

# Sonia Cafieri

**Assistant Professor** (*Maître de Conférences*)

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## Main research interests

- Global optimization and Mixed-Integer Nonlinear Programs (MINLP).  
Applications to air traffic management, to the design of electrical machines and to bioinformatics.
- Reformulation techniques in mathematical programming.
- Combinatorial optimization: Network Clustering.
- Interior point algorithms for nonlinear programming: quadratic optimization, potential reduction algorithm.
- Numerical linear algebra in constrained optimization: iterative solution of KKT systems, preconditioners.

## Education

- *2009*: On the French National University Council (CNU) **qualification** lists for “Maître de Conférences” in section 26 (applied mathematics) and 27 (computer science).
- *Jan 2006*: **Ph.D. in Mathematical Sciences**,  
Thesis title: *On the application of iterative solvers to KKT systems in Interior Point methods for Large-Scale Quadratic Programming problems*.  
Awarded by: University of Naples “Federico II”, Italy.  
Awarded on: 10th January 2006.  
Supervisor: Prof. M. D’Apuzzo.  
Jury: Prof. M. Marino, Prof. D. Giachetti, Prof. M. Lapegna.
- *Oct 2001*: **Master in Mathematics**,  
110/110 cum Laude  
Thesis title: *Quadratic Optimization: Algorithms and Software for sparse problems*.  
Awarded by: Second University of Naples, Italy.  
Awarded on: 30th October 2001.  
Supervisor: Prof. M. D’Apuzzo.

## Employment History

- *Dec 2009 - present*  
**Assistant Professor** <sup>1</sup>  
École Nationale de l'Aviation Civile (ENAC),  
Département of Mathematics and Computer Science,  
Laboratory of Applied Mathematics, Computer Science and Automation for Aeronautics (MAIAA)  
(Mathématiques Appliquées, Informatique et Automatique pour l'Aérien),  
Toulouse, France.
- *Mar 2008 - Nov 2009*  
**Post-doc Researcher**  
Laboratoire d'Informatique (LIX), École Polytechnique, France.  
Topic: Reformulation techniques in Mathematical Programming.  
Research advisor: Prof. L. Liberti.
- *Jun 2007 - Feb 2008*  
**Post-doc Researcher**  
Interdipartimental Research Center Bioagromed, University of Foggia, Italy.  
Topic: PDE-based mathematical models for food science applications.  
Research advisor: Prof. M.A. Del Nobile.
- *Sep 2006 - May 2007*  
**Research Fellow**  
Department of Mathematics, Second University of Naples, Italy.  
Topic: Development of software tools for Quadratic Programming.  
Research advisor: Prof. M. D'Apuzzo.
- *Jun 2001 - Sep 2001*  
**Stage** at Center for Research on Parallel Computing and Supercomputers - CPS/CNR, nowadays  
*Institute for High Performance Computing and Networking - ICAR/CNR - Naples branch.*  
Topic: Algorithms and software for high performance computing.

## Awards

- *Academic year 1998/1999*  
**2nd place in the Annual Second University of Naples Prize,**  
for the best students during the academic year.
- *Academic year 1999/2000*  
**1st place in the Annual Second University of Naples Prize,**  
for the best students during the academic year.

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<sup>1</sup>*Enseignant-Chercheur*, equivalent to *Maître de Conférences* in France.

## Organization Activities

- Editorial responsibilities
  - Associate Editor for *International Transactions in Operational Research* (ITOR) since September 2011.
  - Guest Editor with L. Liberti and F. Messine of a special issue of *Journal of Global Optimization* dedicated to the Toulouse Global Optimization workshop 2010, in preparation.
  - Guest Editor with U. Faigle and L. Liberti of a special issue of *Discrete Applied Mathematics* dedicated to the CTW09 conference, Volume 159 (16), pages 1659-1914, September 2011.
- Conference organization
  - Scientific committee member in Global Optimization Workshop GOW12, Natal, Brasil, June 2012.
  - Organizing co-chair of the Mixed-Integer Nonlinear Programming stream at EURO 2012 Conference (European Conference on Operations Research), Vilnius, Lithuania, July 2012.
  - Session co-chair at ROADEF 2012 (French Conference on Operations Research), Angers, France, April 2012. Session title “Transport et Controle Aérien”.
  - Session chair at OR 2011 (International Conference on Operations Research), Zurich, Switzerland, Sept 2011. Session title “Airline, airport and air traffic management”.
  - Session co-chair at ROADEF 2011 (French Conference on Operations Research), Saint Etienne, France, March 2011. Session title “Transport et Controle Aérien”.
  - Scientific and local organizing committee member in Toulouse Global Optimization workshop (TOGO10) in Toulouse, France, August-September 2010. Co-editor of the Conference Proceedings.
  - Session chair within the stream “Mixed-Integer Nonlinear Programming” at EURO 2010 Conference (European Conference on Operations Research), Lisbon, Portugal, July 2010.
  - Local organizing committee member in CTW09 international workshop on Graphs and Combinatorial Optimization in Paris, France, June 2009. Co-editor of the Conference Proceedings.
- Referee for
  - international journals: Journal Of Global Optimization, Optimization Letters, Computational Optimization and Applications, Journal Of Control, Journal of Computer Mathematics, Information Processing Letters, Discrete Applied Mathematics, SIAM Journal on Optimization, TOPR.
  - international conferences: CTW09, TOGO10, SEA2012, GOW’12.
- Participation in scientific projects:
  - 2005- 2007  
*Innovative Problems and Methods in Nonlinear Optimization*, PRIN Project, funded by Italian Ministry of University and Research (MIUR).
  - 2003- 2006  
*Large Scale Nonlinear Optimization*, FIRB Project, funded by Italian MIUR.

