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SOFTWARE

Summary

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Editorial by Charles Audet

Georges Zaccour acted as director of the *GERAD Newsletters* since its creation back in February 2004. Many topics were discussed in this publication over the years, and we would like to thank George for having conceived and maintained this newsletter. It is with enthusiasm that Gilles Caporossi and I agree to take over as the new editors.

Many strengths and successes from GERAD were presented in the past few years and this new edition seeks to illustrate another type of important contributions. Several software packages are developed within our walls to treat specificities of various problems studied by our researchers. Some of this software is designed to be exported and used on a larger scale, and this issue of the *Newsletters* is devoted to some of these softwares.

More precisely,

- Dominique Orban describes the software packages devoted to numerical optimization NLPy, PyKrylov and PyOrder written in the Python programming language, which allow rapid and efficient implementation of innovative methods.
- Sébastien Le Digabel and Christophe Tribes present the NOMAD blackbox optimization software designed for situations in which the functions defining the problem are the result of a time-consuming numerical simulation, which can possibly be contaminated by noise.
- Guy Desaulniers, Jacques Desrosiers and François Soumis recall the evolution over the last 30 years of the GENCOL software, built for problems in which the number of variables is so large that the memory required to describe it exceeds the capacity of the computer.
- Maria De Lourdes Vazquez, Jean-Philippe Waaub and Adrian Ilinca discuss the TIMED approach for the design and evaluation of wind farms configurations, and offering the possibility of analyzing alternative scenarios.
- Gilles Caporossi presents AutoGraphiX, a software exploiting state-of-the-art optimization methods for graph generation with many applications in artificial intelligence, graph theory, mathematical chemistry and telecomunications.

These different software packages allow GERAD to export its expertise in optimization, modeling, design and analysis to a wide audience. As in many fruitful researches, the development of these softwares is still in progress, and it is certain that their use will continue to grow.

Charles Audet

Numerical optimization in the python™ ecosystem

Dominique Orban

Over the past decade, the popularity of the Python programming language as a general-purpose tool for computational science has grown tremendously. On the day of this writing, a Google search for "Python science" returns 29.3 *million* hits, including scientific libraries, talk or lecture notes and slides, links to Python distributions pre-packaged with numerous scientific extensions, IDEs, companies offering training, and so forth. Libraries are available in most areas of scientific computing but also in computational economics, bioinformatics, graph theory and many more. Contrary to some other scientific development environments, Python is no *little language* – in the sense of Bentley (1986) – in that it supplies an extensive standard library ranging from thread management, compression and encryption to database access, web page generation and multimedia services. It is highly readable and object oriented. It ranks very high in the category of general-purpose languages that also happen to be practical for computational science but is far easier to use and has shorter development cycles than traditional compiled languages. In a graduate class taught at Polytechnique Montréal, students learn enough Python in one to three weeks to allow them to build a basic traveling salesman solver from the ground up in thirteen weeks. This kind of development speed can only be achieved with a flexible interpreted language that offers sufficient power to represent such abstract concepts as tours or spanning trees in few lines of code. Students complete their project by interfacing their solver with Google Maps, allowing to compute tours on-the-fly as locations are selected on a map. This shows how a prototype numerical method can be turned into a more complete application all in the same convenient language.

At GERAD, my graduate students and I use Python for our day-to-day research but also for most other computational tasks, scientific or not. Over time, we developed several packages aiming to solve specific computational mathematics problems. Those problems include continuous optimization, linear algebra and infinite-dimensional optimization problems with differential constraints. For intensive computational tasks, Python is easily interfaced with low-level compiled languages such as C or Fortran. This allows us to implement the logic of numerical methods in a high-level language without sacrificing efficiency. In the rest of this column, I describe a few of our packages. A complete description will shortly be available in the form of a Cahier du GERAD (Orban, 2013) and the software itself can be accessed from my home page at www.gerad.ca/~orban/software.html.

NLPy, which stands for *nonlinear programming in Python*, provides building blocks to construct numerical methods for continuous optimization. It offers modeling facilities optionally supplemented by automatic differentiation, line search and trust-region management, the generation of linear or quadratic models of a nonlinear problem, matrix

factorizations tailored to the structure of constrained problems, several limited-memory approximations of second derivatives, and more. In addition, it provides a number of numerical methods for several problem types: unconstrained, bound-constrained, convex quadratic, constrained linear least-squares, general nonlinear, problems with complementarity constraints and so forth. Lately, problems exhibiting a certain kind of degeneracy have been in the spotlight in NLPy. Several of my current and past graduate students have made important contributions to NLPy and built substantial software that is at the heart of their research work.

The modeling facilities in NLPy are sufficiently general that interacting with other packages is relatively easy. An application that is currently under development interfaces with the FEniCS library (Logg et al., 2012), which specializes in the numerical solution of PDEs by the finite-element method. In this new application, users are able to model infinite-dimensional problems defined over regular or irregular domains in which a functional is optimized subject to satisfying a set of PDE constraints.

It is highly readable and object oriented.

A kernel central to all algorithms for large-scale continuous optimization is the solution of linear systems or linear least-squares problems. The PyKrylov package implements a number of well-known and new Krylov-type methods for such problems. A feature of those methods is that the coefficient operator of the system need not be available in matrix form. Instead, the user provides means to compute products with the operator and possibly with its transpose. High-level objects represent operators but still allow users to use familiar matrix notation such as A*x to compute products. Users can combine operators to construct more elaborate operators by using, e.g, composition and block operators. Addition of new methods is made simple thanks to object orientation. By design PyKrylov communicates transparently with other Python packages such as NLPy and FEniCS.

The PyOrder package is an interface to well-established matrix ordering subroutines from the HSL (2011) and allows to manipulate sparse matrices in well-known exchange formats such as the Harwell-Boeing and Rutherford-Boeing formats.

