PGMO DAYS 2016 – PROGRAM

GASPARD MONGE PROGRAM FOR OPTIMIZATION AND OPERATIONS RESEARCH

Book of Abstracts

Nov 8, 2017

This volume contains the abstracts of the talks presented at PGMO Days 2016: Gaspard Monge Program for Optimization and Operation Research Days 2016 held on November 7-8, 2016 in Palaiseau.

Table des matières

Program Committee

Gregoire Allaire Ecole Polytechnique
Frederic Bonnans Inria
Pierre Carpentier ENSTA ParisTech
Sandrine Charousset EDF
Marie-Christine Costa CEDRIC-Cnam / ENSTA-Paristech
Michel Delara Université Paris-Est, CERMICS
Stephane Gaubert INRIA and CMAP, Ecole Polytechnique
Leo Liberti Ecole Polytechnique
Michel Minoux Université Paris 6
Patrice Perny Université Paris 6
Filippo Santambrogio Université Paris-Sud
Roberto Woler Université Paris Nord

Plenary Talks

Invited Speakers

Giuseppe Calafiore (Politechnico di Turino) : "Foundatons and Recent Developments in Scenario Optimization"

Scenario optimization has become a standard tool for tackling many robust design problems that are difficult to attack via standard, deterministic worst-case methods. In scenario design, a standard convex optimization problem with N randomly sampled constraints (the "scenarios") is solved, and the scenario theory guarantees that the resulting solution is robust in a probabilistic sense against future realizations of the uncertainty. In this talk we will give an overview of the foundations of scenario optimization theory, and also discuss some recent developments and applications.

Mérouane Debbah (Huawei) : "Random Matrices for Engineering 5G"

The asymptotic behavior of the eigenvalues of large random matrices has been extensively studied since the fifties. One of the first related result was the work of Eugène Wigner in 1955 who remarked that the eigenvalue distribution of a standard Gaussian hermitian matrix converges to a deterministic probability distribution called the semi--circular law when the dimensions of the matrix converge to infinity. Since that time, the study of the eigenvalue distribution of random matrices has triggered numerous works, in the theoretical physics as well as probability theory communities. However, as far as communications systems are concerned, until the mid 90's, intensive simulations were thought to be the only technique to get some insight on how communications behave with many parameters. All this changed in 2000 when large system analysis based on random matrix theory was discovered as an appropriate tool to gain intuitive insight into communication systems. In particular, the self--averaging effect of random matrices was shown to be able to capture the parameters of interest of communication schemes. Since then, the results led to very active research in many fields such as MIMO systems or Ultra--Dense Networks. This talk is intended to give a comprehensive overview of random matrices and their application to the latest design of 5G Networks.

Patrick Jaillet (MIT) : "Online Optimization for Dynamic Matching Markets"

There are many situations in which present actions must be made and resources allocated with incomplete knowledge of the future. It is not clear in this setting how to measure the quality of a proposed decision strategy. Online optimization compares the performance of a strategy that operates with no knowledge of the future (on-line) with the performance of an optimal strategy that has complete knowledge of the future (off-line). In some cases some probabilistic information about the future may be available. In this talk, we provide an overview of results obtained from that perspective on problems arising from dynamic matching markets such as (i) online auctions, (ii) display advertisements, and (iii) kidney exchange programs.

Claire Mathieu (ENS) : "The average diameter of social networks "

The friends of my friends are my friends". This well-known observation underlies a probabilistic model of social networks. With that model, one may explain the small world phenomenon: if one considers two a priori unrelated persons, in reality they can be related to each other by a short chain of friends. In a variant of the forest fire model, it is possible to prove this phenomenon rigorously.

Michel PRENAT (Thales Optronique) : "Thales Optronique : Optimization and related Data Analysis Problems"

Thales Optronique SAS, part of Thales, is a leading company in the fields of optronic systems for defense applications (land, naval, airborne) and civil applications (high power lasers dedicated to scientific research and industrial processes), and radiofrequency systems for missile electronics applications. After a review of the applications and related skills, we show some optimization stakes in the fields of complex systems design, complex automatic functions, real time heterogeneous embedded computers, interface with the human operator, maintenance policy, databases acquisition. Some of these problems are a little bit more developed, showing a strong interaction between optimization and data analysis and processing.

PhD Award

Laureates of the 2016 PGMO PhD award are Pauline Sarrabezolles and Bruno Ziliotto.

Pauline SARRABEZOLLES

Pauline Sarrabezolles obtained her PhD thesis in Applied Mathematics at Université Paris-Est and ENPC ParisTech under the supervision of Frédéric Meunier. The title of the thesis is "colorful linear programming" and it stands at the intersection of discrete mathematics, combinatorics, optimization, graph theory and algorithmics. Colorful linear programming is an extension of linear programming where the variables are assigned to different categories (colors) and their number in each category is bounded. It has many applications in geometry and complex optimization problems. She studied the complexity of some algorithms like a colorful version of the simplex algorithm and proved a combinatorial conjecture in connection with the colorful Carathéodory theorem. The jury was impressed by the unique combination of various skills used by Pauline Sarrabezolles to solve these problems.

Bruno ZILIOTTO

Bruno Ziliotto obtained his PhD thesis in Applied Mathematics at Université de Toulouse under the supervision of Jérôme Renault. Its title is "Stratégies et paiements de long terme dans les jeux répétés à deux joueurs" and it is concerned with asymptotics of repeated zero-sum games, possibly with stochastic aspects. In particular it disproves a long-standing conjecture on the existence of a limit value and of a limit optimal strategy for the player. By the dynamic programming approach, this result has a link with the homogenization of stochastic Hamilton-Jacobi equations. More precisely, Bruno Ziliotto also found a striking counter-example of a non-convex Hamiltonian for which no stochastic homogenization occurs. The jury particularly appreciated the various and deep results obtained in different areas of mathematics and optimization.

The jury was chaired by Grégoire Allaire and composed of :

Marianne Akian, INRIA Saclay--Ile-de-France
Grégoire Allaire, École polytechnique
Francis Bach, INRIA Paris--Rocquencourt
Maitine Bergounioux, Université d'Orléans
Marie-Christine Costa, ENSTA
Eric Gourdin, Orange Labs
Christelle Jussien, Université d'Angers
Michel de Lara, ENPC
Aziz Moukrim, UTC

Parallel Sessions

Mean Field Games (invited Session, organized by Daniela Tonon)

Daniela Tonon - On the variational formulation of some Mean field game systems

Mean field games (MFG) systems have been introduced to describe Nash equilibria in differential games with infinitely many players. In some simple cases, the model collapses into a system consisting on a backward Hamilton-Jacobi equation coupled with a forward Fokker-Plank equation. The starting point of the current study is that in some cases the MFG system can be understood as the optimality system of two convex optimization problems in duality. This leads to a variational analysis strategy to study the well-posedness of the PDE system. Following this methodology, we will discuss first the existence and uniqueness of weak solutions of some possibly degenerated Mean Field Games and then the existence of solutions of a modified problem prescribing the final distribution of the agents.

Yves Achdou - A Mean Field Equilibrium as a Model for Mining Industries

A parsimonious long term model is proposed for a mining industry. Knowing the dynamics of the global reserve, the strategy of each production unit consists of an optimal control problems with two controls, first the flux invested into prospection and the building of new extraction facilities, second the production rate. In turn, the dynamics of the global reserve depends on the individual strategies of the producers, so the models leads to an equilibrium, which is described by low dimensional systems of partial differential equations. The dimensionality depends on the number of technologies that a mining producer can choose. In some cases, the systems may be reduced to a Hamilton-Jacobi equation which is degenerate at the boundary and whose right hand side may blow up at the boundary. A mathematical analysis is supplied. Then numerical simulations for models with one or two technologies are described. In particular, a numerical calibration of the model in order to fit the historical data is carried out. This is a joint work with Pierre-Noel Giraud (CERNA, Mines ParisTech), Jean-Michel Lasry (Univ. Paris Dauphine), Pierre-Louis Lions (Collège de France)

Luis Briceño-Arias, Dante Kalise, Francisco José Silva Alvarez - Proximal methods to solve stationary mean field game systems with local couplings

In this talk we consider proximal methods to solve discretized versions of some mean field games systems with local couplings, introduced by Achdou et al. The presence of local interactions imply that, at the continuous level, the mean field games system can be formally obtained as the optimality condition of an associated variational problem. The same argument applies at the discretized level. However, since one term in the cost functional is only sub-differentiable, suitable proximal methods are used in order to obtain globally convergent algorithms. We compare the performance of several methods and we analyze also problems where strong congestion effects are taken into account.

Decomposition methods

Halil Sen, Boris Detienne, Ruslan Sadykov, Francois Vanderbeck - Revisiting Benders decomposition

Benders decomposition is a divide-and-conquer approach to mixed integer programs that entails a decision-making process in two stages. First-stage decisions are optimized using a polyhedral approximation of the full-blown problem projection. Then, a separation subproblem in the second-stage variables is solved to check if the current first-stage solution is in fact feasible, and otherwise, it produces a violated inequality. The algorithm iterates over these two stages until no cuts can be generated. Such cutting-plane algorithms suffer from several drawbacks impairing performance. We review approaches to address such drawbacks and speed-up the algorithm. Our contribution consists in explaining these techniques in simple terms, showing that in several cases, different methods from the literature boil down to the same key ideas. We classify methods into specific initialization modes, strategies to select the separation point, proximal stabilization techniques, and cut generation and management strategies. We report on preliminary tests comparing implementation variants on capacitated facility location, multicommodity capacitated fixed charge network design, unrelated parallel machine scheduling, and stochastic location routing problems.

Shahin Gelareh - BENMIP-- A Generic Benders Decomposition Solver: Challenges and Progress

This presentation is a short report of the first phase from our initially 3-year planning. We will present a rough classification of MIP models which are the possible candidates for Benders-like decomposition techniques. We then will elaborate on the promising structures among such classes and application areas and report some results of our benchmarking. A part of presentation will also be devoted to the challenges and difficulties arising in development and design of a Generic Benders-like automatic decomposition solver.

Kostas Tavlaridis-Gyparakis, Antonio Frangioni - SMS++: a Structured Modeling System with Application in Energy Optimization

The development in both hardware and software has provided to researchers powerful general-purpose solvers for optimization problems; for instance, in the very well studied area of MILP the solution process has become around 100 million times faster over the last 20 years. However, general-purpose solvers mostly ignore any existing structure in the model; therefore, in many applications specialized solvers exist that are better than general-purpose ones. These can be used e.g. in the context of decomposition methods, which need be used for tackling very-large-scale, hard optimization models such as the ones arising in energy optimization. Unfortunately, current modeling systems are mostly geared towards general-purpose solvers, and offer little support for developing decomposition approaches.