- Membership:
  - ROADEF (French Operations Research Society) since 2009,
  - MOS (Mathematical Optimization Society, previously Mathematical Programming Society) since 2010,
  - member of the research group TORO - Toulouse Operations Research and Optimization - which gathers people working on Operation Research and Optimization in research laboratories and Universities in Toulouse, France, since its foundation in 2011: [www.toro-toulouse.fr](http://www.toro-toulouse.fr)
- Presentation of the organization of undergraduated courses of the Second University of Naples.

## Grants and Projects

- *PhD fellowship funding*, awarded by PRES University of Toulouse; at ENAC (PI, 88KEUR, 3 years, started 2011 (supervisioning of PhD thesis)).

## Publications

### • International Journals

1. S. Cafieri, P. Hansen, L. Liberti, *Improving heuristics for network modularity maximization using an exact algorithm*, **Discrete Applied Mathematics**, to appear.
2. S. Cafieri, G. Caporossi, P. Hansen, S. Perron, A. Costa, *Finding communities in networks in the strong and almost-strong sense*, **Physical Review E**, 85(4):046113, 2012.
3. S. Cafieri, P. Hansen, L. Liberti, *Locally optimal heuristic for modularity maximization of networks*, **Physical Review E**, 83(5):056105, 2011.
4. D. Aloise, S. Cafieri, G. Caporossi, P. Hansen, L. Liberti, S. Perron, *Column generation algorithms for exact modularity maximization in networks*, **Physical Review E**, 82(4):046112, 2010.
5. S. Cafieri, P. Hansen, L. Liberti, *Loops and multiple edges in modularity maximization of networks*, **Physical Review E**, 81(4):046102, 2010.
6. S. Cafieri, P. Hansen, L. Liberti, *Edge ratio and community structure in networks*, **Physical Review E**, 81(2):026105, 2010.
7. S. Cafieri, J. Lee, L. Liberti, *On convex relaxations of quadrilinear terms*, **Journal of Global Optimization**, 47:661–685, 2010.
8. S. Cafieri, M. Mastromatteo, S. Chillo, M.A. Del Nobile, *Modeling the mechanical properties of pasta cooked at different times*, **Journal of Food Engineering**, 100: 336–342, 2010.
9. S. Cafieri, S. Chillo, M. Mastromatteo, N. Suriano, M.A. Del Nobile, *A mathematical model to predict the effect of shape on pasta hydration kinetic during cooking and overcooking*, **Journal of Cereal Science**, 48 (3): 857–862, 2008.
10. S. Cafieri, M. D’Apuzzo, V. De Simone, D. di Serafino, G. Toraldo, *Convergence Analysis of an Inexact Potential Reduction Method for Convex Quadratic Programming*, **Journal of Optimization Theory and Applications**, 135: 355–366, 2007.

