **Context:** Stochastic optimization is, by nature, at the crossroads between disciplines. LASON is an effort to bring Chilean and French researchers in the field to join forces and try to solve challenging problems in the area
- ◆ **Objectives :** Cover a large spectrum of methods to handle various applications of optimization especially relevant for both countries: hydroelectricity, smart grids, forestry management...
 - study how risk measures can be included in those models
 - propose algorithms to efficiently solve the resulting problems.

MAORI --Mathematics of Optimization for Imaging



► **Team :** *S. Anthoine (LATP Marseille), J-Fr. Aujol (Univ Bordeaux 1), A. Chambolle (CMAP), C. Chaux, (CNRS, Univ Paris-Est), E. Chouzenoux (Univ Paris-Est), Ph. Ciuciu (CEA), L. Condat (CNRS ENSICAen), J.Fadili (ENSICAen), A. Fraysse, M. Kowalski (Univ Paris-Sud), A. Gramfort (Telecom ParisTech/INRIA Saclay), M. Nikolova (CNRS, ENS Cachan), G. Peyré (CNRS, Univ Paris-Dauphine) N.Papadakis (CNRS), N. Pustelnik (CNRS, ENS Lyon), P. Weiss(INSA Toulouse)*

► Main features

◆ Objectives :

- build a group of researchers motivated by the study of optimization algorithms and their application to imaging and signal processing

Colourful Linear Programming: geometric, combinatorial, and algorithmic aspects



► **Team :** *A. Deza (McMaster University), F. Meunier, P. Sarrabezolles (Ecole des Ponts et Chaussées)*

► **Main features**

- **Context :** A theorem of Barany (1982) states that, given $d+1$ sets of $d+1$ points in dimension d , there exists a d -simplex, generated by one point of each set, containing the origin in its convex hull. This generalization of Carathéodory's theorem gives rise to the Colourful Linear Programming.

◆ **Objectives :**

- Study the theoretical and practical questions related to the Colourful Linear Programming.

Hybrid Approaches Combining Metaheuristics and Methods of Mathematical Analysis for Discrete Trace Ratio Optimization Problem



► **Team :** *F. Glover, M. Guignard, Y. Saad, S. Hanafi, I. Crévits, C. Wilbaut, M. Vasquez (LAMIH), N. Mladenovic, M. Bellalij, F. Baghery, I. Massa-Turpin (Université Valenciennes)*

► **Main features**

◆ **Context:**

- a Hard Problem, involved in many dimensionality reduction algorithms, which integrates the knowledge from statistics and computer science.

◆ **Objectives :**

- Work on hybrid approaches mixing numerical linear algebra techniques with metaheuristics

Graph partitioning under capacity constraints



► **Team :** *M. MINOUX, V. Hung NGUYEN (LIP6), P. BONAMI, (CNRS)*

► **Main features**

- **Objectives :** Study a variant of the graph partitioning problem where the weight of a cluster depends on the edges incident to its nodes.
 - 0/1 non convex quadratic models for the problem
 - different techniques to convexify or linearize them
- **Applications :** network optimization, micro-electronic, embedded systems, large-scale system

Semi-algebraic approaches to doubly sparse problems



- ▶ **Team :** *J. Bolte (Univ. Paul Sabatier), N. Vayatis, E Richard, PS Savalle, (CMLA Cachan), V Perchet, (Univ Paris Diderot)*
- ▶ **Main features**
 - **Context:** The problem of estimating a doubly sparse vector or matrix arises in several fields of applied mathematics (including machine learning and statistics). The underlying structure of doubly sparse problems involves real polynomial functions while natural penalization / relaxation / Lagrangean techniques are also based on real polynomial or real analytic objects. As a consequence, corresponding minimization problems are either real semialgebraic problems or subanalytic problems.
 - **Objectives :** Exploiting qualitatively and quantitatively these facts in order to design and study efficient algorithms
 - **Applications :** analysis of large (social) networks, complex biological networks and collaborative filtering.