We describe a new software tool, the Structured Modeling System++ (SMS++), which aims at closing this gap by providing a modeling system capable of giving to the user the ability of experimenting with different set of decomposition methods and reformulations (like Lagrangian relaxation, Benders' decomposition, Dantzig-Wolfe Decomposition etc). SMS++ represents a mathematical model in a block-structured form that is composed by a set of basic generic abstract C++ classes. A model with a specific structure can be expressed via the Block class, which may contain some static and dynamic Variables and Constraints classes, and some inner Blocks (recursively). Block is a base class for representing the general concept of "a part of a mathematical model with a well-understood identity"; in other words, it is expected that it will be used to define derived classes, each of which represents a model with a specific structure (say, a Knapsack, a Traveling Salesman Problem, a SemiDefinite program, ...). be represented as a Block. Thus, each Block will have information and data structures specific for the (part of) mathematical model it specifies; however, it also has an "abstract view" in which it describes the model through its Variables and Constraints, which can be arranged in any number of "sets", or "groups", each of which can be a multi-dimensional array with (in principle) an arbitrary number of dimensions. Each Block can be attached to any number of different general purpose or ad-hoc solvers, providing the interface between the current mathematical model and the corresponding algorithm. The Block supports modifications of all its components: each time a modification occurs, an appropriate Modification object is dispatched to all Solvers "interested" in the Block. Hence, the next time they are required to solve the Block they will know which modifications have occurred since the last time they have solved it (if any) and be able to react accordingly, hopefully re-optimizing to improve the efficiency of the solution process.

The aim of SMS++ is to provide a well-structured modelling system that allows to efficiently implement (among other things) "generic decomposition" approaches. That is, providing general implementations of the base decomposition techniques that can be easily applied to many different models (with the required structure) by just implementing the required Blocks. We will provide examples of this capability by using SMS++ to tackle the Unit Commitment problem in energy optimization.

Optimization, Games and Renewable Energy - OGRE 1 (invited Session summary organized by Michel De Lara)

Michel De Lara - Charting optimization problems with multiple agents and information

The classical energy management optimization framework considers that a central planner decides how to efficiently dispatch energy to consumers, in a centralized fashion. However, the emergence of new actors (for generation, storage, demand response) challenges this view.

From the mathematical point of view, this requires to move from centralized optimization to decentralized optimization and game theory with information. In this talk, I will focus on how information can be handled in game theory. For this purpose, I will show how the so- called Witsenhausen intrinsic model can help chart the landscape of problems with multiple agents and information.

El-Ghazali Talbi - A Multiobjective Evolutionary Algorithm for Household Appliances Scheduling

This work deals with the scheduling of the household appliances over a one-day time horizon. Given the load profile and the time windows of the time shiftable appliances, the outdoor temperature, the maximum, the minimum, the dead-band limits and the desired indoor temperature, the parameters of the electric heater and the time-varying electricity price, our aim is to minimize the total cost of electricity usage and the total discomfort of all houses while fulfilling the time shiftable and thermal appliances' constraints. The discomfort is divided into two parts: timing discomfort and thermal discomfort, the former part is modeled by lowering the delay time in the use of time shiftable appliances, the latter part a penalty is attributed to deviations from the desired thermal state. In order to avoid the creation of new power peaks caused by the load shifting to the least price periods, the standard deviation from the ideal load curve (the average load of all houses) is also minimized simultaneously with the previous objectives. We propose a multi-objective evolutionary algorithm to tackle the optimization model in a reasonable computing time. The simulation results from different case studies are presented and show the effectiveness of the proposed algorithm in reducing the total cost, ensuring a comfort level for all houses, as well as preventing the creation of new peaks.

Yezekael Hayel - Efficient Coupled Energy-Transport Management for Smart Cities

In this talk, we are interested in a Mixed Traffic Assignment Problem in which electric and gasoline vehicles share the network. In such situation the travel cost function is composed by a common part, the travel time, and a part which is specific to each type, like tolls or energy costs. We introduce first an additional phase into the standard MSA method that improves the computation time of the equilibrium solution. Second, we address the transport problem of finding the optimal tolls that minimize the pollution over the network with a bilevel model. In the second part of this presentation we study the interaction between the transport problem with an energy problem that provides the electricity cost depending on the demand, which is another bilevel problem. We will show how these two problems are coupled and influence each other, particularly in the context of smart cities.

OR 1 - Graphs and Optimization (Invited Session, organized by Marie-Christine Costa, Sourour Elloumi)

Axel Parmentier - Lower bounds in resource constrained shortest path algorithms

Resource constrained shortest path problems arise naturally as pricing sub-problems of column generation approaches to a wide range of routing and scheduling problems. The algorithms for these problems rely on dominance relations between paths to discard partial solutions in an enumeration of all the paths. It is well known that the use of bounds on paths resources in addition to dominance relations strongly accelerates these algorithms. Nonetheless, there is still no standard procedure to build such bounds in non-linear or stochastic settings. We provide such a bounding procedure and show its efficiency on several deterministic and stochastic path problems. Besides, enumeration algorithms exhibit poor performances when the number of constraints increase. We show that using sets of bounds instead of single bounds enable to discard more paths and thus to tackle better with these difficult instances. Finally, we prove the relevance of these procedures in the context of column generation on industrial instances of the airline crew pairing problem.

Viet Hung Nguyen, Paul Weng - Efficient algorithm for fair perfect matching

Given a weighted undirected graph, we consider the fair perfect matching problem that can be described as determining a perfect matching whose edge weights are fairly distributed. This question is important when one wants to be fair to the pairs of nodes in a matching. For instance, this issue appears when forming 2-person teams. Note that the classic minimum weight perfect matching problem, which consists in finding a perfect matching that minimizes the sum of the edge weights, does not allow any control on the distribution of the edge weights.

To model fairness, we use the Ordered Weighted Averaging (OWA) with nonincreasing OWA weights, also known as the Generalized Gini Index (Weymark, Mathematical Social Sciences, Vol. 1, pp 409-430, 1981), instead of the sum, to aggregate the edge weights. While OWA is a non-linear aggregating function, a $0/1$ mixed linear program (P) can be formulated for finding an OWA optimal perfect matching by exploiting a linearization of OWA (Ogryczak and Sliwinski, European Journal on Operational Research, Vol. 148, pp. 80-91, 2003). Program (P) has binary variables describing matchings and real variables representing terms for the computation of OWA. It has a decomposable structure containing blossom inequalities for matchings (Edmonds, Journal of Research of the National Bureau of Standards, Vol. 69, pp. 125-130) and linearized OWA inequalities. Numerical experiments that we have conducted on (P) show that on random hard instances, the integrality gap can be bad (about 0.5) and generic solvers such as CPLEX or Gurobi can take hours for solving (P). In this paper, we focus on designing special-purposed algorithm exploiting the decomposable structure of (P). More precisely, we propose an alternating optimization algorithm which consists of two phases: the first on the primal when binary variables are fixed and the second on the dual when the dual multipliers associated with linearized OWA inequalities are fixed. Although the algorithm is not an exact algorithm, computational results on random hard instances show that it always finds optimal solutions and converges within several minutes while CPLEX and Gurobi take hours.

Youcef Magnouche, Ali Ridha Mahjoub, Sébastien Martin - The multi-terminal vertex separator problem

Let $G = (V \cup T, E)$ be a simple graph with $V \cup T$ the set of vertices, where T is a set of k distinguished vertices called terminals, and E the set of edges. The multi-terminal vertex separator is a subset $S \subseteq V$ such that each path between two terminals intersects S. Given a weight function $w : V \to N$, the multi-terminal vertex separator problem (MTVSP) consists in finding a multi-terminal vertex separator of minimum weight. The problem can be solved in polynomial time when $|T| = 2$ and it is NP-hard when $|T| \geq 3$ [1] [3]. The MTVS problem has applications in different areas like VLSI design, linear algebra, connectivity problems and parallel algorithms. It has also applications in network security. Consider, for instance, a graph $G = (V \cup T, E)$ representing a telecommunication network, with V the set of routers , T the set of customers and an edge between two vertices represents the possibility of transferring data between each other. We search to set up a monitoring system of minimum cost on some routers, in order to monitor all data exchanged between customers. The set of these routers represents a minimum multi-terminal vertex separator. The MTVSP is equivalent to the following integer linear program

min ∑x x_v ≥ 1 ∀ path P_tt', between two terminals t and t', (1)

x v ≥ 0 ∀v ∈ V. (2)

In this work, we first show that the linear system given by inequalities (1)-(2) together with the star tree inequalities [2] is TDI for the star tree graphs. We show also that the linear system given by inequalities (1)-(2) together with the clique star inequalities [2] is TDI for the clique star graphs. Then, we study a composition (decomposition) technique for the multi-terminal vertex separator polytope in graphs that are decomposable by one-node cutsets. If G decomposes into G 1 and G 2 , we show that the multi-terminal vertex polytope of G can be described from two linear systems related to G 1 and G 2 . As consequence, we obtain a procedure to construct this polytope in graphs that are recursively decomposed. Finally, we deduce a linear system characterizing the MTVS polytope for trees and clique-trees.

Moreover, we introduce a new extended formulation for the MTVSP and develop a Branch-and-Price algorithm to solve it.

References

[1] Walid Ben-Ameur and Mohamed Didi Biha. On the minimum cut separator problem. Networks, 59(1):30–36, 2012.

[2] Denis Cornaz, Youcef Magnouche, A Ridha Mahjoub, and Sébastien Martin. The multi-terminal vertex separator problem: Polyhedral analysis and branch-and-cut. In International Conference on Computers & Industrial Engineering (CIE45), 2015.

[3] Naveen Garg, Vijay V Vazirani, and Mihalis Yannakakis. Multiway cuts in directed and node weighted graphs. In Automata, Languages and Programming, pages 487–498. Springer, 1994.

[4] Guyslain Naves and Vincent Jost. The graphs with the max-mader-flow-min-multiway-cut property. arXiv preprint arXiv:1101.2061, 2011.3Large Scale Optimization and Statistics 1

Large Scale Optimization and Statistics 1

Vianney Perchet, Francis Bach - Highly-Smooth Zero-th Order Online Optimization

The minimization of convex functions which are only available through partial and noisy information is a key methodological problem in many disciplines. In this paper we consider convex optimization with noisy zero-th order information, that is noisy function evaluations at any desired point. We focus on problems with high degrees of smoothness, such as logistic regression. We show that as opposed to gradient-based algorithms, high-order smoothness may be used to improve estimation rates, with a precise dependence of our upper-bounds on the degree of smoothness. In particular, we show that for infinitely differentiable functions, we recover the same dependence on sample size as gradient-based algorithms, with an extra dimension-dependent factor. This is done for both convex and strongly-convex functions, with finite horizon and anytime algorithms. Finally, we also recover similar results in the online optimization setting.