11. S. Cafieri, M. D'Apuzzo, V. De Simone, D. di Serafino, *Stopping criteria for inner iterations in inexact Potential Reduction methods: a computational study*, **Computational Optimization and Applications**, special issue on Linear Algebra issues arising in Interior Point methods, J. Gondzio and G. Toraldo eds., 36 (2): 165-193, 2007.
  12. S. Cafieri, M. D'Apuzzo, V. De Simone, D. di Serafino, *On the Iterative Solution of KKT Systems in Potential Reduction Software for Large Scale Quadratic Problems*, **Computational Optimization and Applications**, special issue on High Performance Algorithms and Software for Nonlinear Optimization, A. Murli and G. Toraldo eds, 38: 27-45, 2007.
  13. S. Cafieri, M. D'Apuzzo, M. Marino, A. Mucherino, G. Toraldo, *Interior Point Solver for Large-Scale Quadratic Programming Problems with Bound Constraints*, **Journal of Optimization Theory and Applications**, 129 (1): 55-75, 2006.
- **Edited volumes and journal issues**
    14. S. Cafieri, U. Faigle, L. Liberti (eds.), *Graphs and Combinatorial Optimization*, **special issue of Discrete Applied Mathematics** dedicated to the CTW09 Conference, Volume 159 (16), pages 1659-1914, 2011.
    15. S. Cafieri, B.G. Tóth, E.M.T. Hendrix, L. Liberti, F. Messine (eds.), *Proceedings of the Toulouse Global Optimization workshop (TOGO10)*, Toulouse, 2010.
    16. S. Cafieri, A. Mucherino, G. Nannicini, F. Tarissan, L. Liberti (eds.), *Proceedings of CTW09 Conference on Graphs and Combinatorial Optimization*, Paris, 2009.
  - **Book chapters (refereed)**
    17. P. Belotti, S. Cafieri, J. Lee, L. Liberti, A. Miller, *On the composition of convex envelopes for quadrilinear terms*, in A. Chinchuluun, P.M. Pardalos, R. Enkhbat and E.N. Pistikopoulos (eds.), *Proceedings of the International Conference on Optimization, Simulation and Control*, **Series : Springer Optimization and its Application**, to appear.
    18. L. Liberti, S. Cafieri, F. Tarissan, *Reformulations in Mathematical Programming: a Computational Approach*, in A. Abraham, A.-E. Hassanien, P. Siarry, and A. Engelbrecht (eds.), *Foundations of Computational Intelligence Vol. 3 (Global Optimization: Theoretical Foundations and Applications)*, **Series: Studies in Computational Intelligence**, 203:153-234, Springer, Berlin, 2009.
  - **International Conference publications (refereed)**
    19. S. Cafieri, *Aircraft conflict avoidance: a mixed-integer nonlinear optimization approach*, in **Proceedings of Global Optimization Workshop (GOW) 2012**, Natal, 2012.
    20. S. Cafieri, P. Hansen, L. Létocart, L. Liberti, F. Messine, *Compact relaxations for polynomial programming problems*, in *Experimental Algorithms*, **Lecture Notes in Computer Science**, (proceedings of SEA 2012), accepted.
    21. P. Belotti, S. Cafieri, L. Liberti, J. Lee, *Feasibility-based bounds tightening via fixed points*, in W. Wu and O. Daescu (eds.), *Proceedings of Conference on Combinatorial Optimization and Applications (COCOA 2010)*, **Lecture Notes in Computer Science**, 6508:65-76, 2010.

22. S. Cafieri, L. Liberti, F. Messine, B. Nogarede, *Discussion about formulations and resolution techniques of electrical machine design problems*, in Proceedings of XIX International Conference on Electrical Machines, **IEEE Xplore**, 2010.
23. S. Cafieri, P. Brisset, N. Durand, *A mixed-integer optimization model for Air Traffic Deconfliction*, in **Proceedings of Toulouse Global Optimization workshop (TOGO) 2010**, pp. 27-30, Toulouse, 2010.
24. L. Liberti, S. Cafieri, D. Savourey, *The Reformulation-Optimization Software Engine*, in Komei Fukuda et al. (eds.), International Congress of Mathematical Software (ICMS), **Lecture Notes in Computer Science**, 6327:303-314, 2010.
25. S. Cafieri, P. Hansen, L. Liberti, *Improving heuristics for network modularity maximization using an exact algorithm*, **MatHeuristics 2010**, pp. 130-139, Vienna, 2010.
26. P. Belotti, S. Cafieri, J. Lee, L. Liberti, *On the convergence of feasibility based bounds tightening*, in U. Faigle, R. Schrader, D. Herrmann (eds.), **Proceedings of CTW 2010**, 21-24, Köln 2010.
27. S. Cafieri, P. Hansen, L. Létocart, L. Liberti, F. Messine, *Reduced RLT constraints for polynomial programming*, in P. Bonami, L. Liberti, A. Miller, A. Sartenaer, **Proceedings of European Workshop on MINLP 2010**, Marseille, 2010.
28. S. Cafieri, J. Lee, L. Liberti, *Comparison of convex relaxations of quadrilinear terms*, in C. Ma, L. Yu, D. Zhang, Z. Zhou (eds.), *Global Optimization: Theory, Methods and Applications I*, **Lecture Notes in Decision Sciences**, 12(B):999-1005, Global-Link Publishers, Hong Kong 2009.
29. S. Cafieri, M. D'Apuzzo, V. De Simone, D. di Serafino, *On the Use of an Approximate Constraint Preconditioner in a Potential Reduction Algorithm for Quadratic Programming*, in V. Cutello, G. Fotia and L. Puccio (eds.), *Applied and Industrial Mathematics in Italy II*, **Series on Advances in Mathematics for Applied Sciences** Vol. 75, World Scientific, 2007.