Together, NLPy, PyKrylov and PyOrder provide a complete development environment for novel numerical optimization methods. Pierre-Rémi Curatolo graduated a few years ago and developed a nonlinear interior-point solver for problems with vanishing constraints. His solver could be used to solve shape optimization problems. Zoumana Coulibaly recently graduated and built upon Pierre-Rémi's solver to solve problems with complementarity constraints that is at the same time general purpose and competitive with the best specialized solvers. Mohsen Dehghani is currently finishing his Master's at GERAD and used NLPy to develop a large-scale solver for constrained linear least-squares problems using a regularization approach. His solver can be used to find sparse reconstruction of noisy signals or solve matrix completion problems. Using novel kernels in PyKrylov, he is working on making his solver entirely matrix free. Sylvain Arreckx is working towards his Ph.D. at GERAD and together with Andrew Lambe, who is doing his Ph.D. in the Aeronautics Department of the University of Toronto, he developed a matrix-free augmented

Lagrangian for structural optimization problems. Kien Cong-Dang recently graduated and his thesis revolved around a Python modeling environment for parameter optimization problems. His environment allowed him to tune several optimization solvers and to devise hybrid sort methods that outperform individual sorts – see github.com/dpo/opal. Mehdi Towhidi is currently finishing his Ph.D. and developed a Python environment to conveniently model linear and mixed-integer optimization problems – see github.com/mpy/CyLP. His environment also allows him to customize the solution process by injecting his own pivot rules or cut generators, all in just a few lines of code.

If novel and efficient methods can be implemented in just a few weeks, these are truly exciting times for numerical optimization! ■

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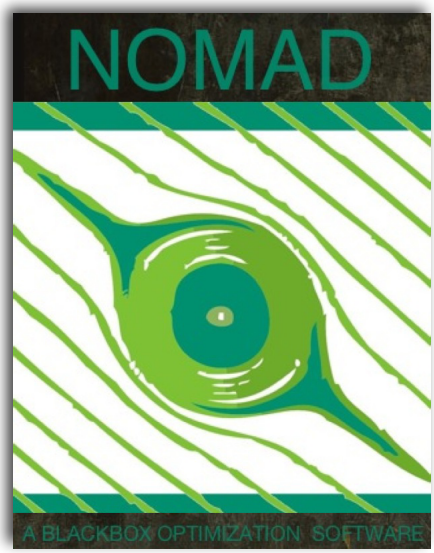
The NOMAD software for blackbox optimization

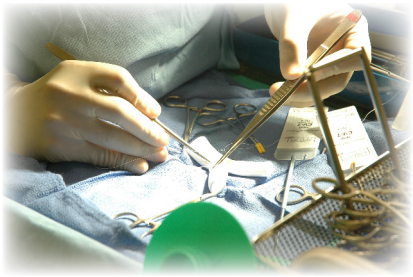


Sébastien Le Digabel & Christophe Tribes

NOMAD is a free software for *blackbox* optimization problems developed at GERAD by the research team of professors Audet and Le Digabel from Polytechnique Montréal.

A blackbox optimization problem consists to minimize an objective subject to constraints, and the different functions defining the problem may require the execution of one (or more) simulation. This may be costly in terms of computational time, and derivatives are not available. Such simulations can be found in many areas of engineering, such as the simulator developed by the team of Professor Alison Marsden from the University of California, San Diego (see in Figure 2 a picture excerpted from her work). Such blackbox simulates the behavior of a cardiac implant designed for newborns and its shape optimization aims to improve in vivo durability.

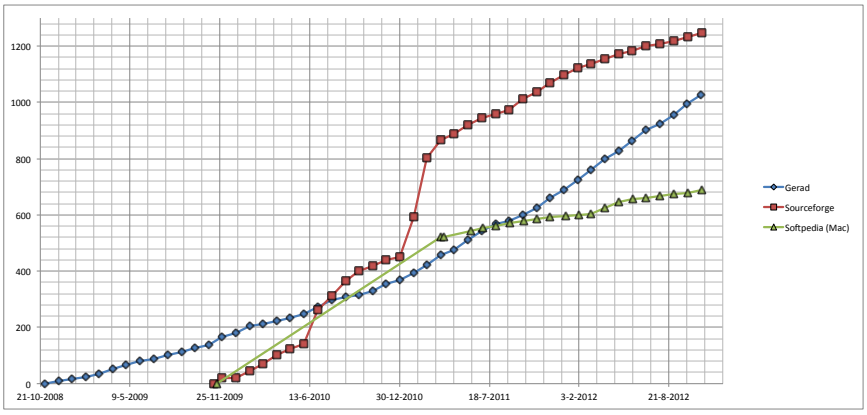
In the optimization context, the aim is to find the best feasible solution given a limited budget of evaluations. For this, we consider the *Mesh Adaptive Direct Search* (MADS) algorithm developed by the professors Audet and Dennis in 2006. This method



NOMAD is coded in standard C++ and is not dependent of any external library, allowing a multi-platform use.

belongs to the family of direct search method, which includes the well-known *Nelder-Mead* a lgorithm, sometimes called the *other simplex method*. However, the Nelder-Mead algorithm dates back to the sixties and is a heuristic that can sometimes behave badly. His descendants, such as MADS, are part of a second generation of methods that have emerged since the nineties and possessing strong convergence analysis based on nonsmooth calculus tools.

NOMAD was created in 2001 under the leadership of professors Audet and Dennis. It was originally an implementation of the *Pattern Search* method, a special case of MADS. Since 2006, NOMAD includes MADS and the software acronym has been changed for *Nonlinear Optimization with the MADS algorithm* (the original choice of the term "nomad" remains unclear).



The software has undergone two major revisions so far and many developers have contributed to it, including the present authors and the research associate Gilles Couture. NOMAD is now under the responsibility of the research associate Christophe Tribes.

NOMAD is coded in standard C++ and is not dependent of any external library, allowing a multi-platform use. It is freely distributed under the LGPL license on three different websites, including its official GERAD webpage www.gerad.ca/nomad. A MATLAB version is also available through the optimization toolbox OPTI Toolbox.

The software is constantly evolving to include recent contributions to expand the range of problems that can be treated and improve its performance. Such extensions include integer and category variables support, biobjective optimization, and the surrogate and quadratic models. External tools are also provided, such as a sensitivity analysis tool for measuring the impact of constraints relaxation on the objective. Finally, three different parallel versions of the software are available to allow high performance computing of costly blackbox evaluations.

NOMAD users include both academic researchers and companies of all sizes including Airbus, Boeing, Hydro-Québec, etc. Since the release of the third version in 2008, NOMAD has been downloaded about 3000 times and the download statistics given in Figure 3 show that the trend is rising. ■

Figures legends

Figure 1: The NOMAD logo inspired from the Dennis-Wood canoe function

Figure 2: *Y-Graft* cardiac implant being prepared for surgery (credit: A.L. Marsden)

Figure 3: NOMAD downloads

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GENCOL

Guy Desaulniers, Jacques Desrosiers & François Soumis

GENCOL is a solver for a wide class of problems arising in operations research. It is used for solving applications whose solutions can be represented as paths in networks. These paths correspond, for example, to locomotive itineraries or to rotations (pairings) of pilots and flight attendants that operate the flights offered by a commercial airline. These applications are relatively difficult to solve given the complexity of the maintenance rules or those established in collective agreements. The methodology used in GENCOL, column generation, allows to solve problems with ... a few hundreds of millions of millions of such paths, in school bus, air, urban, rail, and maritime transportation as well as in personnel scheduling.