Dmitry Ostrovsky, Anatoli Juditsky, Zaid Harchaoui - Adaptive filtering by convex optimization

We consider the problem of estimation and adaptive prediction of noisy signals or images of unknown structure. We develop a convex optimization approach to meet the following challenges: (i) designing estimators which are statistically optimal; (ii) designing numerically efficient implementation algorithms. In particular, we establish oracle inequalities for adaptive filtering procedures and discuss implementation of estimation algorithms using proximal algorithms of convex optimization.

Rémy Degenne, Vianney Perchet - Combinatorial semi-bandit with known covariance

In the online learning setting known as a multi-armed bandit problem, an algorithm chooses an action ("pulls an arm") among several at each stage in order to optimize the cumulative reward they yield, knowing only the result of the actions previously done. The combinatorial stochastic semi-bandit problem is an extension of this setting in which the algorithm pulls more than one arm simultaneously and the rewards of all pulled arms are revealed. We investigate one major difference with the classical variant, which is that the combinatorial dependency structure of the arms is crucial. Previous works on this setting either used a worst-case approach or imposed independence of the arms. We introduce a way to quantify the dependency structure of the problem and design an algorithm that adapts to it. The algorithm is based on linear regression and the analysis develops techniques from the linear bandit literature. By comparing its performance to a new lower bound, we prove that it is optimal, up to a poly-logarithmic factor in the number of pulled arms.

Control 1

Dario Prandi - Neuro-geometry of vision and applications to image processing

Since the works of Hubel and Wiesel ('81 Nobel laureates), it is well-known that neurons in the primary visual cortex V1 of mammals are sensible not only to specific positions in the visual field, but also to local orientations. This suggests to model V1 as the projective tangent space $PT\mathbb R^2$ of the plane, i.e.,

$\mathbb R^2\times \mathbb P^1$.

In the first part of the talk we will introduce the Citti-Petitot-Sarti model of V1. According to this model, neuronal connections follows geodesics associated with a natural sub-Riemannian structure on $PT\mathbb R^2$. Later on, we will present some applications of this model to image processing, in particular in the fields of image reconstruction and recognition. Here, we obtain results comparable with those of current state-of-the-art algorithms, with significant computational gains due to the exploitation of non-commutative Fourier analysis on

$PT\mathbb R^2$.

This is a joint work with U. Boscain, J.-P. Gauthier, A. Remizov.

Jean-Baptiste Caillau, Jean-Baptiste Pomet, Jeremy Rouot - Averaging for minimum time control problems and applications

Consider a system with slow-fast dynamics, typically with one fast angle and slow variables. A canonical example is the motion of a spacecraft in a central field. Without perturbation and control, the simplest motion is the superintegrable Keplerian one where only one fast angle defining the position of the spacecraft on its orbitan ellipse for appropriate values of the energy of the system is changed in time. Adding small control and perturbations, first integrals of the motion are slowly varied. Given a cost to optimize, an efficient way to analyze such an optimal control system is to average the extremal flow provided by Pontryagin maximum principle. This flow governs the evolution of minimizing trajectories in that these trajectories are projections onto the state space of the flow which lives in an extended space of dimension twice the dimension on the state. The difficulty for costs such as time or fuel minimizationis that there is a priori no obvious way to identify slow and fast variables in this extended space. Defining an appropriated averaged system is therefore the first non-trivial task. Previous works have essentially treated the simpler case of energy minimization [6, 7], using for instance the approach in [4]. This analysis has been completed in a series of paper [2, 3] proving that averaging provides in this case a metrical approximation of Riemannian nature. Optimality issues (cut and conjugate loci) of this approximation have been studied in detail in these references. In the case of minimum time, the analysis is more delicate; as shown in the preliminary work of [1], there is still a metric approximation of the system but of Finsler type, and having singularities. While this opens perspectives from the mathematical side, an important task is also to understand related approximations of averaging type used in an industrial context at Thales Alenia Space, see [5].

[1] Bombrun, A.; Pomet, J.-B. The averaged control system of fast oscillating control systems. SIAM J. Control Optim. 51 (2013), no. 3, 2280{2305.

[2] Bonnard, B.; Caillau, J.-B. Geodesic ow of the averaged controlled Kepler equation. Forum Math. 21 (2009), no. 5, 797{814.

[3] Bonnard, B.; Caillau, J.-B. Metrics with equatorial singularities on the sphere. Ann. Mat. Pura Appl. 193 (2014), no. 5, 1353{1382.

[4] Chaplais, F. Averaging and deterministic optimal control. SIAM J. Control Optim. 25 (1987), no. 3, 767- 780.

[5] Dargent, T. Averaging technique in T3D: An integrated tool for continuous thrust optimal control in orbit transfers. 24th AAS/AIAA Space Flight Mechanics Meeting, Santa F_e, January 2014.

[6] Edelbaum, T. N. Optimal low-thrust rendez-vous and station keeping. AIAA J. 2 (1964), no. 7, 1196{1201.

[7] Geffroy, S.; Epenoy, R. Optimal low-thrust transfers with constraints. Generalization of averaging techniques. Acta Astronaut. 41 (1997), no.3, 133{149.

Achille Sassi, Hasnaa Zidani, Jean-Baptiste Caillau, Emmanuel Trélat, Max Cerf - Kernel Density Estimation applied to the chance-constrained Goddard problem

Our goal is to test Kernel Density Estimation as an efficient technique for solving chance-constrained optimal control problems. In order to explore the flexibility of this technique, we apply the KDE to several increasingly complex academic problems before solving the previously described chance-constrained Goddard problem.

Our goal is to test Kernel Density Estimation as an efficient technique for solving chance-constrained optimal control problems. We use a stochastic reformulation of the well-known Goddard problem as an example. Consider the vertical ascent of a single stage launcher in one dimension. The vehicle starts from a still position at ground level, then the thrust force T of the engine pushes the launcher upwards against force of gravity and drag force. We can act on the trajectory of the launcher by means of a control function u(t) 2 [0; 1]: the fraction of the thrust applied at time t. We are interested in the case when the thrust T is a random variable and our objective is to maximize the final mass of the launcher while making sure that its altitude is higher than a given value within a desired probability threshold. Our chance-constrained optimal control problem takes the form

(min u2U J(u) P_G(u; _) _ 0__ p

where U is the set of admissible controls, J : U ! R is the objective function, G : U _ Rm ! R represents the constraint, p 2 (0; 1) is a probability threshold called confidence level and _ is a random vector defined on some probability space.

Our approach consists in reformulating this stochastic optimization problem as a deterministic one by approximating the distribution of the constraint function G (which is a random variable, since it depends on _) via Kernel Density Estimation. Let X be a random variable with an unknown distribution f that we want to estimate and let fX_1;X_2; : : : ;X_ng be a sample of size n of the variable X. A Kernel Density Estimator for the pdf f is the function^ $f_{n;h}$(x) :=1nhXni=1K_x □ X_ih_

where the function K is called kernel and the smoothing parameter h is called bandwidth. The approximation error between f and ^ $f_{n;h}$ depends on the choice of both K and h, as well as on the sample size n. Since the bandwidth plays a much more important role than the kernel, in most applications the study is focused on the choice of h, while K is usually the Gaussian kernel.

In order to explore the exibility of this technique, we apply the KDE to several increasingly complex academic problems before solving the previously described chance-constrained Goddard problem.

Games 1 (Invited Session of GdR « Théorie des jeux », organized by Guillaume Vigeral)

Rida Laraki - Acyclic Gambling Games

We consider general 2-player zero-sum stochastic games where each player controls his own state variable living in a compact metric space. The terminology comes from gambling problems where the state of a player represents its wealth in a casino. Under natural assumptions (such as continuous running payoff and non expansive, possibly stochastic, transitions), we consider for each discount factor the value of the λ-discounted stochastic game and investigate its limit when λ goes to 0. We show that under a strong acyclicity condition, the limit exists and is characterized as the unique solution of a system of functional equations: the limit is the unique continuous excessive depressive function such that each player, if his opponent does not move, can reach the zone when the current payoff is at least as good than the limit value, without degrading the limit value.The approach generalizes and provides a new viewpoint on the Mertens-Zamir system coming from the study of zero-sum repeated games with lack of information on both sides. A counterexample shows that under weak acyclicity, convergence may fail.

Saeed Hadikhanloo - Learning in Anonymous Games with Actions in Banach Spaces: Application in First Order Mean Field Games

We introduce a model for the anonymous games where the set of actions are (possibly player dependent) subsets of an ambient Banach vector space. We propose different learning procedures similar to the well-known Fictitious Play and Online Mirror Descent and prove their convergence to equilibrium under the so-called monotonicity condition. The similar results in First Order Mean Field Game is an application of the model.

Panayotis Mertikopoulos, Yannick Viossat - Imitation dynamics with payoff shocks

The replicator dynamics - the most studied game dynamics - may be seen as a model of natural selection, of learning, or of imitation of successful agents. Introducing payoffs shocks in the natural selection or learning model lead to stochastic replicator dynamics that have been studied in the literature. We study the impact of adding shocks to the imitation model. We obtain new stochastic replicator dynamics, with markedly different properties in terms of convergence to equilibria and elimination of dominated strategies.

Industrial applications (Invited Session, organized by Sandrine Charousset)

Eric Gourdin - Location and routing problems in modern telecommunication networks

Telecommuncation network are still evolving very fast. Always larger amounts of data are offered in innovative services, made available to the private and public customers and delivered throughout interconnections of huge networks. New architectures and concepts emerge every year to improve the efficiency and reliability of these networks. However, some classical OR models remain useful as building blocks within larger and more complex real life problems. In this talk, the focus will be put on two such problems.

A CDN (Content Delivery Network) is an interconnected set of storage servers replicating contents and storing them closer to the final users. The design of an optimal CDN heavily lies on the solution of location problems to decide where and how much capacity should be deployed in the various places of the network.

Most of the large transport networks still use routing protocols where routing paths are computed as shortest-paths according to administrative weights. The large volumes of traffic conveyed on such networks need to be carefully routed to ensure a best possible use of network resources. Multicommodity flow problems are useful tools to derive optimized routing patterns.

Mathieu Leconte, Ioannis Steiakogioannakis, Georgios Paschos - Distributed multi-commodity routing optimization in Software-Defined Networks

In computer networks, Software-Defined Networking (SDN) technology allows operators to centralize traffic engineering to some extent. However, scalability and fragmented network ownership are pushing many SDN systems to use multiple controllers. We study multi-commodity routing in such a multi-operators scenario, where each controller is responsible for a different network domain, which it does not want to disclose, and controllers interact with their neighboring controllers to reach an agreement on how to route traffic across multiple domains. This problem lies in-between the centralized and fully distributed routing cases. The objective here is to leverage the partial centralization to obtain globally optimal routing solutions faster, while maintaining scalability by limiting the memory requirements at the controllers. Our algorithms achieve these goals by gracefully combining fast convex optimization methods for flow agreement at domain boundaries and sparsity-preserving centralized methods for solving intra-domain routing.

