Pietro Belotti September 4, 2020

Education

2003: Doctoral degree in Computer Engineering, Dept. of Electronics and Information, Politecnico di Milano, Italy.

1999: Laurea in Computer Engineering, Dept. of Electronics and Information, Politecnico di Milano, Italy.

Positions

2020–: Assistant Professor, Dept. of Electronics, Information and Bioengineering, Politecnico di Milano, Italy.

2018–2020: Principal Engineer, Fair Isaac Corp., Birmingham UK.

2013–2018: Senior Engineer, Fair Isaac Corp., Birmingham UK.

2013–: Adjunct Professor, Dept. of Mathematical Sciences, Clemson University, Clemson, South Carolina, USA.

2010–2013: Assistant Professor, Dept. of Mathematical Sciences, Clemson University, Clemson, South Carolina, USA.

2008–2010: Visiting Assistant Professor, Dept. of Industrial & Systems Engineering, Lehigh University, Bethlehem, Pennsylvania, USA.

2006–2008: Postdoctoral Fellow, Tepper School of Business, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA.

2003–2006: FIRB Assistant Professor, Dept. of Electronics and Information, Politecnico di Milano, Italy.

Research interests

Mixed Integer Nonlinear Optimization (MINLO): exact methods for MINLO; bound reduction techniques, branching mechanisms, reformulation and convexification of nonconvex optimization problems; exact solvers for convex and nonconvex Mixed Integer Quadratically Constrained problems.
Multiobjective optimization: exact methods for Mixed Integer Linear Optimization (MILO) problems with two or more objective functions; branching rules and fathoming rules for multiobjective MILOs; efficient storage of Pareto points in biobjective MILOs.
Multicommodity network flow problems: exact heuristic methods for network design problems arising in Telecommunications. Valid inequalities for network design with stepwise node costs; valid inequalities and a decomposition approach for shared protection network design; row-column generation for multi-layer network design; robust optimization applied to network design with uncertainty in the traffic matrix.
The Maximum Feasible Subsystem problem: Parallel implementation of a randomized, thermal relaxation methods for the problem of finding, in an infeasible linear system, a feasible subsystem with as many inequalities as possible.
Other interests: obnoxious location problems; Sphere packing problems in n dimensions.

Awards

2019: Oberwolfach *Research in Pairs* fellowship, 22 Sep. – 5 Oct. 2019.

2017: Best paper, "On handling indicator constraints in mixed integer programming", *Computational Optimization and Applications (COAP)* 65: 545–566, 2016.

Nov. 2010: COIN-OR Informs Cup on the best COIN-OR software for Optimization, *Couenne*.

June 2009: Best paper award: G. Panza, A. Capone, D. Pinarello and P. Belotti. "Robustness in Next-Generation Networks", ICT Summit Europe.

1998: Honorable mention, Camerini-Carraresi prize for the best M.Sc. thesis in Operations Research, Italy, 1998.

Research grants

2013: Co-P.I., "Algorithms for mixed integer conical optimization," National Science Foundation, $150,000, with T.K. Ralphs.

2010: P.I., "Robust planning of the production of liquid gases under energy uncertainty," PITA – Pennsylvania Infrastructure Technology Alliance. $27,060, with L.V. Snyder and T.K. Ralphs.

2009: Co-P.I., "Computational models and algorithms for enterprise-wide optimization of process industries," PITA – Pennsylvania Infrastructure Technology Alliance. $19,250, with L.V. Snyder.

2009: Co-P.I., "Capacity planning for a gases supply chain with network disruptions and interruptible power," PITA – Pennsylvania Infrastructure Technology Alliance. $33,000, with L.V. Snyder.

Publications

Refereed Journal Publications.

(1) F. Furini et al., "QPLIB: A library of quadratic programming instances", *Mathematical Programming Computation* **11(2)**:237-265 (2019).

(2) N. Adelgren, P. Belotti, A. Gupte, "Efficient storage of Pareto points in biobjective mixed integer programming", *Informs Journal on Computing* **30(2)**: 324-338 (2018).