GENCOL is a library of functions, coded in the C language, that allows to easily implement a column generation method.

Column generation is an advanced mathematical programming technique that enables the solution of linear programs with a very large number of variables associated with objects that can be represented implicitly in a mathematical model such as paths in networks. It can also be embedded into a branch-and-bound procedure to solve integer programs. GENCOL is a library of functions, coded in the C language, that allows to easily implement a column generation method. This library includes functions to manage a branch-and-bound tree, to call a linear programming solver such as Cplex, and to solve different variants of the shortest path problem with resource constraints.

As told in Desrosiers (2010), GENCOL is more than 30 years old and it is also the name of a team. The solver and the softwares integrating it are the results of the work of around 50 computer analysts, 150 MSc and PhD students, and several post-doctoral fellows recruited from various countries. It was developed at the GERAD under the careful supervision of François, Jacques and Guy. It also ensues from the nice academic-industrial collaboration between HEC Montréal and Polytechnique Montréal on the one hand, and the two main commercial partners AD OPT and GIRO on the other hand. To summarize, 250 000 lines of code and a few millions of working hours, that is, much less than the computational time spent solving industrial problems of various kinds.

The technological transfer started as early as 1988 with GIRO as the industrial partner. GENCOL is at the heart of the HASTUS software system used to construct schedules for bus and train drivers. It can be found around the world, in more than 250 cities: Tokyo, Helsinki, Singapore, New York, Chicago, Montreal,... Today, GIRO is the world leader in this domain and employs more than 250 persons. In 1992, AD OPT started the commercialization of GENCOL in air transportation with the ALTITUDE product family. Over the years, GENCOL was used at Air Canada, Air Transat, Quantas, FlexJet (Bombardier), UPS, Fedex, Atlas, Cargolux, Emirates, United,... In 1999, AD OPT appeared on the Toronto stock exchange market. In 2004, it counted 200 employees with an annual turnover exceeding 30 million dollars, and it then became a division of Kronos. Every day in the world, 500 000 crew members, planners and managers use the product of the research performed by the GENCOL team.

The benefits are multiple. At the academic level, the training of highly qualified personnel is completed by the publication of around 200 papers that greatly helped the evolution of the mathematical decomposition methods. 30 years later, the research is still very active with original ideas: dual variable stabilization, dynamic constraint aggregation, improved primal simplex, etc.

As soon as 1997, the acknowledgement of the contributions in urban and air transportation was highlighted by three major prizes for technological transfer to Montreal-based companies: the *J.-Armand Bombardier Medal* dedicated to Technological Innovation and awarded by ACFAS (Montreal); the *Transfer Prize* awarded by ADRIQ (Montreal); and the *Excellence in University-Industry Innovative Partnership Prize*

awarded by NSERC and the Conference Board of Canada (Vancouver). With savings of 54M$ in 2 years, we can surely add to this list the small masterpiece system conceived for the Flexjet division of Bombardier and presented in 2004 at the INFORMS *Franz Edelman Award for Achievement in Operations Research and the Management Sciences* competition in Boston. With the technological transfer to the GIRO and AD OPT companies, the university partners have collected royalties that were used to support scientific activities at the GERAD. Also, over the years, both companies hired more than 75 employees that completed their graduate studies under the supervision of François, Jacques and Guy. Close to 40 still work there.

Finally, the governments of Canada and of Quebec come out winners of this university-industry partnership conducted by the GENCOL team. Actually, and for several years already, GIRO and AD OPT with their respective employees, pay in taxes *each year* more than all the team received in government grants in the last 30 years. It was and it is still a very good investment in research. ■

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Territorial intelligence modeling for energy development (Timed) – Software analysis of wind farm scenarios

Maria De Lourdes Vazquez, Adrian Ilinca & Jean-Philippe Waaub

This paper presents the software used to apply a new approach, Territorial Intelligence Modeling for Energy Development (TIMED) to the design and evaluation of wind farms configurations. Project development is based on procedure transparency and involvement of all stakeholders (Figure 1). TIMED approach is based on four modules: MCDA (Multi-criteria Decision Aid), participatory and collaborative GIS (Geographic Information System), contributory stakeholder involvement (CSI) and scientific knowledge / local knowledge (SK-LK). Moreover, to be closer to reality, these four modules are articulated with scenario modeling postulates as well as decisional weighting for every stakeholder involved in the decision-making process.

> Project development is based on procedure transparency and involvement of all stakeholders.

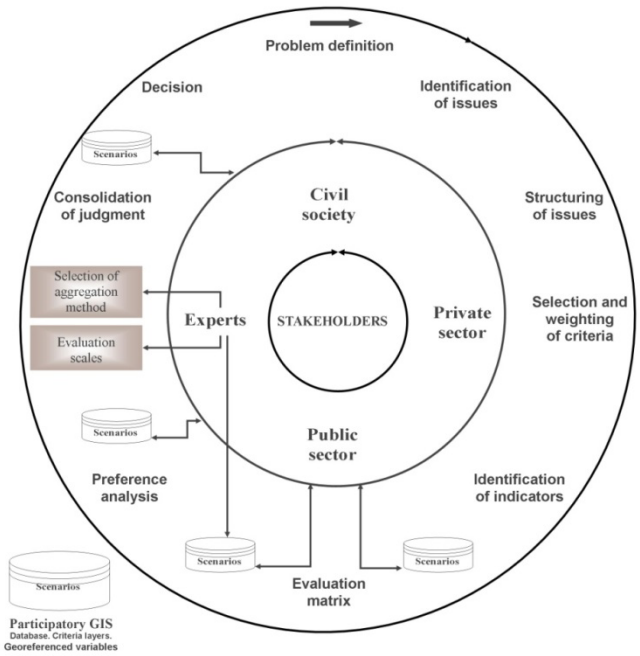

Figure 1: TIMED approach coupling MCDA and GIS

The purpose of MCDA is to assess the preference systems of the stakeholders on a multicriteria basis. The Contributive Stakeholder Involvement module (CSI) identifies four categories of stakeholders: civil society, public sector, private sector and experts. The scientific knowledge/local knowledge module (SK-LK) makes it possible to build a justification framework with a cognitive basis that also takes into account the stakeholders and their values. The participatory and collaborative GIS module is used to analyze the geo-referenced variables involved to design the scenarios. This step uses **ArcGIS software** as a platform to illustrate the characteristics of every wind farm scenario with respect to technical, environmental, socio-economical and regulatory constraints. Variables like wind farm domain, location of wind turbines, wind speed at specific location, electrical grid, roads, buildings, village boundaries, sea shore, vegetation, fauna, etc. are identified with their respective restriction zones dictated by actual regulation or public consultation. A limited number of "final" scenarios are selected to perform a strategic assessment according to the MCDA module. This analysis uses **D-Sight software**.