Tropical Methods in Optimization



► **Team :** X. Allamigeon, M. Akian, S. Gaubert, P. Benchimol (INRIA), R.D. Katz (CONICET, Universidad Nacional de Rosario, Argentine), Zheng Qu (Uni de Fudan, Chine)

► Main features

- Objectives : develop new classes of methods in optimization and game theory, using recent advances in combinatorics and tropical geometry.
 - Algorithmic game theory
 - Curse of dimensionality free methods in dynamic programming



IROE Projects

Consistent Dual Signals and Optimal Primal Solutions



► **Team :** *A. Frangioni*, (Univ Pise), *C. Lemaréchal*, *J. Malick*, (INRIA), *W. Oliveira*, *C Sagastizabal*, (IMPA), *W. van Ackooij*, *G. Doukopoulos*, *N. Oudjane*, *G. Petrou*, (EDF)

► Main features

- Application : Unit Commitment
- Context: current approach is based on Lagrangian decomposition : a first dual phase for finding marginal prices and a second primal phase for finding generation schedules.
- Objective :
 - Primal Heuristics during the Dual Phase: exit the Dual Phase with a primal feasible solution;
 - Improve the Primal Phase to produce a better dual signal;
 - Improve the Bundle methods (*inexact or disaggregate models, specialized models for some components, modifications to the stabilizing term such as using piecewise-linear functions or proximal levels, ...*) used in Primal and Dual Phases.

<http://www.fondation-hadamard.fr/PGMO>

Learning Constraints for Reducing Combinatorics



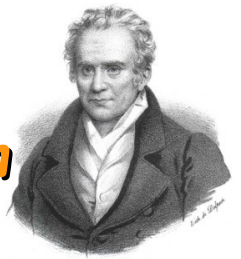
- ▶ **Team :** *N. Beldiceanu (Mines de Nantes), H. Simonis (Cork, Ireland), A. Lenoir, JY. Lucas (EDF)*
- ▶ **Main features**
 - **Application :** Unit Commitment
 - **Objectives :** Learn hidden constraints from past production planning reports of nuclear plants
 - using and adapting the constraints and model seekers
 - extracting structured constraints on selected sub-parts of the production planning.

Stochastic Optimization for Unit-Commitment problems



- ▶ **Team :** *R. Henrion (Weierstrass Berlin), M. Minoux (LIP6), W. van Ackooij (EDF)*
- ▶ **Main features**
 - ◆ **Application :** robust unit-commitment
 - ◆ **Objectives :**
 - Robust and Chance Constrained formulations of unit commitment problems,
 - Decomposition techniques
 - Efficient ways to integrate various laws of uncertainty.

A Stochastic Programming Approach to Finding Robust Reference Schedules for the Unit Commitment problem



► **Team :** T. Schulze, A. Grothey, *K. McKinnon*, (Univ. Edinburgh), *T. Triboulet, N. Oudjane* (EDF)

► **Main features**

- **Application :** Unit Commitment
- **Objectives :** Explore the use of stochastic unit commitment models to generate robust commitments which are flexible with respect to intra-day schedule updates :
 - Apply decomposition techniques which exploit the underlying structure.
 - Investigate the qualitative differences between deterministic and stochastic solutions

Robust optimal sizing of an hybrid energy stand-alone system



► **Team :** *A. BILLIONNET (ENSIIE/Cedric) , M.Ch. COSTA, P.L. POIRION (ENSTA/Cedric), E. SOUTIF (CNAM/Cedric), D. Defossez (EDF)*

► **Main features**

- **Context :** Determine the optimal number of photovoltaic panels, wind turbines and batteries while minimizing the total cost of investment and use. The stochastic behavior of both solar and wind energy and of the demand needs to search for a robust solution.
- **Objectives :**
 - determine good models and methods
 - generalize the results to other problems

Optimality for tough combinatorial Hydro-valleys problems



- ▶ **Team :** C. D'Ambrosio (CNRS, Ecole Polytechnique), F. Roupin, (Univ. Paris XIII), C. Gentile (IASI, CNR, Italia), G. Doukopoulos, T. Simovic (EDF)
- ▶ **Main features**
 - ◆ **Application :** Hydro-valleys optimisation
 - ◆ **Context:** When continuous, this problem can be solved by any LP solver. Introducing combinatorial elements leads to tough problems.
 - ◆ **Objectives :** solve the problem for large hydro-valleys, in short calculation time through
 - Modeling and reformulations,
 - Heuristics