(3) P. Belotti, J.C. Góez, I. Pólik, T.K. Ralphs, T. Terlaky, "A complete characterization of disjunctive conic cuts for mixed integer second order cone optimization", *Discrete optimization* **24**:3-31 (2017).

(4) P. Belotti, T. Berthold, "Three ideas for a feasibility pump for nonconvex MINLP", *Optimization Letters* **11(1)**:3-15 (2017).

(5) P. Belotti, P. Bonami, M. Fischetti, A. Lodi, M. Monaci, A. Nogales-Gómez, "On handling indicator constraints in mixed integer programming", *Computational Optimization and Applications* **65(3)**:545-566 (2016).

(6) P. Belotti, B. Soylu, M.M. Wiecek, "Fathoming rules for biobjective mixed integer linear programs: Review and extensions", *Discrete Optimization* **22**:341-363 (2016).

(7) W. Adams, P. Belotti, R. Shen, "Convex hull characterizations of lexicographic orderings", *Journal of Global Optimization* **66(2)**:311-329 (2016).

(8) B. Rostami, F. Malucelli, P. Belotti, S. Gualandi, "Lower bounding procedure for the asymmetric quadratic traveling salesman problem", *European Journal of Operational Research* **253(3)**:584-592 (2016).

(9) P.M. Dearing, P. Belotti, A.M. Smith, "A primal algorithm for the weighted minimum covering ball problem in", *TOP* **24(2)**:466-492 (2016).

(10) T.J. Mullin, P. Belotti, "Using branch-and-bound algorithms to optimize selection of a fixed-size breeding population under a relatedness constraint", *Tree genetics & genomes* **12(1)**:4 (2016).

(11) P. Belotti, J.C. Góez, I. Pólik, T.K. Ralphs, T. Terlaky, "A conic representation of the convex hull of disjunctive sets and conic cuts for integer second order cone optimization", *Numerical Analysis and Optimization*, 1-35 (2015).

(12) P. Belotti, Z. Csizmadia, S. Heipcke, S. Lannez, "Robust Optimization with FICO TM Xpress", White paper, Fair Isaac Corp. (2014)

(13) P. Belotti, J.C. Góez, I. Pólik, T.K. Ralphs, T. Terlaky, "On families of quadratic surfaces having fixed intersections with two hyperplanes", *Discrete Applied Mathematics*, **161(16)**:2778-2793 (2013).

(14) Ç. Latifoğlu, P. Belotti, L.V. Snyder, "Models for production planning under power interruptions", *Naval Research Logistics*, **60(5)**:413-431 (2013).

(15) P. Belotti, C. Kirches, S. Leyffer, J. Linderoth, J. Luedtke, and A. Mahajan, "Mixed-Integer Nonlinear Optimization", *Acta Numerica* **22**:1-131 (2013).

(16) G. Nannicini and P. Belotti, "Rounding-based heuristics for nonconvex MINLPs", *Mathematical Programming Computation* **4(1)**:1-31 (2012).
(17) P. Belotti, "Bound reduction using pairs of linear inequalities", *Journal of Global Optimization* **56(3)**:787-819 (2012).
(18) P. Belotti, A.J. Miller, M. Namazifar, "Linear inequalities for bounded products of variables", *SIAG/OPT Views-and-News* **22(1)**:1-7 (2011).
(19) A. Altın, P. Belotti, M.Ç. Pınar, "OSPF routing with optimal oblivious performance ratio under polyhedral demand uncertainty," *Optimization and Engineering* **11(3)**:395-422 (2010).
(20) P. Belotti, J. Lee, L. Liberti, F. Margot, A. Wächter, "Branching and bounds tightening techniques for non-convex MINLP," *Optimization Methods and Software* **24(4-5)**:597-634 (2009).
(21) P. Belotti, M.Ç. Pınar, "Optimal oblivious routing under linear and ellipsoidal uncertainty," *Optimization and Engineering* **9(3)**:257-271 (2008).
(22) P. Belotti, A. Capone, G. Carello, F. Malucelli, "Multi-layer MPLS network design: the impact of statistical multiplexing," *Computer Networks* **52(6)**:1291-1307 (2008).
(23) P. Belotti, M. Labbé, F. Maffioli, M. M. Ndiaye, "A branch-and-cut method for the obnoxious p-median problem," *4OR* **5(4)**:299-314 (2007).
(24) S. Kucherenko, P. Belotti, L. Liberti, N. Maculan, "New formulations for the kissing number problem," *Discrete Applied Mathematics* **155(14)**:1837-1841 (2007).
(25) A. Altın, E. Amaldi, P. Belotti, M.Ç. Pınar, "Provisioning virtual private networks under traffic uncertainty," *Networks* **49(1)**:100-115 (2007).
(26) P. Belotti, F. Malucelli, L. Brunetta, "Multicommodity network design with discrete node costs," *Networks* **49(1)**:90-99 (2007).
(27) E. Amaldi, P. Belotti, A. Capone, F. Malucelli, "Optimizing base station location and configuration in UMTS networks," *Annals of Operations Research* **146(1)**:135-151 (2006).
(28) P. Belotti, "Multicommodity network design with survivability constraints: Some models and algorithms," *4OR* **3(1)**:79-81 (2005).