TIMED model was validated using the Baie-des-Sables wind farm located in Quebec, Canada. This was done as an academic research and did not impact the current operation of the farm, which started back in November 2006. If this approach requires more efforts from the wind farm developer at the preparation stage it has the advantages of reducing the risks and overall duration of the infrastructure launching. Voluntary and upstream use of the proposed TIMED approach provides the ability to analyze alternative scenarios and build consensus in decision-making that eventually produce an acceptable if not optimal plan for the stakeholders. ■

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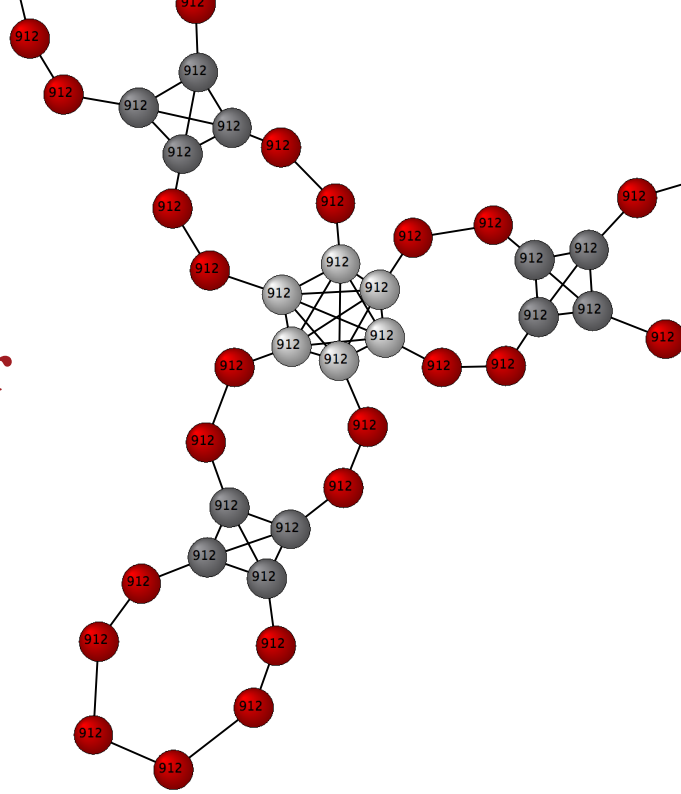
AutoGraphiX
A software for computer aided graph theory



Gilles Caporossi

Few words on computer aided graph theory

During the 1980's, appeared the first software for computer aided graph theory, the most popular of them being *Graph* (Cvetkovic) and *Graffiti* (Fajtlowicz). New software of this kind became rare until the end of the 1990's, when *AutoGraphiX* (Caporossi, Hansen) was created.

AutoGraphiX (AGX) was developed since 1997, during Gilles Caporossi's PhD, under the guidance of Pierre Hansen at GERAD.

At that time, the first developments of the Variable Neighborhood Search (VNS) were also occurring at GERAD by Nenad Mladenović and Pierre Hansen.

> The main characteristic of AGX, compared to other software is the use of optimization.

Of course this synergy had a positive impact on AGX.

Other computer aided graph theory softwares were developed later, like *Graphedron*, *GrinvIn* or *NewGraph* for example, but AGX is still the only one to use optimization.

General principles of operation of AGX

The concept of graph invariant, a value that is computed for a graph regardless the way it is drawn or the way its vertices are labeled is central in the way AutoGraphiX works. The main characteristic of AGX, compared to other software is the use of optimization.

Indeed, the integration of the VNS metaheuristic allows the identification of extremal graphs (graphs minimizing or maximizing the value of an invariant). The same problem could be solved with various parameters (varying the value of some invariants), it is possible to build families of extremal graphs. Data mining techniques are then used to find some properties shared by those graphs and to propose conjectures [3].

A graphical interface finally allows the researcher to test some ideas or to use the software as a tool to stimulate his intuition. The capability of AGX to compute easily and quickly the values of some invariants is very useful. After the proof of concept with the original version, a second version of the software was developed at GERAD by students in computer science between 2001 and 2007. In 2005, a Windows version of AGX2 was made freely available through the GERAD's website (www.gerad.ca/agx).

Since 2010, a third generation of the software is under development. This version uses new concepts and should be available for free during the forthcoming months from the GERAD's website.

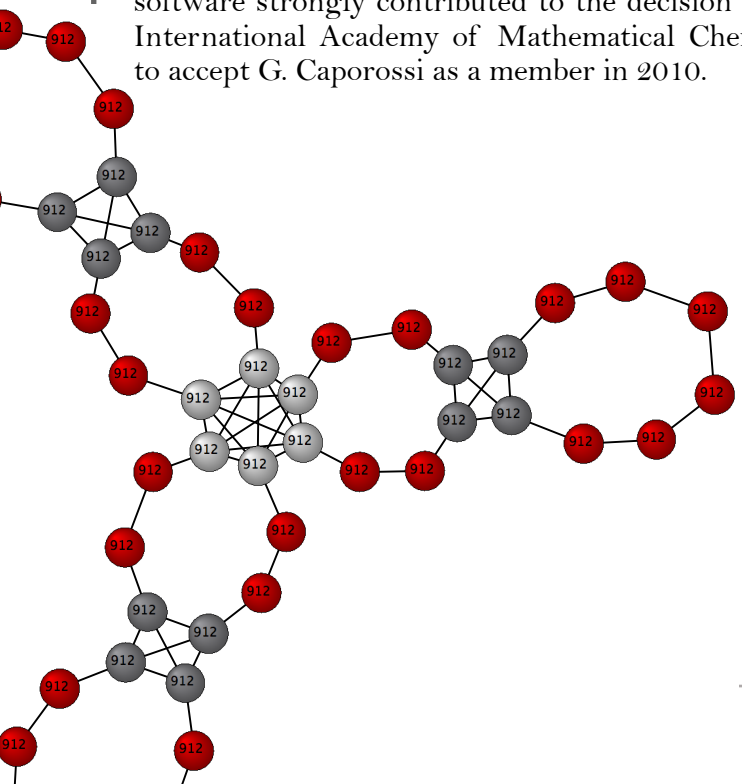
Contributions of AGX in various fields of science

Artificial intelligence: In his report as external examiner for G. Caporossi's thesis, Herbert Simon, Nobel prize of Economics in 1978 and pioneer in the development of artificial intelligence software, describes AutoGraphiX as an innovative software in artificial intelligence. Moreover, he emphases on the fact that it clearly distinguishes the discovery task from demonstration, which is important in artificial intelligence.