Bayram Kaddour, Olivier Beaude - Enedis strategic planning

Digital electricity metering has become popular in the recent years in Europe. Smart meters allow utilities to collect real-time data on customer consumption and manage networks remotely, eliminating the need to send out technicians and visits by meter readers. Enedis, the main electricity distribution system operator in France plans to deploy 35 million Linky smart meters by 2022.
On the one hand, introducing such technology will reduce the volume of technicians' outside operations. On the other hand, Enedis will manage its own teams, whereas until recently, it shares mutual staff with GRDF, the gas distribution system operator.
This makes Enedis wonder if there is a need to change its service planning and the location of its facilities in the coming years. Enedis works closely with EDF R&D to develop a decision-making application that helps solving this problem and analysing different scenarios.
We will present the model chosen by EDF R&D to solve this location routing problem and how the associated vehicle routing subproblem was approximated in the whole model. This application was developped using Python and Gurobi.

Optimization, Games and Renewable Energy - OGRE 2 (Invited Session, organized by Michel de Lara)

Bernardo Pagnoncelli, Tito Homem-De-Mello, Rodrigo Carrasco, Mailyng Carrasco - Microgrid energy management with renewables and storage

We present a microgrid model consisting of a small community, or city, comprised of a photovoltaic panel (PV) and two types of storages units: batteries and pumping. Demand will be deterministic, for example via contracts, but energy generated from the PV is stochastic. We frame the problem as a multistage stochastic programming problem in which the goal is to produce the schedule that minimizes average costs, while satisfying demand at every time period. We illustrate our methodology with an example of a one-week operation of such system.

Didier Aussel, Anton Svensson - Multi-leader-follower-games: a state of art of applications to energy problems and of their (global vs local) reformulations

Multi-leader-follower games (MLFG) are at the same time a generalizations of a Nash's models for non-cooperative games and of bilevel problems. Indeed in such a MLFG, several agents (the leaders) try to find a Nash equilibrium for their non-cooperative interactions, with their decision variables being constrained to be chosen in the solution sets of some (lower level) optimization problems driven by a set of other agents, the followers. MLFG provides a perfect setting for the modelization of a very large number of non-cooperative interactions, in economics of course but also in engineering, transportation, network.... It has been recently used by different authors for the analysis of electricity markets and network management. We will first recall/summarize the main insights of these works.

But when considering a possible first order reformulation, the MLFG inherits of the difficulties of both Nash approach and of bilevel programming. Nevertheless the interrelations between MLFG models and their

reformulations were very recently investigated in [1] and [2]. Our second aim in this talk is to present these recent works.

Bibliography:

[1] S. Dempe and J. Dutta. Is bilevel programming a special case of a mathematical program with complementarity constraints? Mathematical programming, 131(1-2):37{48, 2012.

[2] D. Aussel and A. Svensson. Is bilevel programming a special case of a mathematical program with complementary constraints?, the pessimistic counterpart, submitted, 2016.

Luce Brotcorne, Léonard von Niederhäusern - Energy Pricing Problems for Demand side and Revenue Management

Pricing models for demand side management methods are traditionally used to control electricity demand which became quite irregular recently and resulted in inefficiency in supply. In this work, we propose bilevel pricing models to explore the relationship between energy suppliers and customers who are connected to a smart grid. The smart grid technology allows customers to keep track of hourly prices and shift their demand accordingly, and allows the provider to observe the actual demand response to its pricing strategy. Moreover, we assume that the smart grid optimizes the usage of a renewable energy generation source and a storage capacity.

OR 2 - Mathematical programming in Energy (Invited Session, organized by Marie-Christine Costa, Sourour Elloumi)

Sandra Ulrich Ngueveu - Piecewise linear bounding of energy conversion functions and resulting MILP-based solution methods

Different energy sources can have very different characteristics in terms of power range and energy demand/cost function also known as efficiency function or energy conversion function. Such functions are usually defined on an interval [0, maximum energy], bounded from above and below on the interval, efficiently computable at any point of the interval, with a derivative also efficiently computable on the interval and piecewise convex or concave with a polynomial number of pieces. This is for example the case of polynomials. It appears that energy conversion functions are often polynomial functions. Introducing these energy sources characteristics in combinatorial optimization problems such as energy resource allocation problems or energy-consuming activity scheduling problems results into mixed-integer non-linear problems neither convex or concave. Approximations via piecewise linear functions have been proposed in the literature. Non-convex optimization models and heuristics exist to compute optimal breakpoint systems subject to the condition that the piecewise linear continuous approximator (under- and overestimator) never deviates more than a given delta-tolerance from the original continuous univariate function over a given finite interval, or to minimize the area between the approximator and the function. We present an alternative solution methods based on the upper and lower bounding of energy conversion expressions using discontinuous piecewise linear functions with a relative epsilon-tolerance. We prove that such approaches yield a pair of mixed integer linear programs with a performance guarantee. Models and heuristics to compute the discontinuous piecewise linear functions with a relative epsilon-tolerance will also be presented. Computational results have shown the efficiency of the methods in comparison to state-of-the-art methods on instances derived from the literature and on real-world instances from various energy optimization problems such as energy optimization in hybrid electric vehicles.

Thomas Ridremont, Cédric Bentz, Marie-Christine Costa, Pierre-Louis Poirion - Mixed-integer Bilevel programs for designing robust networks. An application to wind power collection.

Nowadays, the design of networks is crucial in many fields such as transport, telecommunications or energy. We focus in particular on networks designed to collect energy produced through ecological devices, in particular wind turbines. We aim to find a network allowing the routing of the energy produced by a set of wind turbines to the sub-station in respect to some technical constraints (cable capacities, non-splitting constraints, etc.) [BCH2016,DS2013]. Furthermore, we want those networks to be resilient to cable failures.

We are interested in the design of capacitated rooted Steiner networks called survivable [GB1993]. Given a graph G=(V,E), capacity and cost functions on E, a root r, a subset T of V called terminals and an integer k, we want to find a subset E' of E of minimum cost, covering T and r, such that the network induced by E' is k-survivable. We mean that a network is k-survivable with respect to the capacities if, after the removal of any k edges, there still exists a flow respecting the capacities, starting from the root, and routing a unit of flow to each terminal. This problem has been shown to be NP-Hard.

We propose three different formulation : a cut-set, a flow and a bi-level formulation (with an attacker and a defender). In the bi-level formulation, the second level is a min-max problem (corresponding to a special case of network interdiction [W1993]). For each formulation, we propose an algorithm to solve this problem (using columns or/and constraints generation) and compare their efficiency. We also consider the possibility of protecting a given number of edges.

References:

[BCH2016] Bentz, A., Costa, M.C., & Hertz,A. (2016). On the edge capacitated Steiner tree problem. Technical Report 1607.07082, arXiv.

[DS2013] Du, D. Z., Smith, J. M., & Rubinstein, J. H. (Eds.). (2013). Advances in Steiner trees (Vol. 6). Springer Science & Business Media.

[GB1993] Goemans, M. X., & Bertsimas, D. J. (1993). Survivable networks, linear programming relaxations and the parsimonious property. Mathematical Programming, 60(1-3), 145-166.

[W1993] Wood, R. K. (1993). Deterministic network interdiction. Mathematical and Computer Modelling, 17(2), 1-18.

Pierre-Louis Poirion, Cédric Bentz, Marie-Christine Costa, Thomas Ridremont, Camille Zakhour - Optimal design of a robust wind-farm under power constraints.

In this talk, we consider the problem of designing a robust network, of offshore wind-turbines, at minimal cost (c.f. [1]). More precisely, given a set of wind-turbines and a set of power cables, we look for the optimal way to link the wind-turbines with the power cables such that all the wind-turbines are rooted to the power station, even if a shortage occurs at one or several power cables.

We look hence to build a *survivable* network (c.f. [2]) at minimum cost. However, the main difference here is that we require that the electrical powers running through the network satisfy the *Load Flow* equations, which induce a set of non-linear constraints in the model.

We first show that, if we forget the robustness, then we can formulate the problem into a Mixed Integer Linear program, then we show that the robust problem can be formulated into a compact way through a bilevel model. Finally, we give a general framework to solve the model.

References

[1] Bentz, A., Costa, M.C., & Hertz, A., On the edge capacitated Steiner tree problem. Technical Report 1607.07082, arXiv, 2016.

[2] Goemans, M. X., & Bertsimas, D. J., Survivable networks, linear programming relaxations and the parsimonious propert. Mathematical Programming, 60(1-3), 145-166, 1993.

Large Scale Optimization and Statistics 2

Eugene Ndiaye, Olivier Fercoq, Alexandre Gramfort, Joseph Salmon - Gap Safe Screening Rules for Sparse-Group Lasso

For statistical learning in high dimension, sparse regularizations have been proven to be useful to boost both computational and statistical efficiency. Sparse-Group Lasso has recently been introduced in the context of linear regression to enforce a mixed sparsity by adding a regularization term to the data-fitting: l_1 norm for feature sparsity and $l_{1,2}$ norm for group sparsity.

Safe screening rules exploit the known sparsity of the solutions to speed up optimization algorithms. They discard inactive features/groups whose coefficients are guaranteed to be zero for optimal solutions. Then, a significant reduction in computing time can be obtained ignoring "irrelevant" features/groups.

The Sparse-Group Lasso benefits from two levels of screening: the safe rules can detect exactly both group-wise zeros in the optimal solution and coordinate-wise zeros in the remaining groups.

We propose the first (provably) safe screening rules for Sparse-Group Lasso.

Thanks to efficient dual gap computations relying on the geometric properties of the ϵ-norm, our proposed method lead to significant gains in term of computing time.

Emilio Carrizosa, Amaya Nogales Gómez, Dolores Romero Morales - Clustering categories in support vector machines

The support vector machine (SVM) is a state-of-the-art method in supervised classification. In this work the Cluster Support Vector Machine (CLSVM) methodology is proposed with the aim to increase the sparsity of the SVM classifier in the presence of categorical features, leading to a gain in interpretability. The CLSVM methodology clusters categories and builds the SVM classifier in the clustered feature space. Four strategies for building the CLSVM classifier are presented based on solving: the SVM formulation in the original feature space, a quadratically constrained quadratic programming formulation, and a mixed integer quadratic programming formulation as well as its continuous relaxation. The computational study illustrates the performance of the CLSVM classifier using two clusters. In the tested datasets our methodology achieves comparable accuracy to that of the SVM in the original feature space, with a dramatic increase in sparsity.