Book chapters.

(1) P. Belotti, "Disjunctive cuts for non-convex MINLP". J. Lee and S. Leyffer (eds.), *Mixed Integer Nonlinear Programming*, IMA Volumes in Mathematics and its Applications, vol. 154, Springer, 117-144 (2012).
(2) A. Qualizza, P. Belotti, F. Margot, "Linear programming relaxations of quadratically constrained quadratic programs". J. Lee and S. Leyffer (eds.), *Mixed Integer Nonlinear Programming*, IMA Volumes in Mathematics and its Applications, vol. 154, Springer, 407-426 (2012).
(3) P. Belotti, L. Liberti, A. Lodi, G. Nannicini, A. Tramontani, "Disjunctive inequalities: applications and extensions." J. Cochran et al. (eds.), *Encyclopedia of Operations Research and Management Science*, John Wiley and Sons (2010).
(4) S. Orlowski, C. Raack, A.M.C.A. Koster, G. Baier, T. Engel, P. Belotti, "Branch-and-cut techniques for solving realistic two-layer network design problems," in A.M.C.A. Koster, X. Muñoz (eds.), *Graphs and Algorithms in Communication Networks*, Springer-Verlag, 95-117 (2009).

Conference Proceedings (Reviewed).

(1) P. Belotti, S. Cafieri, J. Lee, L. Liberti, A. Miller, "On the composition of convex envelopes for quadrilinear terms". In A. Chinchuluun et al. (ed.), *Proceedings of International Conference on Optimization, Simulation and Control*, series: Springer Optimization and its Application, Springer, 2012.
(2) N. Touati-Moungla, P. Belotti, V. Jost, L. Liberti, "A Branch-and-Price Algorithm for the Risk-Equity Constrained Routing Problem". In J. Pahl, T. Reiners, S. Voß (eds.), *Network Optimization*, Lecture Notes in Computer Science 6701, 439-449, Springer Berlin/Heidelberg (2011).

(3) G. Nannicini, P. Belotti, J. Lee, J. Linderoth, F. Margot, A. Wächter, "A Probing Algorithm for MINLP with Failure Prediction by SVM," *Proceedings of the eighth International Conference on Integration of Artificial Intelligence (AI) and Operations Research (OR) techniques in Constraint Programming (CPAIOR 2011)*, 154-169, Berlin, Germany (June 2011).

(4) P. Belotti, S. Cafieri, J. Lee, L. Liberti, "Feasibility-based bounds tightening via fixed points," *Proceedings of the 4th Annual International Conference on Combinatorial Optimization and Applications (COCOA 2010)*, Big Island, Hawaii (December 2010).

(5) A. Karabis, P. Belotti, D. Baltas, "Optimization of catheter position and dwell time in prostate HDR brachytherapy using HIPO and linear programming," *Proceedings of the World Congress on Medical Physics and Biomedical Engineering*, 612-615, Munich, Germany (September 2009).

(6) G. Panza, A. Capone, D. Pinarello, P. Belotti, "Robustness in next-generation networks," *Proceedings of the ICT Summit Europe*, Santander, Spain (June 2009).