Hydro-electric scheduling under uncertainty



- ▶ **Team :** *A. Philpott (Electric Power Optimization Center, University of Auckland, New Zealand), F. Bonnans (CMAP – INRIA), A. Dallagi (EDF)*
- ▶ **Main features**
 - ◆ **Application :** optimizing weekly schedules for hydro-electric valleys, with uncertainty in demand, prices and inflows.
 - ◆ **Objectives :** model the problem as a multi-stage stochastic mixed integer program and develop new techniques for solving it based around decomposition.

Decomposition/coordination methods in stochastic optimal control



- ▶ **Team :** *P. Carpentier (ENSTA), M. De Lara, J-Ph. Chancelier, V. Leclère (CERMICS), K. Barty, S. Charousset, A. Dallagi (EDF)*
- ▶ **Main features**
 - ◆ **Application :** hydro-valleys
 - ◆ **Objectives :**
 - ➔ Mix decomposition/coordination and dynamic programming for stochastic dynamical optimization problems.
 - ➔ A first step consists in investigating problems with a special structure: "flower model", "cascade model".

Stochastic Nuclear Outage problems with chance constraints



► **Team :** *A. Lisser, C. Giquel, J. Cheng (Uni. Paris Sud), R. Zorgati, M. Porcheron (EDF)*

► **Main features**

- ◆ **Application :** planning outages for nuclear power plants
- ◆ **Context :** stochastic combinatorial problem with joint chance constraints
- ◆ **Objectives :**
 - Compare individual and joint chance constraints with normally distributed random variables
 - Use SOCP approximations for the relaxed problem.
 - Extend to the combinatorial case using either Branch and Bound framework or efficient heuristics to come up with feasible solutions.
 - Apply to simplified models proposed by EDF on real world data.

Optimization of the scheduling of the Nuclear Power Plant stops



- ▶ **Team :** *R. Wolfer-Calvo, A. Rozenknop Antoine, (Paris XIII), V. Jost, D. Savourey, (CNRS, LIX), F. Vanderbeck, N. Dupin Nicolas, (Bordeaux 1, INRIA), P. Bendotti, M. Porcheron (EDF)*
- ▶ **Main features**
 - **Application :** scheduling maintenance and refueling stops of Nuclear Power Plants over an horizon of five years.
 - **Context:** The Nuclear Power Plant must stop at least once a year, but the scheduling must guarantee energy demand satisfaction at minimum cost. Taking into account the stochastic variation (either on the demand or on the capacity) is very important.
 - **Objective :** look for the best way of modeling this problem and use the experience and the expertise of the work done during the Challenge ROADEF 2010 competition for solving the problem.

Nash equilibria for the valuation of offers in the management of daily production : the point of view of the producer



► **Team :** *D. Aussel* (Univ. Perpignan), *Miroslav Písteck* (Académie des Sciences Tchèque, Prague), *P. Bendotti* (EDF)

► **Main features**

- ◆ **Application :** daily production of electricity
- ◆ **Context:** When continuous, this problem can be solved by any LP solver. Introducing combinatorial elements leads to tough problems.
- ◆ **Objectives :** propose a development strategy valuating the offers of the producer on
 - The day ahead markets,
 - The adjustment mechanism

Optimal stochastic control for asset-liability management



► **Team :** *F. Bonnans (CMAP), O. Klopfenstein, K. Barty (EDF)*

► **Main features**

- **Application :** The hedging problem of nuclear decommissioning
- **Objectives :** Solve Portfolio Management Problems in incomplete markets
 - Liability hedging will be modeled through probability constraints.
 - The problem will be solved, either analytically, or by some numerical approximation.

Optimization of the Core of a Sodium Fast Reactor (SFR).