Quoc Tran-Dinh, Olivier Fercoq, Volkan Cevher - A Smooth Primal-Dual Optimization Framework for Nonsmooth Composite Minimization

We propose a new first-order primal-dual optimization framework for a convex optimization template with broad applications.
Our optimization algorithms feature optimal convergence guarantees under a variety of common structure assumptions on the problem template.

Our analysis relies on a novel combination of three classic ideas applied to the primal-dual gap function: smoothing, acceleration, and homotopy.

The algorithms due to the new approach achieve the best known convergence rate results, in particular when the template consists of only non-smooth functions.

We also outline a restart strategy for the acceleration to significantly enhance the practical performance. We provide numerical evidence with two examples and illustrate that the new methods can outperform the state-of-the-art, including Chambolle-Pock, and the alternating direction method-of-multipliers algorithms.

Semidefinite programming (Invited Session, organized by Xavier Allamigeon)

Didier Henrion, Simone Naldi and Mohab Safey El Din - Exact Algorithms for Linear Matrix Inequalities

Let $A(x) = A_0+x_1A_1+\cdots+x_nA_n$ be a linear matrix, or pencil, generated by given symmetric matrices $A_0,A_1,\ldots,A_n$ of size m with rational entries. The set of real vectors x such that the pencil is positive semidefinite is a convex semi-algebraic set called spectrahedron, described by a linear matrix inequality (LMI). We design an exact algorithm that, up to genericity assumptions on the input matrices, computes an exact algebraic representation of at least one point in the spectrahedron, or decides that it is empty. The algorithm does not assume the existence of an interior point, and the computed point minimizes the rank of the pencil on the spectrahedron. The degree d of the algebraic representation of the point coincides experimentally with the algebraic degree of a generic semidefinite program associated to the pencil. We provide explicit bounds for the complexity of our algorithm, proving that the maximum number of arithmetic operations that are performed is essentially quadratic in a multilinear B\'ezout bound of d. When the size m of the pencil is fixed, such a bound, and hence the complexity, is polynomial in n, the number of variables. We conclude by providing results of experiments showing significant practical improvements with respect to state-of-the-art computer algebra algorithms.

Hamza Fawzi - Semidefinite programming lifts and sparse sums of squares

A central question in optimization is to maximize (or minimize) a linear function over a given polytope. To solve such a problem in practice one needs a concise description of the polytope. In this talk I will consider representations of a polytope as the projection of a spectrahedron (the feasible set of a semidefinite program). Such a representation is called a semidefinite programming lift and encompasses linear programming extended formulations. I will describe a connection between semidefinite programming lifts, sums of squares and certain matrix factorization problems and will show in particular how the idea of sparse sums of squares allows us to construct semidefinite programming lifts for certain classes of polytopes that are vanishingly smaller than linear programming lifts.

Based on joint work with Joao Gouveia, Pablo Parrilo, Richard Robinson, James Saunderson, Rekha Thomas.

Xavier Allamigeon, Stephane Gaubert, Mateusz Skomra - Solving Generic Nonarchimedean Semidefinite Programs using Stochastic Game Algorithms

Semidefinite programming (SDP) is a fundamental tool in convex and polynomial optimization. One of the basic algorithmic questions associated with SDP is to decide whether the feasible region of such a program (i.e., a spectrahedron) is nonempty. It is unknown whether this problem belongs to NP in the Turing machine model, and the state-of-the-art algorithms that solve this task exactly are based on cylindrical decomposition or the critical points method. We study the nonarchimedean analogue of this problem, replacing the field of real numbers by the field of Puiseux series. We introduce the notion of tropical spectrahedra and show that, under genericity conditions, these objects can be described explicitly by systems of polynomial inequalities in the tropical semiring. Furthermore, we demonstrate a subclass of tropical spectrahedra which encode Shapley operators associated with stochastic mean payoff games. As a result, we show that a large class of semidefinite feasibility problems defined over Puiseux series can be solved efficiently using combinatorial algorithms designed for stochastic games.

Games 2 (Invited Session of GdR « Théorie des jeux », organized by Guillaume Vigeral)

Marie Laclau, Frédéric Koessler, Tristan Tomala - Competitive Information Design

We study games between n information designers, each of whom can perform an experiment about a piece of information, the pieces being independent. They aim at persuading a decision maker to take their most preferred action. For such games with discontinuous payoffs, we show that there exists a mixed (subgame perfect) equilibrium. We show by example that the equilibrium strategies may require an infinite number of messages.

We characterize the equilibrium distributions of actions for rectangular games where the optimization problem of the decision maker is separable across designers.

Stefano Lovo - Markov Perfect Equilibria in Stochastic Revision Games

We introduce the model of Stochastic Revision Games where a finite set of players control a state variable and receive payoffs as a function of the state at a terminal deadline. There is a Poisson clock which dictates when players are called to choose to revise their actions.

This paper studies the existence of Markov perfect equilibria in those games. We give an existence proof assuming some form of correlation. We deduce the existence of subgame perfect equilibria (without correlation).

Sylvain Sorin - Limit value of dynamic zero-sum games with vanishing stage duration

We consider two person zero-sum games where the players control, at discrete times $\{t_n \}$ induced by a partition $ \Pi $ of $\rit^+ $, a continuous time Markov process. We prove that the limit of the values v_{Π} exist as the mesh of Π goes to 0.

The analysis covers the cases of :

1) stochastic games (where both players know the state)

2) games with unknown state and symmetric signals.

The proof is by reduction to a deterministic differential game.

Numerical methods for optimal transport (Invited Session organized by Quentin Mérigot)

Jean-Marie Mirebeau - Monotone and consistent discretizations of diffusion PDEs using Obtuse Superbases

I will describe the discretizations of anisotropic diffusion PDEs and of second order Hamilton-Jacobi-Bellman PDEs, on cartesian grid domains, using Obtuse Superbases as a key ingredient, which are special coordinate systems in lattices of dimension 2 and 3. The proposed approach is versatile, enjoys the property of monotony as well as some optimality properties. As an illustration I will demonstrate a generalisation of Varadhan's formula to Rander's metrics.

Marco Cuturi - Algorithmic Wasserstein Distances and Applications to Histogram Regression

We consider in this talk the inverse problem behind Wasserstein barycenters. Given a family of measures, several algorithms have been recently proposed to compute efficiently the Wasserstein barycenter of that family under a given weight vector. I will describe an algorithmic solution to tackling the corresponding inverse problem: how to estimate, given an input measure, the measure in the set of all Wasserstein barycenters of the original family of measures that is the closest, under some distance, to the input measure. I will show during the talk that an alternative definition of Wasserstein distances, defined as the output of an algorithmic procedure and not as the result of an optimization, can prove useful. I will present applications in graphics and brain imaging. This is joint work with Nicolas Bonneel (INRIA) and Gabriel Peyré (ENS).

Boris Thibert - Semi-discrete optimal transport and applications in non-imaging optics

Optimal transport problems appear in many applications, such as for example in geometric optics. The general problem amounts to send a measure to another one while minimizing a cost of transportation. A classical way to solve this problem is to consider that the source measure is absolutely continuous while the target is supported on a finite set, which is referred as the semi-discrete framework. I will present in this talk a damped Newton algorithm, which is efficient in practice and whose convergence is proven to be linear for cost functions satisfying a classical condition appearing in the regularity theory of optimal transport. I will then show applications in non-imaging optics for the modeling of reflectors and refractors that satisfy light energy constraints

Energy 1

Claudia Sagastizábal, Wim van Ackooij, Rene Henrion, Alexander Kruger, Michel Thera,Welington de Oliveira - Bilevel Models for Unit Commitment with Demand-Side Management

Unit-commitment problems in electrical power energy management deal with finding production schedules that satisfy, preferably at minimum cost, all operational and technological rules of the considered thermal and hydraulic generation units, and system-wide constraints, including customer load.

Because the resulting optimization problems are often large-scale, to come up with a solution in computational times that are acceptable in practice decomposition methods are needed. Furthermore, due to the complexity of large power systems like the French one, many unit-commitment models in the literature are set in a deterministic environment. The increasing penetration of renewable sources makes it crucial to consider uncertainty and, hence, a stochastic modelling.

Indeed, the energy landscape undergoes significant changes worlwide, and an important share of intermittent generation is planned to be built / already part of the system. Furthermore, in addition to classical generating companies, large consumers have gained protagonism and can perform actions which may significantly impact on the load of the system. In particular, by using advanced information technology, they are (or will soon be) able to partially control their consumption of energy, for example by transferring this control to a third party specialized in Energy Management.

The information technology brings a new set of tools, refered to as **demand-side management** (DMS). Essentially, the tools make it possible to shift consumption from one moment of the day (typically, a peak-load time)to another one, deemed more convenient or profitable for the consumer (typically, out-of peak). As a consequence of the change in the demand of a large consumer, the load of the network is changed and power gets redistributed in the system (for instance, preventing congestion at peak times). Such modifications are globally beneficial for the system because generation costs and constraints are highly non-linear. Another important feature of this new setting is the (imminent) use of batteries which partially store intermittent energy and, hence, contribute to mitigate the uncertainty that is inherent to such power systems. These batteries may take the form of electrical vehicles.

In order to represent the relations above, and to best exploit the DMS flexibility, two new elements must be incorporated in the energy management model of the system. Specifically, the so-called **aggregators** and **microgrids**. While the former take advantage of regrouping a set of customers without generation assets, the latter deals with nearly isolated systems that handle locally their generation, in the quest of remaining (as much as possible) independent of the global network. In either case, a possibility to analyze the interactions with classical generators is to consider a set of suggested prices for buying and selling energy.

A further crucial feature in the unit-commitment modelling refers to data that is unknown, such as load, renewable generation, inflows, unit availability. To understand the impact of uncertain data, stochastic models that are suitable both for theoretical analysis and computational methods need to be studied.

To address the problematic above from a theoretical point of view, we consider a bilevel decentralized unit-commitment model for which we derive optimality conditions to be compared with the ones obtained with a classical unit-commitment model.

Fabio D'Andreagiovanni, Giovanni Felici, Fabrizio Lacalandra - Zero-price Energy Offering by (Multiband) Robust Optimization

We consider the problem of a price-taker generating company that wants to select energy offering strategies for its generation units, to maximize the profit while considering the uncertainty of market price. First, we review central references available in literature about the use of Robust Optimization (RO) for price-uncertain energy offering, pointing out how they can expose to the risk of suboptimal and even infeasible offering. We then propose a new RO-based offering method, which is characterized by making offers at zero price and overcomes all the limits of the benchmark methods. We show the effectiveness of the new method on realistic instances provided by our industrial partners, getting very high increases in profit. Our method is based on Multiband Robustness (MR - Büsing, D'Andreagiovanni, 2012), an RO model that refines the classical Bertsimas-Sim model, while maintaining its computational tractability and accessibility. MR is essentially based on the use of histogram-like uncertainty sets, which result particularly suitable to represent empirical distributions commonly available in uncertain real-world optimization problems.