(7) P. Belotti, A. Capone, G. Carello, F. Malucelli, F. Senaldi, A. Totaro, "Design of Multi-layer networks with traffic grooming and statistical multiplexing," *Proceedings of the International Network Optimization Conference (INOC 2007)*, Spa, Belgium (April 2007).

(8) P. Belotti, A. Capone, G. Carello, F. Malucelli, F. Senaldi, A. Totaro, "MPLS over transport network: two layer approach to network design with statistical multiplexing," *Proceedings of the 2nd Conference on Next Generation Internet Design and Engineering*, 333-340, Valencia, Spain (April 2006).

(9) E. Amaldi, P. Belotti, R. Hauser, "Randomized relaxation methods for the maximum feasible subsystem problem," *Proceedings of the 11th International Conference on Integer Programming and Combinatorial Optimization (IPCO 2005)*, 259-264, Berlin, Germany (June 2005).

(10) P. Belotti, F. Malucelli, "Row-column generation for multilayer network design," *Proceedings of the International Network Optimization Conference (INOC 2005)*, 422-427, Lisbon, Portugal (March 2005).

(11) P. Belotti, F. Malucelli, "Relaxation approach to network design with shared protection," *Proceedings of the International Network Optimization Conference (INOC 2003)*, 72-77, Paris-Evry, France (October 2003).

(12) P. Belotti, T. Stidsen, "Optimal placement of wavelength converting nodes," *Proceedings of the Third International Workshop on Design of Reliable Communication Networks (DRCN 2001)*, 15-21, Budapest, Hungary (October 2001).

Teaching

Spring '13:	"MthSc816 – Network Algorithms and Data Structures" (grad.), Clemson University. Syllabus: graphs, binary trees, red-black trees, optimization problems on graphs.
Spring '13:	"MthSc311 – Linear Algebra" (undergrad.), Clemson University. Syllabus: vectors, matrices, null space, eigenvalues, polynomial, linear transformations.
Fall '11,'12:	"MthSc810 – Mathematical Programming" (grad.), Clemson University. Syllabus: modeling of optimization problems, convex sets Linear programming: duality, simplex, sensitivity analysis.
Spring/Fall '12:	"MthSc365 – Numerical Methods for Engineers" (undergrad.), Clemson University. Syllabus: basics of programming, linear systems, interpolation, root finding.
Spring '11:	"MthSc101 – Essential Mathematics for the Informed Society" (undergrad.), Clemson University. Syllabus: Boolean algebra, digital data formats, randomness, graphical representation of data, inference and estimation, interest, annuities, and amortization.

Spring '11,'12: "MthSc811 – Nonlinear Programming" (grad.), Clemson University. Syllabus: Convex sets and functions, unconstrained optimization, constrained optimization, feasible point methods, penalty and barrier methods.

Fall '10: "MthSc440/640 – Linear Programming" (undergrad.), Clemson University. Syllabus: Linear Programming examples, duality, sensitivity analysis, the simplex method, the revised simplex method.

Spring '09,'10: "IE341 – Data communication systems analysis and design" (undergrad.), Lehigh University. Syllabus: design, simulation, and technological aspects of Local, Metropolitan, Wide-area, and distributed computing networks.

Spring '09,'10: "IE172 – Algorithms for systems engineering" (undergrad.), Lehigh University. Syllabus: Design, analysis, and implementation of algorithms for common engineering applications. Sorting and searching, graph algorithms, algorithms for numerical applications.

Fall '08, '09: "IE426 – Optimization models and applications" (graduate), Lehigh University. Syllabus: convexity and relaxation; models in Linear Programming, Integer Programming, Stochastic Programming, and Nonlinear Programming. Case studies with hands-on experience on real-world problems.

2006: Section classes, "C++ for Java users", LIX, École Polytechnique, Paris, France.

2004-2005: Co-lecturer, "Design of telecommunication networks," Telecommunications Engineering, Politecnico di Milano, Italy. Syllabus: Models for uncapacitated and capacitated network design problems. Solution techniques: cutting planes, column generation, Lagrangean Relaxation, heuristics. Case studies of synthesis of real-world networks.