Graph theory: It is not surprising to notice that one of the main applications of AGX is graph theory. It is now widely used across the world and the original paper describing AGX in 2000 [2] was cited 94 times according to ISI Web of Science.

An important contribution was M. Aouchiche's PhD thesis under the guidance of P. Hansen. M. Aouchiche studied 1520 problems and used AutoGraphiX to find conjectures for these problems. 1465 conjectures were found and it turns out that almost all were true as only 24 were disproved and 159 were still open at the end of his thesis.

Mathematical chemistry: AGX produced important results in the field of mathematical chemistry, among other problems the study of molecular energy (which may be computed as a graph invariant). The paper of 1999 on that topic [1] was cited 74 times (according to ISI Web of Science) and it clearly renewed the interest of the research community on that topic. The software strongly contributed to the decision of the International Academy of Mathematical Chemistry to accept G. Caporossi as a member in 2010.



Telecommunications: During her PhD thesis, Marcia Paiva, a Brazilian student visiting GERAD for one year used AGX to build graphs with some given desirable properties for a robust telecommunication network. An important part of her thesis is related to these results.

Forthcomming developments

AGX is still in evolution and its future version will implement studies of values computed for each vertex (and not restraining to invariants, values associated to the whole graph), which will extend its application fields to new problems such as analysis of social networks. ■

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G-2012-44 **François, P., Gauthier, G., Godin, F.**
Optimal Hedging when the Underlying Asset Follows a Regime-Switching Markov Process

G-2012-45 **Boudreault, M., Gauthier, G., Thomassin, T.**
Credit Spreads, Recovery Rates and Bond Portfolio Risk Measures in a Hybrid Credit Risk Model

G-2012-46 **Saboonchi, B., Hansen, P., Perron, S.**
A Greedy Variable Neighborhood Search Heuristic for the MaxSumSum p-Dispersion Problem

G-2012-47 **Peyrega, M., Soumis, F.**
Optimisation stochastique de l'affectation des types d'avions dans un réseau en étoile

Les Cahiers du GERAD – GERAD Technical Reports *(continued)*

G-2012-48 **Namuli, R., Jaumard, B., Pillay, P.**
Adaptation of Tabu Search for Optimisation of Biomass Waste to Energy Conversion Systems

G-2012-49 **Li, H., Jaumard, B.**
Minimum CAPEX Design of Segment p-Cycles with Full Node Protection

G-2012-50 **Anjos, M.F., Ghaddar, B., Hupp, L., Liers, F., Wiegele, A.**
Solving k-way Graph Partitioning Problems to Optimality: The Impact of Semidefinite Relaxations and the Bundle Method

G-2012-51 **Goffin, J.-L.**
Subgradient Optimization in Nonsmooth Optimization (including the Soviet Revolution)

G-2012-52 **Cafieri, S., Costa, A., Hansen, P.**
Reformulation of a Model for Hierarchical Divisive Graph Modularity Maximization

G-2012-53 **Audet, C.**
A Survey on Direct Search Methods for Blackbox Optimization and their Applications

G-2012-54 **Shevkoplyas, E., Reddy, P.V., Zaccour, G.**
Time-Consistent Shapley Value for Games Played over Event Trees

G-2012-55 **Andrés-Domenech, P., Martín-Herrán, G., Zaccour, G.**
An Empirical Differential Game for Sustainable Forest Management

G-2012-56 **De Giovanni, P., Zaccour, G.**
A Two-Period Game of a Closed-Loop Supply Chain

G-2012-57 **Adulyasak, Y., Cordeau, J.-F., Jans, R.**
Benders Decomposition for Production Routing under Demand Uncertainty

G-2012-58 **Ben-Ameur, H., Chérif, R., Rémillard, B.**
American Options in a Jump-Diffusion Framework: Estimation and Evaluation

G-2012-59 **Cousineau, M., Perron, S., Caporossi, G., Paiva, M., Segatto, M.**
RWA Problem with Geodesics in Realistic OTN Topologies

G-2012-60 **Saboonchi, B., Hansen, P., Perron, S.**
Franchise Location Models and Cannibalization Effects: A Variable Neighborhood Search Approach

G-2012-61 **Ostrowski, J., Anjos, M.F., Vannelli, A.**
Modified Orbital Branching with Applications to Orbitopes and to Unit Commitment

G-2012-62 **Laporte, G.**
Scheduling Issues in Vehicle Routing

G-2012-63 **Costa, A., Hansen, P.**
A Locally Optimal Hierarchical Divisive Heuristic for bipartite Modularity Maximization

G-2012-64 **Cafieri, S., Hansen, P., Létocart, L., Liberti, L., Messine, F.**
Compact Relaxations for Polynomial Programming Problems

G-2012-65 **Mladenović, N., Hansen, P., Brimberg, J.**
Sequential Clustering with Radius and Split Criteria

G-2012-66 **Mladenović, N., Todosijevic, R., Urosevic, D.**
An Efficient General Variable Neighborhood Search for Large Travelling Salesman Problem with Time Windows

G-2012-67 **Carrizosa, E., Mladenović, N., Todosijevic, R.**
Variable Neighborhood Search for Minimum Sum-of-Squares Clustering on Networks

G-2012-68 **Mladenović, N., Urosevic, D., Hanafi, S.**
Variable Neighborhood Search for the Travelling Deliveryman Problem

G-2012-69 **Bettinelli, A., Hansen, P., Liberti, L.**
Community Detection with the Weighted Parsimony Criterion

G-2012-70 **Nguyên Hoang, L., Soumis, F., Zaccour, G.**
The Return Function: A Tool for Computing Bayesian-Nash Equilibria in Mechanism Design