- **National Conference publications (refereed)**

30. L. Cellier, S. Cafieri, F. Messine, *Résolution de conflit aérien par contrôle optimal basé sur la régulation en vitesse*, in Proceedings of ROADEF 2012, Angers, France, 2012.
31. S. Cafieri, A. Gondran, S.U. Ngueveu, *Un algorithme mémétique pour construire des trajectoires d'aéronefs robustes aux aléas météorologiques*, in Proceedings of ROADEF 2012, Angers, France, 2012.
32. S. Cafieri, P. Hansen, *Modularity Clustering on Trees*, in Proceedings of ROADEF 2012, Angers, France, 2012.
33. A. Costa, S. Cafieri, P. Hansen, *Reformulation of a locally optimal heuristic for modularity maximization*, in Proceedings of ROADEF 2012, Angers, France, 2012.
34. S. Cafieri, P. Hansen, L. Liberti, *Hierarchical clustering for the identification of communities in networks*. Proceedings of ROADEF 2011, Saint Etienne, France, 2011.
35. D. Aloise, S. Cafieri, G. Caporossi, P. Hansen, L. Liberti, S. Perron, *Algorithms for network modularity maximization*, Proceedings of ROADEF 2010, Toulouse, France, 2010.
36. L. Liberti, S. Cafieri, J. Lee, *Range reduction using fixed points*, Proceedings of ROADEF 2010, Toulouse, France, 2010.

- 37. S. Cafieri, J. Lee, L. Liberti, *Convex relaxations for quadrilinear terms*, Proceedings of ROADEF 09, Nancy, France, 2009.
- 38. S. Cafieri, P. Hansen, L. Liberti, *Reformulations between structured global optimization problems and algorithms*, Proceedings of ROADEF 09, Nancy, France, 2009.

- **Technical Reports and submitted papers**

- 39. P. Belotti, S. Cafieri, J. Lee, L. Liberti, *On feasibility based bounds tightening*, Optimization Online preprint n.3325, Jan 2012, submitted.
- 40. S. Cafieri, L. Liberti, F. Messine, B. Nogarede, *Optimal Design of Electrical Machines: Mathematical Programming Formulations*, Optimization Online preprint n.3059, 2011, submitted.
- 41. S. Cafieri, A. Costa, P. Hansen, *Reformulation of a model for hierarchical divisive graph modularity maximization*, Optimization Online preprint n.3334, Dec 2011, submitted.
- 42. A. Mucherino, S. Cafieri, *A New Heuristic for Feature Selection by Consistent Biclustering*, arXiv e-print, arXiv:1003.3279v1, March 2010.

- **Theses**

- 43. S. Cafieri, *On the application of iterative solvers to KKT systems in Interior Point methods for Large-Scale Quadratic Programming problems*, Ph.D. Thesis, University of Naples “Federico II”, 2006.
- 44. S. Cafieri, *Ottimizzazione quadratica: algoritmi e software per problemi sparsi* (in Italian), Tesi di Laurea, Second University of Naples, 2001.

## Conferences and Workshops presentations

- ROADEF’12, Angers, France, avril 2012.  
“Modularity Clustering on Trees”.
- AFG’11 - *15th Austrian-French-German conference on Optimization*, Toulouse, France, Sept. 19-23, 2011.  
“Reduced RLT compact relaxations for polynomial programming”.
- OR 2011 - *International Conference on Operations Research*, Zurich, Switzerland, Aug 30-Sept 2, 2011.  
“Aircraft deconfliction: a heuristic based on local exact solutions”.
- IFORS 2011 - *Conference of the International Federation of Operations Research Societies*, Melbourne, Australia, July 10-15, 2011.  
“Hierarchical Network Clustering”.
- ROADEF’11, Saint Etienne, France, March 2011.  
“Hierarchical clustering for the identification of communities in networks”.
- ICEM 2010 - *XIX International Conference on Electrical Machines*, Rome, Italy, Sept 6-8, 2010.  
“Discussion about formulations and resolution techniques of electrical machine design problems”.

- TOGO10 - *TOulouse Global Optimization workshop*, Toulouse, France, Aug 31-Sept 3, 2010.  
“A mixed-integer optimization model for Air Traffic Deconfliction”.
- COSC10 - *International Conference on Optimization, Simulation and Control*, Ulan Baatar, July 25-28, 2010.  
“On the composition of convex envelopes for quadrilinear terms”.
- EURO XXIV - *European conference on Operations Research*, Lisbon, Portugal, July 11-14, 2010.  
“Reduced Reformulation-Linearization Technique for Polynomial Programs”.
- *MatHeuristics 2010*, Vienna, Austria, June 27-30, 2010.  
“Improving heuristics for network modularity maximization using an exact algorithm”.
- EWMINLP - *European Workshop on MINLP*, Marseille, France, March 2010.  
“Reduced RLT constraints for polynomial programming”.
- ROADEF10, Toulouse, France, February 2010.  
“Algorithms for network modularity maximization”.
- Colloque ANR STIC, Paris, France, January 2010.  
“Automatic Reformulation Search”.
- ISMP09 - *The 20th International Symposium of Mathematical Programming*, Chicago, USA, August 2009.  
“Comparing convex relaxations of quadrilinear terms”.
- WCGO09 - *1st World Congress on Global Optimization in Engineering and Science*, Hunan, China, June 2009. “Comparison of convex relaxations of quadrilinear terms”.
- CIMINLP - *Computational Issues in MINLP*, Bordeaux, France, March 19-20, 2009 (**Invited speaker**).  
“Comparing convex relaxations of quadrilinear terms”.
- ROADEF09, Nancy, France, Feb 10-12 2009.  
“Convex relaxations for quadrilinear terms”.
- ARS08 - *first ANR Automatic Reformulation Search Project Workshop*, École Polytechnique, Palaiseau, France, Oct 31st 2008.  
“Rose: Reformulation/Optimization Software Engine”; “Convex relaxations for quadrilinear terms”.
- *Journée Optimeo*, Versailles, France, June 11 2008.  
“Linear Algebra issues in Interior Point solvers for Quadratic Programming”.
- *IMA Conference on Numerical Linear Algebra and Optimisation*, Birmingham, UK, Sept 13-15 2007.  
“Approximate Constraint Preconditioners for KKT Systems arising in Interior Point Methods”.
- *Conference of the Italian MIUR FIRB project “Large Scale Nonlinear Optimization”*, Capri, Italy, Apr 19-20 2007.  
“Sviluppo di software Interior Point per problemi di Ottimizzazione Quadratica”.
- SIMAI06 - *8th Congress of the Italian Society for Applied and Industrial Mathematics*, Ragusa, Italy, May 22-26 2006.  
“On the use of Constraint Preconditioners in Potential Reduction methods”.