2005: Lecturer, "Introduction to Operations Research," Computer Engineering, Politecnico di Milano, Italy. Syllabus: Graph Theory, flow problems, Linear Programming, Mixed Integer Linear Programming. Complexity theory, heuristic and approximation algorithms.

2000-2001: Section classes, "Operations Research," Computer Engineering, Politecnico di Milano, Italy. Lecturer: F. Maffioli.

2001-2004: Section classes, "Introduction to Operations Research," Computer Engineering, Politecnico di Milano. Lecturers: F. Maffioli, F. Malucelli, N. Maculan.

2000-2001: Instructor, UNIX system programming, C, and C++, EU-funded Computer Science courses, Bergamo, Italy (60 hours).

2000-2001: Instructor, UNIX C and C++, *SpazioZeroUno* Computer Science courses, Vimercate, Milan, Italy (80 hours).

Editorial work

2008–: Technical editor, *Mathematical Programming Computation* (Springer).

2010–: Associate editor, *RAIRO-RO*.

2011–: Associate editor, *Mathematical Models of Operations Research*.

2010–2017: Web editor, *INFORMS Optimization Society*.

2019–: Co-editor, *SIAG/OPT News and Views*.

Organization

MINLP: Workshop on MINLP, Imperial College London, June 2020.

SIOPT: SIAM Conference on Optimization, Hong Kong, May 2020.

CPAIOR: One-day workshop on Open Source Tools for Constraint Programming and Mathematical Programming. Organized within the 7th International Conference on Integration of Artificial Intelligence (AI) and Operations Research (OR) techniques in Constraint Programming (CPAIOR), Bologna, Italy, June 14-18, 2010.

CPAIOR: One-day Workshop on Hybrid Methods for Nonlinear Combinatorial Problems. Organized within CPAIOR, Bologna, Italy, June 14-18, 2010.

MOPTA: Organizing committee (2009 and 2010), Modeling and OPtimization: Theory and Application, Lehigh University, Bethlehem PA.
http://mopta.ie.lehigh.edu

BR-OPT: Chair, BR-OPT: Bound Reduction for Mixed Integer Nonlinear Programming. CPAIOR conference, Carnegie Mellon University, Pittsburgh PA, May 27-31, 2009.
http://www.cs.utep.edu/mceberio/Research/br-cpaior09

IntCP: Organizing committee, IntCP 2009: Interval analysis, constraint propagation, applications (http://icwww.epfl.ch/~sam/IntCP09). Held within the 15th International Conference on Principles and Practice of Constraint Programming (CP 2009), September 20-24, 2009.

MINLP: Cyber-infrastructure for Mixed Integer Nonlinear Programming (MINLP) problems (http://www.minlp.org). A website for exchange of MINLP instances and discussion forums for modeling and solving real-world MINLP problems.

Service activities

2008-09: Technical supervision for the REEF (Reconfigurable Educational Experimental Facility) laboratory for undergraduate students, ISE Dept., Lehigh University.

2008-10: On the graduate application committee for the ISE Dept., Lehigh University.

Since 2001: Served as a referee for Operations Research, Siam J. on Optimization, Mathematical Programming A, Informs J. on Computing, Discrete Applied Mathematics, J. of Global Optimization, Networks, 4OR, European J. of Operational Research, OR Letters, Optimization and Engineering, Optimization Methods & Software, Mathematical models of OR, Comp. Opt. & Applications, Telecommunication Systems, Computer Networks, the AIChE Journal, and ESA.

2000-2006: Supervision, ORLAB – the Operations Research laboratory at the Department of Electronics and Computer Science, Politecnico di Milano.

Memberships

2010-: COIN-OR Foundation

2008-: Mathematical Optimization Society

Software

COUENNE: A Branch&Bound solver for non-convex, Mixed Integer Nonlinear problems, based on Linearization techniques and released within the Coin-OR framework.

CRÈME: Parallel randomized thermal relaxation method. Tested on instances with up to 18 million constraints on a BlueGene/L supercomputer. Released within the Coin-OR framework.