G-2012-71 **Masoudi, N., Zaccour, G.**
A Differential Game of International Pollution Control with Evolving Environmental Costs

G-2012-72 **Azarfar, A. Frigon, J.-F., Sansò, B.**
Dynamic Selection of Priority Queueing Discipline in Cognitive Radio Networks

G-2012-73 **Riquelme-Rodríguez, J.-P., Gamache, M., Langevin, A.**
Periodic Capacitated Arc Routing Problem with Inventory Constraints

G-2012-74 **Kort, P., Taboubi, S., Zaccour, G.**
Optional-Contingent-Products Pricing in Marketing Channels

G-2012-75 **M'Hallah, R., Alkandari, A., Mladenović, N.**
Packing Unit Spheres into the Smallest Sphere Using VNS and NLP

G-2012-76 **Charest, L., Plante, J.-F.**
Using BIRCH to Compute Approximate Rank Statistics on Massive Datasets

G-2012-77 **Towhidi, M., Desrosiers, J., Soumis, F.**
The Positive Edge Pivot Rule Within COIN-OR's CLP

Les Cahiers du GERAD – GERAD Technical Reports *(continued)*

Revisions

G-2007-63 **Ben-Ameur, H., de Frutos, J., Fakhfakh, T., Diaby, V.**
Upper and Lower Bounds for Convex Value Functions of Derivative Contracts
Revision: November 2012

G-2011-37 **Gramacy, R.B., Le Digabel, S.**
The Mesh Adaptive Direct Search Algorithm with Treed Gaussian Process Surrogates
Revision: September 2012

G-2011-56 **Benchimol, P., Desaulniers, G., Desrosiers, J.**
Stabilized Dynamic Constraint Aggregation for Solving Set Partitioning Problems
Revision: July 2012

G-2012-13 **Fertel, C., Bahn, O., Vaillancourt, K., Waaub, J.-Ph.**
Canadian Energy and Climate Policies: A SWOT Analysis in Search for Federal/Provincial Coherence
Revision: July 2012

G-2012-42 **Greif, C., Moulding, E., Orban, D.**
Bounds on Eigenvalues of Matrices Arising from Interior-Point Methods
Revision: November 2012

Awards, honours and contributions

- **Miguel F. Anjos**, professor at the Department of Mathematics and Industrial Engineering at Polytechnique Montréal, received the Queen Elizabeth II Diamond Jubilee Medal at a ceremony held by Mitacs in Ottawa on November 28, 2012. The commemorative medal was created by the Governor General of Canada to mark the 2012 celebrations of the 60th anniversary of Her Majesty Queen Elizabeth II's accession to the Throne as Queen of Canada, and serves to honour significant contributions and achievements by Canadians.
- **Pierre-Henri Bombenger**, supervised by Jean-Philippe Waaub, Corinne Larrue and Maurice Blanc, is the winner of the 2012 Special Award given by the CNFPT (Centre National de la Fonction Publique Territoriale, France), for his thesis in Spatial Planning - Urbanism, intitled: "L'urbanisme en campagne. Pratiques de planification des sols et d'aide à la décision dans des communes rurales françaises".
- **Michèle Breton**, professor at the Department of Management Sciences at HEC Montréal, has been elected President of the International Society of Dynamic Games (ISDG) for a renewable two-year term.
- **Frédéric Godin**, doctoral student under the supervision of Geneviève Gauthier professor at the Department of Management Sciences at HEC Montréal, was awarded Lieutenant-Governor's Youth Medal. This distinction recognizes his academic excellence and examplary community involvement.
- **Gilbert Laporte**, professor at the Department of Management Sciences of HEC Montréal, received the Pierre-Laurin Award for excellence in teaching and research, which crown the particularly noteworthy career of individuals who have gained their peers' highest respect. Gilbert Laporte and Danny Miller tied for this award.
- **Pierre L'Ecuyer**, professor at the Department of Computer Science and Operations Research of the Université de Montréal, won the first place at the June 29 Master D cycling race of the 2012 COLD-FX Canadian Road Cycling Championships, which were held in Lac-Mégantic from June 21 to July 1, 2012.
- **Claire Lucas**, directed by Pierre Hansen, professor at the Department of Management Sciences of HEC Montréal, obtained a Scholarship of $ 4,000 from the HEC Alumni Foundation.
- **Georges Zaccour**, professor at the Department of Management Sciences of HEC Montréal, received the 2012 Roger-Charbonneau Award for the book entitled "Games and Dynamic Games", written with Alain Haurie and Jacek B Krawczyk. This award recognizes the quality of an educational handbook published over the year by a professor of HEC Montréal.
- Three students from GERAD had been listed at the Honour Roll of the MSc in Administration program management of HEC Montréal for the winter 2012 term:
    - **Martin Cousineau**, directed by Gilles Caporossi and Sylvain Perron
    - **Erik Frenette**, directed by Olivier Bahn and Jean-Philippe Waaub (UQAM)
    - **Fabien Peyrol**, directed by Jean-François Cordeau
- Supervised by Alain Hertz, professo rat the Department of Mathematics and Industrial Engineering of Polytechnique Montréal, 12 students participated to the third contest of Mathematical Games and they won the first place ahead of 27 other teams. These games, organized by the Fédération Française des Jeux Mathématiques and the Société de Calcul Mathématique SA, are to solve a social problem. The winners are **Bassem Bouslah, Guillaume Blanchet, Mélisende Brazeau, Ariane Duchesne, Jean Bertrand Gauthier, Charles Gauvin, Maykel Geagea, Adham IsMayl, Thibault Lehouillier, Abderrazak Moutassim, Mathilde Peyrega, Samuel Rosat**.