- IFIP TC 7 *Conference on System Modeling and Optimization*, Torino, Italy, July 18-22 2005.  
“A Potential Reduction Solver for Large-Scale Quadratic Programming Problems”.
- AIRO04 - *35th Annual Conference of the Italian Operations Research Society*, Lecce, Italy, Sept 7-10 2004.  
“On Linear Algebra Solvers in Potential Reduction Software for Large Scale Quadratic Problems”.
- *Large Scale Nonlinear Optimization*, Erice, Italy, June 22-July 1 2004.  
“Linear Algebra Issues in Developing Potential Reduction Software for Large Scale Quadratic Programs”.
- *Numerical Methods for Local and Global Optimization: Sequential and Parallel Algorithms*, Cortona, Italy, July 14-20 2003.  
“An Interior Point Solver for Large-Scale Quadratic Programs”.

## Conferences attendance without contribution

- 7me Journée du GT Transport et Logistique, LAAS-CNRS, Toulouse, France, Dec. 5 2011.
- *The First SESAR Innovation Days* - conference of the European project SESAR on Air Traffic Management, ENAC, Toulouse, France, Nov 29-Dec 1, 2011.
- MARAMI 2010 - conference on models and analysis of networks, Toulouse, France, Oct. 11-12 2010.
- *Advanced Methods and Perspectives in Nonlinear Optimization and Control*, Toulouse, France, Feb. 3-5 2010.
- Forum Digiteo 2009, École Polytechnique Paris, France, Oct. 21 2009.
- 5ème Journée Optimeo, Supélec, France, Oct. 1 2009.
- JSPOC5 - *5th Polyhedra and Combinatorial Optimization Workshop*, Institut Henri Poincaré Paris, Apr. 7-9 2009.
- Meeting on “Modélisation, optimisation et analyse statique”. CIRM, Marseille, France, Mar. 10-12 2009.
- 3ème Journée Optimeo, LRI Université Paris-Sud XI Orsay, France, Nov. 21 2008.
- 1ère Journée Optimeo, École Polytechnique Paris, France, Apr. 4 2008.

## Visiting terms and seminars

- INRA (French Institute for Agricultural Research) Toulouse. March 2012. 1 seminar. Invited by unité de Biométrie et Intelligence Artificielle.  
Seminar: *Clustering dans les réseaux basé sur la maximisation de la modularité*.
- Institut de Mathématiques de Toulouse. May 2011. 1 seminar. Invited by équipe MIP (Mathématiques pour l’Industrie et la Physique).  
Seminar: *Résoudre les conflits aériens par l’optimisation non-linéaire en variables mixtes*.

- GERAD, HEC Montréal. March 2011. Visiting Researcher, 2 weeks. 1 seminar. Invited by P. Hansen. Seminar: *Mixed-Integer Optimization for Air Traffic Deconfliction*.
- GERAD, HEC Montréal. July 2009. Visiting Researcher, 1 month. 1 seminar. Invited by P. Hansen. Seminar: *Convex relaxations in Branch and Bound global optimization methods: quadrilinear terms*.
- LRI, Université Paris XI. 2009, 1 seminar, invited by A. Lisser. Seminar: *Convex relaxations in Branch and Bound global optimization methods: quadrilinear terms*.
- Lamsade, Université Paris Dauphine. 2009, 1 seminar, invited by R. Mahjoub. Seminar: *Convex relaxations in Branch and Bound global optimization methods: quadrilinear terms*.
- Center for Applied Optimization, University of Florida, Gainesville. March 2007. Visiting Scholar, 3 weeks. 1 seminar. Invited by P.M. Pardalos. Seminar: *On the development of Interior Point Software for Quadratic Programming*.