Essential References:

1. C. Büsing, F. D'Andreagiovanni: New Results about Multi-band Uncertainty, in Robust Optimization, Proc. of SEA 2012, Springer LNCS 7276, 2012, doi: 10.1007/978-3-642-30850-5_7

2. C. Büsing, F. D'Andreagiovanni: Robust Optimization under Multiband Uncertainty - Part I: Theory, Experimental Algorithms, 2013, http://arxiv.org/abs/1301.2734

3. F. D'Andreagiovanni, G. Felici, F. Lacalandra: Revisiting the use of Robust Optimization for optimal energy o_ering under price uncertainty, 2016, Preprint available at http://arxiv.org/abs/1601.01728

Mahbubeh Habibian, Golbon Zakeri, Anthony Downward, Miguel Anjos, Michael Ferris - Co-optimization of Demand Response and Reserve Offers

We study demand-side participation in an electricity market for a major consumer who has flexibility in its demand and thus can respond to electricity prices as well as offer interruptible load reserve. We construct models of this consumer's optimal bidding strategies under two different assumptions. First, we treat all agents as price takers, leading to a competitive equilibrium in both energy and reserve. Second, we consider the consumer as a price maker, anticipating how its bidding may affect the market prices. The price making model is a bi-level optimization problem that embeds the optimal power flow problem, where electricity and reserve are co-optimized. In the upper level, the consumer's profit is maximized as a function of its demand bid and reserve offer. We reformulate this bi-level problem as a mixed-integer program with deterministic and stochastic versions. We show the results of co-optimization for a large consumer of electricity in the New Zealand Electricity Market.

OR 3 - Combinatorial Optimization (Invited Session, organized by Marie-Christine Costa and Sourour Elloumi)

Bruno Escoffier - Reoptimization algorithms for combinatorial problems

As part of the project entitled "Stability versus Optimality in Dynamic Environment Agorithmics", I will present algorithmic aspects of reoptimization problems. In these problems, we have an initial solution S of an initial instance I of a given optimization problem. I is subject to some slight modifications, and the goal is to transform S into a good solution for I'. Running time, quality of the solution and closeness to the initial solution are three important criteria to focus on.

I will illustrate the topic with some known results, and present some questions we want to address in this project.

Guillaume Sagnol, Thibaut Sauvage - A Completely-positive representation of the cone of flow matrices

We introduce the cone F(G) of flow matrices associated with a directed acyclic graph G with given source and sink nodes. A matrix is in this cone if, for some flow from the source to the sink, the entry (i,j) of the matrix is equal to the amount of flow that uses both arcs i and j. We show that the separation problem for the dual cone of F(G) reduces to solving a quadratic shortest-path problem in G, from which we deduce that the membership problem in F(G) is NP-hard. We show that several NP-hard optimization problems can be formulated as linear programs over this cone. As a consequence, there is no compact polyhedral or SDP-representation of F(G) unless P=NP. However, we show that F(G) admits a completely-positive representation, and we provide two approximation hierarchies for F(G). To demonstrate the strength of our relaxations, we present preliminary results for the maximum flow problem with pairces.

Spyros Angelopoulos, Christoph Dürr, Thomas Lidbetter - The expanding search ratio of a graph

We study the problem of searching for a hidden target in an environment that is modeled by an edge-weighted graph. A sequence of edges is chosen starting from a given root vertex such that each edge is adjacent to a previously chosen edge. This search paradigm, known as expanding search was recently introduced for modeling problems such as coal mining in which the cost of re-exploration is negligible. We define the search ratio of an expanding search as the maximum over all vertices of the ratio of the time taken to reach the vertex and the shortest-path cost to it from the root. Similar objectives have previously been studied in the context of conventional (pathwise) search.

In this paper we address algorithmic and computational issues of minimizing the search ratio over all expanding searches, for a variety of search environments, including general graphs, trees and star-like graphs. Our main results focus on the problem of finding the randomized expanding search with minimum expected search ratio, which is equivalent to solving a zero-sum game between a Searcher and a Hider. We solve these problems for certain classes of graphs, and obtain constant-factor approximations for others.

Black-Box Optimization

Benjamin Doerr, Carola Doerr, Timo Kötzing - Optimizing Multi-Valued Decision Variables with Evolutionary Algorithms

The most common representation in evolutionary computation are bit strings. This is ideal to model binary decision variables, but less useful for variables taking more values. With very little theoretical work existing on how to use evolutionary algorithms for such optimization problems, we study the run time of simple evolutionary algorithms on some functions defined over $\Omega = \{0, 1, \dots, r-1\}^n$. More precisely, we regard a variety of problem classes requesting the component-wise minimization of the distance to an unknown target vector $z \in \Omega$.

For such problems we see a crucial difference in how we extend the standard-bit mutation operator to these multi-valued domains. We propose and analyze several natural extensions. Interestingly, a good performance can be achieved for an algorithm using **self-adjusting mutation strength**. In this algorithm the size of the steps taken in each iteration depends on the success of previous iterations. That is, the mutation strength is increased after a successful iteration and it is decreased otherwise. We show that this idea yields an expected optimization time which is best possible for a wide class of algorithms.

This talk is based on work within the PGMO project "Parameter Optimization via Drift Analysis (PODA)".

Anne Auger - Revisiting the Benchmarking of Derivative Free Optimization Algorithms

Benchmarking is an important task to assist the design of optimization algorithms, to quantitatively compare and appraise performance of algorithms. It typically consists in collecting the runtime of algorithms on a set of test functions and displaying performance based on those runtimes. For this latter purpose, performance and data profile turn out to be central tools.

In this talk, we will revisit the benchmarking of derivative free optimization algorithms and how performance and data profile are often used. We will particularly discuss the importance of a representative set of test functions in order to avoid bias and misinterpretation of performance. We will explain aggregation over targets and discuss the shortcoming associated to aggregating over problem dimension.

We will illustrate our purpose using the COCO benchmarking platform (https://github.com/numbbo/coco).

Carola Doerr, Johannes Lengler - Cost of Elitist Selection in Discrete Black-Box Optimization

General-purpose optimization techniques such as local search or evolutionary and genetic algorithms form a powerful class of algorithms in discrete optimization. Many of these heuristics are **elitist** in the sense that they base their decisions only on best-so-far samples. It can be easily seen that such behavior can be disadvantageous, as these elitist algorithms do not exploit the information contained in samples of low function values.

In a series of recent work funded by PGMO project "Towards a Complexity Theory for Black-Box Optimization" we have proposed a model to analyze the cost of such elitist behavior. We have also analyzed in depth two classic optimization problems. Surprisingly, we find that elitism does not necessarily yield a performance loss for the Hamming distance problem, while for the related LeadingOnes problem the cost of elitism can be shown to be quite large.

The talk is based on results published at ACM GECCO 2015 and 2016, and to appear in Algorithmica and Evolutionary Computation.

Icode (Invited Session of the Institute for Control and Decision of the Idex Paris Saclay, organized by Yacine Chitour)

Paolo Mason - Optimal control methods for the stability of switched systems

The purpose of this presentation is to discuss recent results related to the problem of (uniform) stability of switched systems. Based on the work of N. Barabanov, it is well known that the stability properties of these systems are completely determined by the behavior of special paths called extremal trajectories. The latter can be defined as the trajectories that lie on the Barabanov spheres of suitably normalized switched systems. In this talk I will present a characterization of these trajectories as solutions of an optimal control problem and apply it in a particular three-dimensional case.

The presented results were obtained in collaboration with Yacine Chitour and Moussa Gaye

Antoine Girard - Robust controllers for nonlinear systems with performance guarantees: an approach based on discrete abstractions.

We present a methodology to synthesize robust controllers for nonlinear systems.

Our approach relies on the use of discrete abstractions, which are dynamical systems with finitely many states (e.g. an automaton) and whose trajectories encompass the trajectories of the original system.

Robust controller synthesis can then be handled at the level of the discrete abstraction. Moreover, a performance criteria can be optimized using dynamic programming over the discrete abstraction, which also provides performance guarantees for the original system. Furthermore, we show how compositional techniques allow us to use our approach for complex interconnected systems.

Finally, we show an application of our approach to temperature regulation for an experimental small-scale building.

Frédéric Jean - Inverse Optimal control: the sub-riemannian case

A problem of inverse control can be formulated as follows: given a set of trajectories and a control system, find a cost function for which the given trajectories are optimal. The first question is hat of the uniqueness of the solution of such a problem. For general classes of cost functions, the question seems very difficult, even for a trivial dynamic. We therefore focus on the class of cost functions which are quadratic in the control and the dynamic linear in the control (riemannian and sub-riemannian cases). In the latter one, we reduce the problem to the existence of geodesically equivalent metrics and we will describe the existing results, from Levi-Civitta's theorem (1890) until those obtained recently with Sofya Maslovskaya and Igor Zelenko.

Games and Probabilities

Rene Henrion, Wim van Ackooij, Pedro Perez Aros - Aspects of Nonsmoothness for Gaussian Probability Functions

We consider probability functions $\varphi(x):=P(g(x,\xi)\leq 0)$ assigning to each decision vector x the probability that a random inequality system induced by a Gaussian random vector ξ is satisified. Such functions play a crucial role in optimization problems involving probabilitic constraints or aiming at reliability maximization. Even for smooth mappings g the resulting probability function φ may fail to be so. The characterization of continuity, Lipschitz continuity and differentiability of φ requires appropriate constraint qualifications for the inequality system along with some growth condition imposed on the partial derivatives of g. Using the spheric-radial decomposition of a Gaussian random vector, we provide the required conditions complemented by (sub-) gradient formulae for φ.

Piernicola Bettiol - Differential Games confined to path-wise constraints

In some circumstances the design of control systems has to take account of both path-wise constraints, which represent the necessity to avoid particular ‘dangerous’ regions, and the presence of disturbances (or modelling inaccuracies), which might affect the system performance. Interpreting the disturbances as ‘strategies’ of an antagonistic player, we obtain a Differential Game. We shall introduce the topic of state constrained Differential Games (in the deterministic context), discussing some recent results.

Charles Bertucci - Optimal stopping in mean field games

Mean field games (MFG) have been widely studied since their introduction ten years ago by Lasry and Lions. Those games typically model situations where an infinite number of identical agents face the same optimal control problem. The cost depends on the other agents uniquely through their repartition as the agents are indiscernable. We will here present a new model of MFG where the agents are now facing an optimal stopping problem instead of an optimal control problem. This new question leads to the apparition of new phenomena like the non existence of solution which differs from the classical model of MFG. We will then present a new approach for MFG in terms of mixed strategies. In this new setting we will see that the optimal stopping problem in MFG is now well posed under the classical monoticity hypothesis on the cost functions. We will also talk about the problem of the meaning of the equation satisfied by the agents' distribution. This question is non trivial and we believe it is crucial to elaborate new results around the problem of optimal stopping in MFG. This work has been realized with Pierre-Louis Lions.