Thesis defences

- **Leandro Callegari Coelho**, cosupervised by Jean-François Cordeau and Gilbert Laporte
  Doctoral Thesis: Flexibility and Consistency in Inventory-Routing
- **Réal A. Carbonneau**, cosupervised by Gilles Caporossi and Pierre Hansen
  Doctoral Thesis: Data Mining for Commerce Problems: Global Optimization of Clusterwise Regression and Neural Networks Applied to Electronic Negotiations
- **Dominique Cartier**, cosupervised by Charles Audet and Sébastien Le Digabel
  Master Thesis: Optimisation sous contraintes d'un modèle hydrologique pour une représentation de la physique des processus
- **Zoumana Coulibaly**, supervised by Dominique Orban
  Doctoral Thesis: Algorithmes pour la programmation non linéaire dégénérée
- **Cong Kien Dang**, cosupervised by Charles Audet and Dominique Orban
  Doctoral Thesis: Optimization of Algorithms with the Opal Framework
- **Mahsa Elahipanah**, supervised by Guy Desaulniers
  Doctoral Thesis: Task Scheduling and Activity Assignment to Work Shifts with Schedule Flexibility and Employee Preference Satisfaction
- **Mohammed Kharbach**, supervised by Michèle Breton
  Doctoral Thesis: Essays on Utility Regulation

Trainees

December 2011 | December 2012
Fabien Ngendakuriyo (UCL, Belgium)

February 2010 | June 2012
Wiem Ben Dhia (Tunisia Polytechnic School, Tunisia)

February | June 2012
Kaouthar Fehri (Tunisia Polytechnic School, Tunisia)
Walid Majdoub (Tunisia Polytechnic School, Tunisia)
Salma Nachi (Tunisia Polytechnic School, Tunisia)

February 2012 | February 2013
Puduru Viswanadha Reddy (GERAD, Canada)
Luca Gianoli (Politecnico Di Milano, Italy)

March | August 2012
Régis Bardet (ENSTA Paris Tech, France)
Illyas Himmich (INSEA, Morocco)
Younes Skandrani (ENSIAS, Morocco)

March | October 2012
Carmelo Cascone (Politecnico di Milano, Italy)

April | June 2012
Nathalie Turin (HEG, Switzerland)

April | August 2012
Théophile Lohier (ISIMA, France)

April | September 2012
Mehdi Boutrif (ISIMA, France)
André Linhares (ENSTA Paris Tech, France)
Théophile Lohier (ISIMA, France)
Bénérice Petit-Romec (ISIMA, France)

May | July 2012
Yassine Ameur (ENSTA Paris Tech, France)

May | August 2012
Rachid Cherkaoui (Polytechnique Montréal, Canada)
Théophile Irie Bi Tiesse (Polytechnique Montréal, Canada)
Stephen Maher (UNSW, Australia)

June | July 2012
Andre Ianni (Università di Roma, Italy)

June | September 2012
Yoann Couble (ENSEEIHT, France)

June | October 2012
Remy Spliet (Erasmus School Rotterdam, The Netherlands)

June 2012 | March 2013
Nabila Remli (Université Laval, Canada)

July | August 2012
Dounia Lakhrimi (ENSEEIHT, France)

July | September 2012
Yvann Nzengue (INSAT, France)

July | October 2012
Yazhou Zufferey (Shanghai Jiao Tong University, China)

September 2012 | August 2013
Rafael Ponti Martinelli (Brazil)

October 2012 | October 2013
The Amouh (University of Namur, Belgium)

Visitors

April | June 2012
Paolo Caravani (Université de L'Aquila, Italie)

May 2012
Elad Cohen (Université Charles Golumbic, Israel)
Andrew Lambe (UTIAS, Canada)

May | September 2012
Oumar Koné (Université Abobo-Adjamé, Côte-D'Ivoire)

June 2012
Slim Belhaiza (KFUPM, Saudi Arabia)
Abdelmoutalib Metrane (ENSA de Khouribga, Morocco)

June | July 2012
Angelika Wiegele (University of Klagenfurt, Austria)

July 2012
Cristina da Silva Martins Ribeiro
(Universidade do Porto, Portugal)

July | August 2012
Alexander Engau (CU Denver, United States)
Caroline Rocha (Brazil)
Daniel Aloise (UFRN, Brazil)
Fatima Zara Mhada (Université Mohammed 5, Morocco)

August | September 2012
Javid Ahmadi (Amirkabir University of Technology, Iran)
Jonathan Gheyssens (University of Zurich, Switzerland)
Manuel Vieira (Universidade Nova de Lisboa, Portugal)

September 2012
Rikard Bakkehaug (NTNU, Norway)
Marino Widmer (University of Fribourg, Switzerland)

September 2012 | August 2013
Xiao-Wen Chang (McGill University, Canada)

September | October 2012
Jørgen Glomvik Rakke (NTNU, Norway)
Mabel Tidball (LAMETA, INRA, Montpellier, France)

October | November 2012
Bernardetta Addis (Politecnico di Milano, Italy)

November 2012
Pietro De Giovanni (Essec Business School, France)

November | December 2012
Alessandra Buratto (University of Padoua, Italy)
Florian Wagener (University of Amsterdam, The Netherlands)

December 2012 | February 2013
Bastien Talgorn (France)

December 2012
Alexis Toukias (Université Paris Dauphine, France)

Activities

Workshops | Schools | Congresses

November 29-30, 2012
Fourth Workshop on Game Theory in Energy, Resources and Environment

September 20, 2012
Collaborative multicriteria decision aid in public health: D-Sight solutions

June 26, 2012
GERAD - IEEE Control Systems Society Outreach meeting: « Application de la commande des systèmes dans le domaine médical »

June 10-13, 2012
International Workshop on Column Generation 2012

May 10, 2012
Thematic Workshop: Canadian Climate and Energy Policies: Strategic Assessment with the New Model TIMES-Canada

May 9-12, 2012
2012 GERAD Spring School on Cooperative Games in Operations Research

Activities

GERAD Seminars

October 30, 2012
Bruno Tuffin (INRIA Rennes Bretagne Atlantique, France)
Introduction to the Network Neutrality Debate. Description of a related model of Internet Service Provider (ISP) Inter-Relations: Traffic Exchange, Revenue Sharing, and Disconnection Threat

October 25, 2012
Charalambos D. Charalambous (University of Cyprus, Cyprus)
Team Games for Distributed Stochastic Dynamical Decision Systems with Different Information Structures

October 25, 2012
Mojtaba Nourian (McGill University, Canada)
Mean Field Games for Nonlinear Systems with Major and Minor Agents I

October 25, 2012
Anja Fischer (University of Chemnitz, Allemagne)
TSP Reloaded - Solution Approaches for the Quadratic Traveling Salesman Problem

October 2, 2012
Vahid Partovinia (Polytechnique Montréal, Canada)
Convergence Assessment in Bayesian Clustering

August 7, 2012
Nicolas Zufferey (HEC Geneva, Switzerland)
Consistent Neighborhood Search for Assignment Problems with Incompatibility Constraints

June 8, 2012
Nelson V. Morales (Universidad de Chile, Chili)
New Models for Mine Planning