## Teaching experience

*Note:* Some didactic material for the courses can be downloaded from <http://www.recherche.enac.fr/~cafieri/teaching.html>

- **Calcul Différentiel et Optimisation.** Given at École Nationale de l'Aviation Civile. The course is taught in the academic years 2011/12, in the first semester. *Syllabus:* basic concepts and results of Differential Calculus and continuous local Optimization. 18 students, 40h lectures. Course level: first year engineers ENAC.
- **Optimisation Discrete.** Given at École Nationale Supérieure d'Electrotechnique, Electronique, Informatique, Hydraulique et Télécommunications (ENSEEIHT). The course is taught in the academic years 2011/12, in the first semester. *Syllabus:* introduction to Discrete Optimization, classical problems, solution methods. 10 students, 8h lectures + 2h computer labs. Course level: third year engineers ENSEEIHT.
- **Programming and Algorithms** (in French "Programmation et Algorithmique"). Given at École Nationale de l'Aviation Civile. Responsable of the course: Prof. N. Barnier. The course was taught in the academic years 2009/10, 2010/2011 and 2011/2012, in the second semester. *Syllabus:* introduction to development of algorithms and programming in C and Caml languages. Approximately 35 students, 50h computer labs. Course level: first year engineers ENAC.
- **Constraint Programming.** Given at École Nationale de l'Aviation Civile. Responsable of the course: Prof. N. Barnier. Computer labs (TDs), academic year 2010/11, in the first semester. *Syllabus:* introduction to constraint programming, use of the software ILOG Solver. 16 students, 20h computer labs. Course level: third year engineers ENAC.
- **Operations Research: Modelling and Software** (in French "Recherche Operationelle: Modélisation et Utilisation logiciel"). Given 2 times at École Polytechnique, as assistant to Prof. L. Liberti. *Syllabus:* the language of mathematical programming, choice of solution algorithms, basic reformulations, complex applications. The course was taught as assistant in the academic years 2008/09 and 2009/2010, in

the first semester. Approximately 15 students, 2 hours of lectures, 16 hours of computer labs. Course level: M.Sc.

- **Introduction to C++**. Given 1 time at École Polytechnique. The course was taught as assistant in the academic year 2009/2010, in the first semester. Approximately 25 students, 6 hours of computer labs. Course level: M.Sc.
- **Informatics** (in Italian, “Informatica”). Given 1 time at the Second University of Naples, for the Course in *Biology*, as teacher. *Syllabus*: fundamentals of computer organization and architecture, introduction to the development of algorithms, use of Microsoft Office and basic use of Matlab for visualization and analysis of biological data. The course was taught the academic year 2005/06, in the second semester. Approximately 300 students, 40 hours of lectures, 20 hours of computer labs. Course level: B.Sc.
- **Informatics** (in Italian, “Informatica”). Given 3 times at the Second University of Naples, for the Course in *Biology*, as assistant. *Syllabus*: fundamentals of computer organization and architecture, introduction to the development of algorithms, use of Microsoft Office and basic use of Matlab for visualization and analysis of biological data. Course level: B.Sc.
  - II semester 2002-2003. Assistant to Prof. D. Romano. 200 students. Computer labs: 50 hours.
  - II semester 2003-2004. Assistant to Prof. M. D’Apuzzo. 300 students. Computer labs: 50 hours. Lectures: 10 hours.
  - II semester 2004-2005. Assistant to Prof. M. D’Apuzzo. 300 students. Computer labs: 50 hours. Lectures: 14 hours.
- **Introduction to Numerical Methods for Optimization** (in Italian, “Elementi di metodi numerici per l’ottimizzazione”). Given 1 time at the Second University of Naples, for the Courses in *Mathematics* and *Mathematics and Informatics*, as assistant to Prof. M. D’Apuzzo and D. di Serafino. *Syllabus*: methods for solving unconstrained optimization problems. The course was taught as assistant in the academic year 2005/06 in the second semester. Approximately 10 students, 8 hours of lectures. Course level: M.Sc.
- **Parallel Computing** (in Italian, “Calcolo Parallelo”). Given 4 times at the Second University of Naples, for the Courses in *Mathematics* and *Mathematics and Informatics*, as assistant to Prof. M. D’Apuzzo and D. di Serafino. *Syllabus*: methods and strategies for developing parallel software procedures for MIMD computers. The course was taught as assistant every academic year, from 2002/03 to 2005/06, in the first semester. Approximately for every year: 20 students, 10 hours of computer labs and 10 hours of lectures. Course level: B.Sc.
- **Numerical Computations** (in Italian, “Calcolo Numerico”). Given 4 times at the Second University of Naples, for the Courses in *Mathematics* and *Mathematics and Informatics*, as assistant to Prof. M. D’Apuzzo and D. di Serafino. *Syllabus*: solution of linear systems by direct and iterative methods, data representation and interpolation, quadrature formulas, the C programming language. The course was taught as assistant every academic year, from 2002/03 to 2005/06, in the second semester. Approximately for every year: 50 students, 20 hours of computer labs and 10 hours of lectures. Course level: B.Sc.