OR 5

Margaux Nattaf, Christian Artigues, Pierre Lopez - An exact method for a continuous scheduling problem with concave efficiency functions

We consider a cumulative scheduling problem where a task duration and resource consumption are not fixed. The consumption profile of the task, which can vary continuously over time, is a decision variable of the problem to be determined and a task is completed as soon as the integration over its time window of a non-decreasing and continuous efficiency function of the consumption profile has reached a predefined amount of energy.

The goal is to find a feasible schedule, which is an NP-completeproblem. For the case where functions are concave and piecewise linear, we present a propagation algorithm. This algorithm is an adaptation to concave functions of the variant of the energetic reasoning previously established for linear functions. Furthermore, a full characterization of relevant intervals for time-window adjustments is provided. A Mixed Interger Linear Program (MILP) solving the problem is also provided and its performance is compared to the ones of a hybrid branch-and-bound combining the propagation algortihm and the MILP.

Stephane Chretien, Nathalie Herr, Jean-Marc Nicod, Christophe Varnier - Scheduling independent parallel machines with convex programming

In the field of production scheduling, this paper adresses the problem of maximizing the production horizon offuel cell systems under service constraint. Convex optimization is used to define at each time the contributionof each fuel cell to the global output so as to satisfy a power demand as long as possible. An algorithm basedon the Mirror-prox for Saddle Points method is proposed to cope with the assignment problem. Results basedon computational experiments assess the efficiency of this approach in comparison with an intuitive resolutionperforming successive basic convex projections onto the sets of constraints associated to the optimization problem

Stephane Chretien, Paul Clarkson, Alistair Forbes - A convex relaxation of the optimal sensor placement problem in power grids

Power grids have recently been the subject of an extensive research activity. The observations in such systems are usually quadratic functions of the voltages and the resulting state estimation problem turns out to be nonconvex. In this work, we present a refinement of the E-optimal design criterion for sensor placement in power grids based on an asymptotic analysis of the optimality conditions in the convex Semi-Definite Programming relaxation of the state estimation problem. We will present an implementation of the level bundle method for this problem and show encouraging simulation experiments.

Jia Liu, Immanuel Bomze, Abdel Lisser, Jianqiang Cheng, Peter Dickinson - New formulations, relaxations and penalisations for mixed binary Qps

Since Burer's seminal paper on the copositive reformulation of mixed-binary QPs, many alternative formulations have been discussed. Moreover, most of them can be used as proper relaxations, if the intractable completely positive cones are replaced by tractable approximations. While most of the approximation hierarchies have the disadvantage to use psd matrices of orders which rapidly increase with the level of approximation, alternatives focus on the problem of keeping psd matrix orders small, with the aim to avoid memory problems in the interior point algorithms. Some variants even avoid SDPs completely, using an alternating projection method (for which however no convergence proof is available yet). This study is the first to treat the various variants from a common theoretical perspective (for the exact formulations), using concise arguments. Moreover, a small study of the notoriously hard multidimensional quadratic knapsack problem adds some empirical evidence on performance differences among them. We also propose an alternative approach using penalization of various classes of constraints which in some sense are similar in spirit to the alternating project methods but where some theoretical analysis can be done. Some preliminary numerical results will be given.

Energy Management and economic valuation (Invited Session, organized by Jean-Philippe Chancellier)

Teemu Pennanen - Asset valuation and optimal investment

We present a unifying framework for optimal investment and asset valuation in incomplete markets. We study hedging-based notions of asset value and relate them to the classical notions of risk neutral and net present values. The framework allows various classical results from financial mathematics to be extended to illiquid markets and assets with optionalities. The techniques are illustrated with applications to derivatives markets in energy and finance.

François Pacaud - Optimization of a district microgrid

Most of european countries must produce more than 20 % of their electrical energy with renewable energies by 2020, and smart and micro-grids are more and more put forward to achieve this goal. These new technologies allow utility managers to control in real time the consumption of consumers and the production of different power plants. Deterministic controls, such as Model Predictive Control (MPC), are the most used methods to manage a microgrid. But consumptions and renewable energy productions are hardly foreseeable, and it is often difficult to satisfy the adequation between demand and production in deterministic framework. That is why we focus on stochastic optimal management to control a microgrid. We consider here a district microgrid, with several houses connected together via a local net-work. Some houses are equipped with solar panels and batteries, thus providing local distributed sources of energy. Each house is modelled with discrete time equations, which describe the behaviour of electrical and thermal systems, and we aim to satisfy at each timesteps the thermal and electrical demands while minimizing the operationnal cost. This problem is a large-scale multistage stochastic problem, hence difficult to solve through classical approach as Stochastic Dynamic Programming. That is why we consider here Approximate Dynamic Programming methods | such as Stochastic Dual Dynamic Programming (SDDP) | to tackle the challenge offered. We will put emphasis on the algorithms used and the numerical results obtained.

This work is part of a larger program, aiming to control large-scale microgrid where several houses and decentralized power sources are connected together through the local network. As the size of the problem increases, other methods must be investigated to tackle the curse of dimensionality. Decomposition and coordination schemes have proved their effectiveness in deterministic settings , and DADP (Dual Approximate Dynamic Programming) offers promising results in the stochastic framework. We will sketch some perspectives to apply such algorithms to large-scale smart-grid problems (for instance several district microgrids connected together).

Tristan Rigaut - Energy Efficiency Investment and Management for Subway Stations

Urban railway stations represent a significant amount of energy consumption of cities subway system. We could improve their energy efficiency by harversting various unexploited renewable or recoverable energy resources.

Regenerative braking from the subways represent an important amount of energy that is currently partially wasted. To fully exploit this energy potential we need an electrical storage system in order to handle the variability and the numerous uncertainties that pervade the electrical network. Even though their price is predicted to drop in the next few years, that kind of systems is currently particularly expensive. They require therefore an optimal usage during their whole lifetime to minimize their effective cost. Moreover getting a return on investment with batteries is totally dependent of the energy market. In a country like France where the electricity is cheap it is even harder to realize a viable investment. We present hereby stochastic optimization methods for real time control of such systems to cover the liabilities generated by our energy efficiency investments. The future state of electricity markets as well as batteries and supercapacitors prices evolution are uncertain. To handle and model this stochasticity and actors risk averse behaviour, we use stochastic optimization to compute the price of energy efficiency for a given subway station. First we compare different methods to control batteries in real time in a subway station context. Then we propose a financial valuation strategy that takes into account the uncertainties and risk aversion of an electrical storage buyer. Finally we integrate the return provided by the real time optimal control of a battery into the investment problem. We solve the interdependent optimization problems with a dynamic programming framework. Simulations and optimization results based on an industrial case study are presented.

Energy 2

Rodolphe Griset - Nuclear Power Plant Outage Planning : an exact optimization approach to test robustness to demand variations and power plant availability

Electricity in France is mainly generated from nuclear power plants. The multi-annual outage planning of these power plants has to comply with various constraints regarding safety, maintenance, logistics and plant operations, while it must lead to a feasible production program at minimum cost. Given the size of the problem, EDF currently uses local search based tools to optimize the planning. This approach leads to important limitations: a search space limited to local solutions around a given planning; optimization at the aggregated level of weekly time steps; and the use of an estimated average production cost of the remaining production to be fulfilled by conventional thermal power plants, rather the actual scenarios of demand and plant availability. We develop an approach that rely on exact mathematical optimization tools in the aim of gradually lifting those limitations. Our model makes use of column and row generation techniques. It considers a wider search space and allows to satisfy the demand at an infra-daily time step. The use of Benders decomposition (via a row generation algorithm) enables us to test robustness over several demand scenarios. Our model can be extended to account for "smooth" fluctuations in nuclear power plant availability.

OR 4 - Robust and bilevel optimization (Invited Session, organized by Marie-Christine Costa and Sourour Elloumi)

Pierre-Louis Poirion, Sonia Toubaline, Claudia D'Ambrosio, Leo Liberti - On the Binary Bilevel Problem

In this talk, we present a new algorithm to solve the Binary Bilevel Linear Problem (BBLP), which is a linear program where some of the variables are constrained to belong to the set of optimal solutions of another Mixed Integer Linear Program (MILP), called the *lower level.* More precisely the decision variables, (x,y), are such that x is binary, y is mixed-integer and must minimize a linear function over a polytope that depends of x. We will first preset how to solve a simplified version of this problem through a cut algorithm, as well as an application for monitoring a smart-grid. We will then explain how to generalize our approach.

Dritan Nace, Akli Fundo, David Savourey, Fatjon Gjata - The robust flight level assignment problem

The objective of the talk is twofold. First, we present a generic heuristic approach. Our goal is to show how one can deduce an approximated method for a robust optimization problem when the counterpart for the deterministic version is given, for a large range of problems, especially those which could exploit the available experimental data, present in large quantity. The method is easily to cases when data are not necessarily available but can be randomly generated/simulated given the context of the application. Second, for illustrating the practical relevance of this approach, we present a study on the problem of robust flight level assignment problem, which comes up in air traffic management area. The main idea is to allocate different altitude levels to flights in order to avoid conflicts. Then, if two flights are assumed to be in conflict, they must be routed on two different levels. The problem becomes trickier when the uncertainty aspect is considered. Numerical results will be provided.

Céline Gicquel, Safia Kedad-Sidhoum, Quan Vu - A multi-stage stochastic programming approach for remanufacturing planning under uncertainty

One possible way of mitigating the environmental impact of industrial products in terms of waste generation and natural resource consumption is by remanufacturing them once they have reached their end of life. Remanufacturing consists in replacing components or reprocessing damaged parts from used products in order to bring them to a like-new condition. In the present work, we consider the problem of planning production for a remanufacturing system involving three production echelons: disassembly of returned products, refurbishing of recovered parts and reassembly of remanufactured products. We first investigate a deterministic variant of the problem. We formulate it as a mixed-integer linear program and focus on its resolution through Cut & Branch and Branch & Cut algorithms. We then investigate a stochastic variant of the problem in which the uncertainties on the quantity of returned products and on the demand for remanufactured products are explicitly taken into account. We propose a multi-stage stochastic programming approach relying on a scenario tree to represent the uncertainty. The extension of the solution algorithms proposed for the deterministic problem to solve its stochastic counterpart is then discussed. Preliminary computational results are presented.