► **Team :** *O. Pantz, (CMAP), G. Gourlaouen, D. Schmitt (EDF)*

► **Main features**

- **Application :** Nuclear Core design
- **Context:** We use shape and parametric optimization methods in order to conceive new designs for the core of a SFR.
- **Objective :** improve the stability and safety of the reactor while ensuring a target efficiency.

Working Groups



▶ Most projects will be invited to attend following Working Groups

IROE

- ▶ Optimisation of daily and intra-daily generation schedules
- ▶ Planning nuclear outages
- ▶ Optimising Hydro-valleys

PRMO

- ▶ Probabilistic constraints and robust optimisation
- ▶ Combinatorial Optimisation
- ▶ Dynamic programming, big size systems and stochastics

▶ Regular meetings

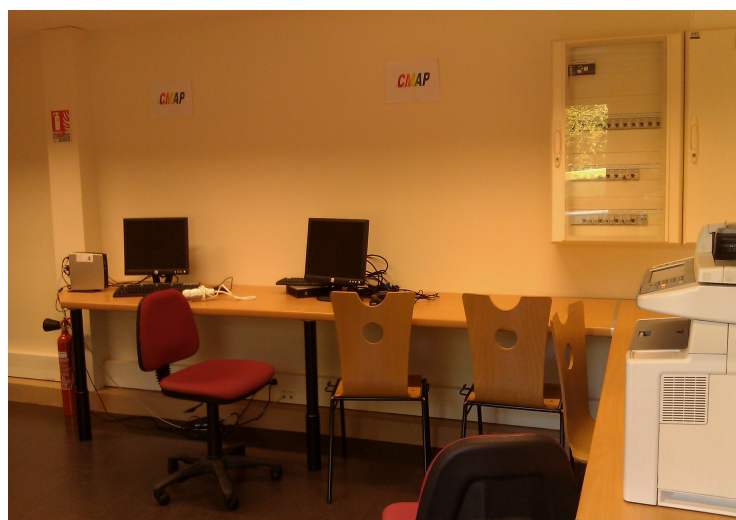
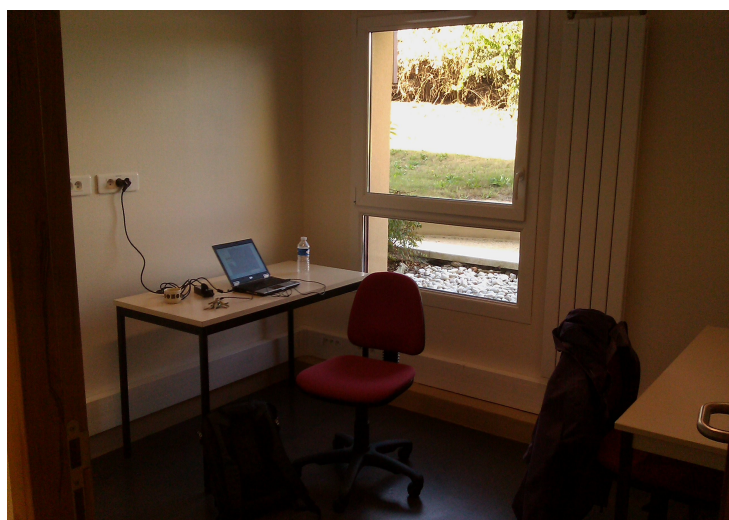
▶ Organisation of an open Workshop once or twice a year.

Seminars



- ▶ **PGMO will organise a regular seminar once a month**
 - ◆ 16th october
 - ◆ 20th november
 - ◆ 18th december
- ▶ **At PGMO offices**
- ▶ **Projects are invited to propose seminars**

PGMO Offices



<http://www.fondation-hadamard.fr/PGMO>

2013 call for project - agenda



► Agenda

- ◆ Publication of the call for project : **november 2012**
- ◆ First submission : **end of february 2013**
- ◆ Final submission : **mid-april 2013**
- ◆ Results : **may 2013**

Invited professors



- ▶ **PGMO proposes 6 months (separable) of invited professor in 2013 :**
 - ◆ **Research project**
 - ◆ **Optimization teaching (6h/Month, PhD level)**



Thanks !