- **Introduction to Programming** (in Italian, “Laboratorio di Programmazione e Calcolo”). Given 4 times at the Second University of Naples, for the Courses in *Mathematics* and *Mathematics and Informatics*, as assistant to Prof. M. D’Apuzzo, D. di Serafino and V. De Simone. *Syllabus*: floating-point arithmetic, round-off errors and basic matrix computation. The course was taught as assistant every academic year, from 2002/03 to 2005/06, in the second semester. Approximately for every year: 100 students, 20 hours of computer labs and 10 hours of lectures. Course level: B.Sc.
- **Introduction to Informatics** (in Italian, “Laboratorio di Programmazione”). Given 4 times at the Second University of Naples, for the Courses in *Mathematics* and *Mathematics and Informatics*, as assistant to Prof. M. D’Apuzzo, D. di Serafino and V. De Simone. *Syllabus*: basic informatics concepts and introduction to Fortran. The course was taught as assistant every academic year, from 2002/03 to 2005/06, in the first semester. Approximately for every year: 100 students, 20 hours of computer labs and 10 hours of lectures. Course level: B.Sc.
- **Introduction to HTML**. Mini-course of 8 hours. Given 3 times at the Second University of Naples. *Syllabus*: introduction to the development of simple web pages by HTML. The mini-course was taught as teacher the academic years 2003/04, 2004/05 and 2005/2006. Approximately 20 students.
- **Computational Mathematics** (in Italian, “Matematica Computazionale”). Given 2 times at the Second University of Naples, for the Courses in *Mathematics*, as assistant to Prof. M. D’Apuzzo and D. di Serafino. *Syllabus*: methods and strategies for developing parallel software procedures for MIMD computers. The course was taught as assistant in the academic years 2002/03 and 2003/04, in the first semester. Approximately for every year: 20 students, 10 hours of computer labs and 10 hours of lectures. Course level: M.Sc.
- **Programming and Numerical Computations** (in Italian, “Calcolo Numerico e Programmazione”). Given 2 times at the Second University of Naples, for the Courses in *Mathematics*, as assistant to Prof. M. D’Apuzzo and D. di Serafino. *Syllabus*: data representation, interpolation, quadrature formulas, direct and iterative methods for linear systems, solution of nonlinear equations, the C programming language, introduction to Matlab. The course was taught as assistant every academic years 2002/03 and 2003/04, in the second semester. Approximately for every year: 30 students, 10 hours of computer labs and 6 hours of lectures. Course level: M.Sc.
- **Numerical Analysis** (in Italian, “Analisi Numerica”). Given 3 times at the Second University of Naples, for the Courses in *Mathematics*, as assistant to Prof. M. D’Apuzzo and D. di Serafino. *Syllabus*: computer architecture, floating-point arithmetic, round-off errors, basic linear algebra and introduction to Fortran. The course was taught as assistant every academic year, from 2002/03 to 2004/05, in the first semester. Approximately for every year: 30 students, 10 hours of computer labs and 6 hours of lectures. Course level: M.Sc.

## Supervisioning and tutoring

- Since October 2011: **Supervision of the Ph.D. thesis** of Loïc Cellier.  
Topic: Deterministic Global Optimization applied to Air Traffic Management problems (co-supervision with Frédéric Messine).
- 2011: Supervision of 2 mini-projects on development of C and Caml code by 4 students (each project is developed by 2 students) 1st year engineers ENAC.

- 2010: Supervision of a mini-project (implementation in Java) by 4 students second year engineers ENAC. Topic: Analysis of air traffic network.
- 2010: Supervision of 4 mini-projects on development of C code by 8 students (each project is developed by 2 students) 1st year engineers ENAC.
- 2006: Co-supervision (with M. D'Apuzzo) of the M.Sc. thesis of A. Aldanese. Second University of Naples. Topic: Software for linear programming problems.
- 2006: Co-supervision (with D. di Serafino) of the M.Sc. thesis of E. Giannelevigna. Second University of Naples. Topic: A Potential Reduction method for quadratic optimization.
- 2004: Co-supervision (with M. D'Apuzzo) of the M.Sc. thesis of L. Minicucci. Second University of Naples. Topic: Interior Point methods for quadratic optimization.
- Personal tutor for students of Second University of Naples every academic year from 2003/2004 to 2005/2006.

## Computer-related skills

- Programming Languages: C, C++, Fortran77/90, Caml, Matlab, Perl.
- Operating Systems: Unix, Linux, Windows.
- Linear Algebra Packages: BLAS, LAPACK, ICFS, HSL.
- Optimization Systems and Software: KNITRO, MOSEK, LANCELOT, CPLEX, AMPL, SNOPT and others, both commercial and free.
- Parallel Computing Packages: MPI, SCALAPACK.