May 24, 2012
Jean Bigeon (CNRS, Laboratoire G-SCOP (Grenoble-INP), France)
Problématique d'optimisation en conception préliminaire (phase 0) en ingénierie manufacturière

May 2, 2012
Elad Cohen (University of Haifa, Israel)
Vertex Intersection Graphs of Paths on a Grid

GERAD/CRC-ONDI Optimization Seminars

December 6, 2012
Bastien Talgorn (France)
Three Trajectory Optimization Problems in Civil Aeronautics

November 29, 2012
Guillermo Bautista (CAISO, United States)
MIP in Practice: The Case of the California Energy Market

November 8 2012
Endre Boros (RUTCOR, United States)
Quadratization of Pseudo-Boolean Functions

November 5 2012
Immanuel M. Bomze (University of Vienna, Austria)
A Nasty Cone with Nice Properties - New Issues in Copositive Optimization

November 1, 2012
Sven Leyffer (Argonne National Laboratory, United States)
MINOTAUR: A New Toolkit for Mixed-Integer and Nonlinear Optimization

October 25, 2012
Anja Fischer (University of Chemnitz, Germany)
TSP Reloaded - Solution Approaches for the Quadratic Traveling Salesman Problem

October, 4 2012
Luis Zuluaga (Lehigh University, United States)
Distribution-Free Optimization for Decision-Making Problems Under Uncertainty: Applications to Option Pricing

October 2, 2012
Remy Spliet (Erasmus University, The Netherlands)
The Discrete Time Window Assignment Vehicle Routing Problem

September 27, 2012
Jean-Pierre Dussault (Université de Sherbrooke, Canada)
Primal Path Following Methods Based on the Log-Barrier Function

September 20, 2012
Naoki Katoh (Kyoto University, Japan)
Generating Redundantly Rigid Frameworks in 2-Dimensions

September 13, 2012
Bala Venkatesh (Ryerson University, Canada)
Unit Commitment - Challenges and Wind Energy

POLYTECHNIQUE MONTRÉAL

Canada Research Chair in Discrete Nonlinear Optimization in Engineering

Activities

E2G Seminars

December 10, 2012
Alexis Tsoukiàs (Université Paris-Dauphine, France)
Policy Analytics: A Challenge for Decision Analysis and Operational Research

December 6, 2012
Hamed Ghoddusi (MIT, United States)
Energy Security Concerns of Biofuels

October 18, 2012
Alain Haurie
(University of Geneva, Switzerland & ORDECSYS/C-ORDEE)
Nouveaux défis pour les modèles intégrés d'évaluation des politiques environnementales

October 12, 2012
Marchhal Wang (Environnement Canada, Canada)
Oil Sands Production and Export - The New Energy Model Design

October 12, 2012
Glasha Obrekht (Environnement Canada, Canada)
Andy Wong (Environnement Canada, Canada)
Environment Canada's E3MC Model

"Meet a GERAD researcher!" Seminars

October 17, 2012
Ali Boudhina (HEC Montréal, Canada)
Pricing the Guarantees Offered by Segregated Funds

October 10, 2012
Michèle Breton (HEC Montréal, Canada)
Recursive Approaches for the Evaluation of Financial Derivatives

Séminaires pas ordinaires

December 11, 2012
Charles Gauvin (Polytechnique Montréal, Canada)
Analyse des différents types de plus court chemin

November 30, 2012
Lê Nguyên Hoang (Polytechnique Montréal, Canada)
New Definitions of Fairness

October 16, 2012
Lê Nguyên Hoang (Polytechnique Montréal, Canada)
Mechanism Design for Fair Shift Scheduling

October 9, 2012
Sivan Altinakar (Polytechnique Montréal, Canada)
Breaking Symmetry in Consecutive Edge-Coloring

October 1, 2012
Marilène Cherkesly (Polytechnique Montréal, Canada)
Problème de tournées de véhicules avec cueillettes et livraisons, fenêtres de temps et politique de dernier entré premier sorti

September 11, 2012
André Linhares (GERAD, Canada)
Unloading Boxes Off a Gravity Conveyor

September 5, 2012
Medhi Boutrif (GERAD, Canada)
Développement de méthodes de classification non supervisée

August 28, 2012
André Linhares (GERAD, Canada)
Dynamic Programming Algorithms for the (Elementary) Resource Constrained Shortest Path Problem

June 27, 2012
Lê Nguyên Hoang (Polytechnique Montréal, Canada)
Mechanism Design Through Optimization

May 10, 2012
Pascal Benchimol (Paris, France)
Le chemin central tropical

CRM/ISM/GERAD Statistics Colloquium

November 23, 2012
Peter Mueller (University of Texas, United States)
A Nonparametric Bayesian Model for Local Clustering

October 19, 2012
David Madigan (Columbia University, United States)
Observational Studies in Healthcare: Are They Any Good?

September 21, 2012
Fang Yao (Toronto, Canada)
Regularized Semiparametric Functional Linear Regression

Activities

GERAD Seminars cofunded by Fondation HEC and the Data Mining Chair

July 19, 2012
Daniel Aloise (Universidade Federal Do Rio Grande Do Norte, Brazil)
A Column Generation Heuristic for Microdata Protection

Fondation HEC MONTRÉAL

HEC MONTRÉAL
DATA MINING CHAIR

GERAD Seminars cofunded by Fondation HEC and the Chair in Game Theory and Management

November 27, 2012
Florian Wagener (University of Amsterdam, The Netherlands)
The Lake Game: Strategic Decisions Interacting with Nonlinear Dynamics

November 20, 2012
Alessandra Burrato (University of Padua, Italy)
A Dynamic Approach to Commercial Piracy

May 16, 2012
Paolo Caravani (University of L'Aquila, Italy)
Learning and Distributed Learning in Multi-Agent Systems #2

May 15, 2012
Michael Grothe (Bielefeld University, Germany)
Effects of Vertical Integration from a Dynamic Point of View

May 14, 2012
Paolo Caravani (University of L'Aquila, Italy)
Learning and Distributed Learning in Multi-Agent Systems #1

May 4, 2012
Puduru Vishwanadha Reddy (GERAD, Canada)
Optimal Management and Differential Games in the Presence of Threshold Effects - The Shallow Lake Model

May 1, 2012
Mabel Tidball (INRA Montpellier, France)
Optimal Control with Mixed Constraints: An Application to Carbon Sequestration and Storage

Fondation HEC MONTRÉAL

HEC MONTRÉAL
CHAIR IN GAME THEORY AND MANAGEMENT