Matteo Fischetti, Ivana Ljubic, Michele Monaci, Markus Sinnl - Interdiction Games and Monotonicity

Two-person interdiction games represent an important modeling concept for applications in marketing, defending critical infrastructure, stopping nuclear weapons projects or preventing drug smuggling. In these problems, two non-cooperative players (the leader and the follower) share a set of items, that may be used by at most one of the two players, and the leader may select some items and interdict their usage by the follower. The two players optimize over the same objective function, but in the opposite direction.

We present an exact branch-and-cut algorithm for interdiction games, under the assumption that feasible solutions of the follower problem satisfy a certain monotonicity property. Prominent examples that fall into this category are knapsack interdiction, matching interdiction, and packing interdiction problems. Our branch-and-cut algorithm uses a solution scheme akin to Benders decomposition, based on a family of so-called interdiction cuts. We present modified and lifted versions of these cuts along with exact and heuristic procedures for the separation of interdiction cuts, and heuristic separation procedures for the other versions. In addition, we derive further valid inequalities and present a new heuristic procedure.

We computationally evaluate the proposed algorithm on a benchmark of 360 knapsack interdiction instances from literature, including 27 instances for which the optimal solution was not known. Our approach is able to solve each of them to optimality within about one minute of computing time on a standard PC (in most cases, within just seconds), and is up to 4 orders of magnitude faster than any previous approach from the literature. To further assess the effectiveness of our branch-and-cut algorithm, an additional computational study is performed on 144 randomly generated instances based on 0/1 multidimensional knapsack problems.

Tropical methods (Invited Session, organized by Xavier Allamigeon)

Anne Bouillard - Computing optimal worst-case performance bounds with Network Calculus

Network calculus is a theory that has been developed since the 1990's to compute worst-case performance bounds in networks, with applications to communication and real-time networks. It is based on the (min,plus) algebra: flows of data are modeled by (min,plus) functions named arrival curves, and the service offered by any network element by (min,plus) functions named service curves. Worst-case performance bounds (end-to-end delay of a flow, maximum occupancy of a buffer) are computed using (min,plus) operations such as the (min,plus) convolutions and deconvolutions.

Unfortunately, the bounds computed this way can be very pessimistic even for very simple networks. In this talk, I will show how to get rid of this pessimism and obtain optimal worst-case performance bounds in feed-forward networks using linear programming or greedy algorithms.

Laure Daviaud - About the description of functions computed by max-plus automata

Max-plus automata are a kind of quantitative automata closely related with matrices over the max-plus semiring. They compute functions from a set of finite words to the set of integers. In this talk, I will present some results about the description of such functions. In particular, comparing such a function with the function that maps a word to its length is an undecidable problem. Even though, I will give algorithms that approximate this problem. I will also expain the link between these problems and the computation of a quantity associated with finite sets of matrices : the joint spectral radius. This talk is based on joint works with Thomas Colcombet, Pierre Guillon, Glenn Merlet and Florian Zuleger.

Marianne Akian, Mustapha Bouhtou, Jean Bernard Eytard, Stéphane Gaubert - Price incentives in mobile networks: a tropical approach

We propose a model of price incentives in mobile networks, in which an operator wishes to balance the traffic.

We assume that each user has a given total demand per day, which he may assign to different locations and time slots, depending on his own preferences and on price discounts proposed by the operator. We show that this can be cast as a special bilevel programming problem which can be solved by a decomposition method: first, we determine the optimal traffic (which maximizes a measure of balance); next, we determine the prices generating this traffic. Our results exploit recent applications of tropical geometry to economic problems (Baldwin, Klemperer, 2012, Yu, Tran, 2015) , as well as algorithms in discrete convexity (Murota 2003).

Applications

Bayarbaatar Amgalan - An integrated method for uncovering key effects on cancer-activated multi-dimensional network

Uncovering the key insights responsible for miscoordination among biological processes is essential for demonstrating cellular malfunctions in cancer. The details of control mechanisms in biological process can be understood by analyzing interacting neighbors and local patterns. Network structures often have been used to describe these complex bio molecular pathways and functional modules by representing a whole set of interactions as overlapping sub-networks, each associated with a specific condition such as cancer. In this work, we construct a large scale gene network by simultaneously estimating the weights of all incoming influences for each gene based on minimization of a convex least square error function subject to an l_1 norm constraint. The solution to the optimization problem represents the weights of relationships between gene pairs in each of three sets of genomic data.

The condition-specific alterations can be observed in several data types, such as DNA copy numbers, gene expressions, mutations and so on, since cells are complex system with multiple levels of organizations that interact and influence each other in a data type or across different data types. The coordination between regulatory mechanisms on activations of biological processes can be understood by simultaneously analyzing multiple type data.

Here, we propose an integrated method for identifying key genes whose alterations produce a major effect on a cancer-activated multi-dimensional gene network. Functional associations between genes in a data type or across different data types are measured to form three different weighted networks, then the interactions in data types are mapped onto a network to construct a multi-dimensional gene network by an optimal linear combination of the weight matrices with an l_2 norm constraint in the first octant. Finally, based on the interaction behavior of genes, the majority effect of a gene is measured using centrality and betweenness node scores.

We first tested our method on simulated data sets, then applied it to a real breast cancer data. KPOCN successfully uncovered the significant explanatory variables (regulators) with their corresponding response variables (targets) in simulated data, and identified well-known oncogenes in breast cancer. The results demonstrated that our efficiently uncover key genes whose alterations cause dramatic effects on cancer activation.

Control 2

Dominikus Noll - Robust control for mixed system uncertainty

By way of examples we discuss forms of uncertainty under which controlled systems may suffer. The challenge for control engineering is to enable system stability and performance despite these degrading effects. We sketch how we design control laws which are robust against two notorious types of uncertainty known as real parametric, and as complex dynamic. Our novel approach is developed as part of the PGMO project «Robust Optimization for Control» and presents the first valid algorithmic solution to the so-called mixed uncertainty problem, which had been posed in the late 1970s, and due to its importance for practice, had remained high on the agenda since then.

Francisco José Silva Alvarez, Joseph Frédéric Bonnans, Justina Gianatti - On the convergence of discrete optimal controls

In this talk we survey some classical and new results regarding the discretization of stochastic optimal control problems. We focus our attention on time-discrete approximations recalling first some classical convergence result for the value function which can be proved by using analytic or probabilistic arguments. Next we discuss the more delicate issue of the convergence of the optimizers as well as an algorithm for the time-discrete problem.

Michael Orieux, Jean Baptiste Caillau, Jacques Féjoz - Problème de transfert en temps optimal

Si l'on cherche à contrôler un engin spatiale dans un système planétaire, on étudie l'équation de Kepler contrôlée, cela conduit à étudier le problème de contrôle optimal en temps min donné de manière générale par un système Sous-Riemannien. On étudie ici le comportement des solutions optimale qui possèdent des pi-singularités, aussi appelées switch, en dimension 4.

On montre qu'il y a unicité des trajectoires extrémales contenant ce type de singularité. Ce travail est inspiré entre autre de travaux d'A. Agrachev en dimension inférieur.

Index of authors

Carrasco, Mailyng	15
Carrasco, Rodrigo	15
Homem-De-Mello, Tito	15
Pagnoncelli, Bernardo	15
Aussel, Didier	16
Svensson, Anton	16
Brotcorne, Luce	16
von Niederhäusern, Léonard	16
Ngueveu, Sandra Ulrich	16
Zakhour, Camille	17
Gramfort, Alexandre	18
Ndiaye, Eugene	18
Salmon, Joseph	18
Carrizosa, Emilio	18
Nogales Gómez, Amaya	18
Romero Morales, Dolores	18
Cevher, Volkan	18
Tran-Dinh, Quoc	18
Henrion, Didier	19
Naldi, Simone	19
Safey El Din, Mohab	19
Fawzi, Hamza	19
Allamigeon, Xavier	19
Gaubert, Stephane	19
Skomra, Mateusz	19
Koessler, Frédéric	19
Laclau, Marie	19
Tomala, Tristan	19
Lovo, Stefano	20
Sorin, Sylvain	20
Mirebeau, Jean-Marie	20
Cuturi, Marco	20
Thibert, Boris	20
de Oliveira, Welington	21
Kruger, Alexander	21
Sagastizábal, Claudia	21
Thera, Michel	21
D'Andreagiovanni, Fabio	21
Felici, Giovanni	21
Lacalandra, Fabrizio	21
Anjos, Miguel	21
Downward, Anthony	21
Ferris, Michael	21
Habibian, Mahbubeh	21
Zakeri, Golbon	21
Escoffier, Bruno	22
Sagnol, Guillaume	22
Sauvage, Thibaut	22
Angelopoulos, Spyros	22
Dürr, Christoph	22
Lidbetter, Thomas	22
Doerr, Benjamin	23

Kötzing, Timo	23
Auger, Anne	23
Lengler, Johannes	23
Mason, Paolo	24
Girard, Antoine	24
Jean, Frédéric	24
Perez Aros, Pedro	24
Bettiol, Piernicola	24
Fischetti, Matteo	25
Ljubic, Ivana	25
Monaci, Michele	25
Sinnl, Markus	25
Bertucci, Charles	25
Artigues, Christian	25
Lopez, Pierre	25
Nattaf, Margaux	25
Herr, Nathalie	25
Nicod, Jean-Marc	25
Varnier, Christophe	25
Clarkson, Paul	25
Forbes, Alistair	25
Bomze, Immanuel	26
Cheng, Jianqiang	26
Dickinson, Peter	26
Lisser, Abdel	26
Liu, Jia	26
Pennanen, Teemu	26
Pacaud, François	26
Rigaut, Tristan	26
Griset, Rodolphe	27
D'Ambrosio, Claudia	27
Liberti, Leo	27
Toubaline, Sonia	27
Fundo, Akli	27
Gjata, Fatjon	27
Nace, Dritan	27
Savourey, David	27
Gicquel, Céline	28
Kedad-Sidhoum, Safia	28
Vu, Quan	28
Bouillard, Anne	28
Daviaud, Laure	29
Akian, Marianne	29
Bouhtou, Mustapha	29
Eytard, Jean Bernard	29
Gaubert, Stéphane	29
Amgalan, Bayarbaatar	29
Noll, Dominikus	30
Bonnans, Joseph Frédéric	30
Gianatti, Justina	30
Caillau, Jean Baptiste	30
Féjoz, Jacques	30

Orieux, Michael	30
Silva Alvarez, Francisco José	8,3
Perchet, Vianney	12
Caillau, Jean-Baptiste	13
Bentz, Cédric	17
Costa, Marie-Christine	17
Ridremont, Thomas	17
Poirion, Pierre-Louis	17,27
Fercoq, Olivier	18
Henrion, Rene	21,24
van Ackooij, Wim	21,24
Doerr, Carola	23
Chretien, Stephane	25