## Developed Software

- PRQP (*Potential Reduction for Quadratic Programming*) solves convex quadratic problems with linear constraints
  - primal-dual infeasible PR method, feasible whenever possible;
  - different solvers for the KKT system: direct, CG, SQMR;
  - exact and reused constraint preconditioner, limited-memory ICF for bound constrained problems;
  - MA27 routine by the HSL library for sparse  $LDL^T$  computation;
  - custom SQMR and sparse matrix-vector products;
  - AMPL and SIF interfaces;
  - Fortran77, C drivers.
- PR-BCQP solves convex quadratic problems with only bounds on the variables; it is currently part of PRQP, but can be used as stand-alone software.

- ROSE (*Reformulation/Optimization Software Engine*)  
software framework for automatic reformulations of mathematical programming problems. Co-developer.
  - reformulators able to automatically provide convex relaxations of non-convex nonlinear problems.
  - data format translators.

## Languages

- Italian: mother tongue.
- English: good level.
- French: good level.

## A Research Activity

- *Global Optimization and Reformulation techniques in Mathematical Programming.* I am mainly interested in deterministic global optimization and its applications. An interesting application arising in Air Traffic Management is the resolution of aircraft conflicts, that occur when aircraft are “too close” each other in their predicted trajectories. The problem can be modeled as a global optimization problem. Research in this context concerns modeling and resolution techniques.

I started working on global optimization during my post-doc activity at École Polytechnique, when I worked within the context of the ANR-funded project *ARS* on reformulations. A reformulation of a mathematical program  $P$  is a mathematical program  $Q$  obtained from  $P$  via symbolic transformations applied to the set of variables, objective and constraints. Reformulation techniques are often used to recast a particular type of problem into a formulation which is amenable to be solved by a given algorithm. The research line is devoted to the investigation of new reformulation techniques, to the formalization and implementation of solution algorithms based on such techniques and to the development of software tools for automating mathematical programming reformulation. The final aim of this research is to develop a software able to automatically reformulate optimization problems and solve it by using one of the implemented methods. Software: ROSE-Reformulation/Optimization Software Engine (co-developer).

A reformulation is a relaxation if one or more constraints are eliminated. These reformulations are useful because provide a bound on the objective function value at the optimum. Such bounds are mainly used in Branch and Bound based global optimization methods, that work recursively partitioning the search space and computing a lower and an upper bound to the optimal value of the objective function in each subregion. In particular, different convex relaxations for quadrilinear terms, based on the idea of exploiting bilinear and trilinear convex envelopes, have been investigated. Convex relaxations of polynomial problems are currently under investigation.

- *Network Clustering.* Network clustering is a powerful tool for the automatic analysis of complex systems, with applications in many fields, such as natural sciences, sociology, medicine, engineering, marketing. A topic of particular interest in the study of complex networks is the identification of communities, also called modules or clusters. Given a network (or graph)  $G = (V, E)$  with a vertex set  $V$  and an edge set  $E$ , a community is a subset of vertices such that there are more edges within the community than edges joining it to the outside. A clustering criterion is chosen, in terms of presence or absence of edges. A mathematical programming problem can be formulated corresponding to such a criterion, usually a combinatorial problem. This research line concerns criteria for the identification of communities and solution strategies for the corresponding optimization problem. I am interested in exact algorithms as well as heuristics to detect communities in complex networks. New exact algorithms and a new locally optimal hierarchical divisive heuristic have been proposed.
- *Interior Point algorithms for nonlinear programming.* Interior Point algorithms for nonlinear programming represent the main research line during my Ph.D. and the first stage of my post-doc activity. Interior Point methods are effective and widely used methods for nonlinear programming problems. The focus is mainly on large-scale convex Quadratic Programming and related numerical Linear Algebra issues. In particular, I investigated the Interior Point Potential Reduction method. My research activity concerned the re-examination of the global convergence properties of such method in order to take into account an inexact solution of the inner linear KKT systems. The final product of this

research activity is a software package for quadratic programming. Software: PRQP - Potential Reduction software for Quadratic Programming.

- *Numerical Linear Algebra in constrained optimization.* A crucial issue in the effective solution of optimization problems with Interior Point methods is the availability of efficient and robust computational linear algebra kernels, especially for the solution of the linear KKT system that arises at each iteration of the method. In this context, the research activity has been mainly aimed to the development, the analysis and the implementation of iterative methods for the efficient solution of the KKT systems arising at each iteration of Interior Point methods for large-scale quadratic programming problems. Approaches based on a Constraint Preconditioner and an Incomplete Cholesky factorization coupled with Krylov solvers have been analyzed, in a Potential Reduction (PR) framework. Adaptive stopping criteria for the inner iterations have been developed, that relate the accuracy in the solution of the KKT system to the quality of the current PR iterate, to increase the overall computational efficiency. Moreover, we proposed an approximation strategy for the constraint preconditioner, with the aim of reducing the cost of the preconditioner application. Numerical experiments show that this approach is effective in reducing the computational cost. The above methods have been implemented and tested within the PRQP software.