



Curriculum vitae

# Alberto Bemporad

## Personal data

- Alberto Bemporad was born in Florence, Italy, on March 26, 1970
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## Work experience

- 2011-today: Full professor, IMT Institute for Advanced Studies Lucca, Italy. Director of the Institute since 2012
- 2011-today: Cofounder of the startup company ODYS S.r.l.
- 2010-2011: Associate professor, Faculty of Engineering, University of Trento, Italy
- 2005-2009: Associate professor, Faculty of Engineering, University of Siena, Italy
- 1999-2005: Assistant professor ("Ricercatore"), Faculty of Engineering, University of Siena, Italy
- 1997-2002: Postdoctoral fellow and then senior researcher at the Automatic Control Laboratory, ETH, Zurich, Switzerland
- 1994/1995: Officer in the "Corpo Tecnico" of the Italian Army (Electronic and Precision Equipment Military Factory, Roma, Italy)
- 1993/1994: Research assistant, University of Florence, Italy

## Education

- 1997: Ph.D. degree in Control Engineering, University of Florence, Dipartimento di Sistemi e Informatica. Advisor: Prof. Edoardo Mosca
- 1996/1997: visiting researcher at the Center for Robotics and Automation, Dept. Systems Science and Math, Washington University, St. Louis, MO, USA (invited by Prof. T.J. Tarn)
- 1993: Degree granted in Electrical Engineering summa cum laude, University of Florence (average mark 29.8/30; 19 out of 28 exams *cum laude*)
- 1988: Scientific High School leaving certificate, with full marks (60/60)

## Awards and professional recognitions

- IFAC High-Impact Paper Award for the 2011-14 triennial.
- IEEE Fellow (since January 2010).
- Certificate of scientific ability for the position of full professor by the Commission for Scientific Merits of the Italian Control Association "C.I.R.A." (Centro Interuniversitario di Ricerca in Automatica), December 2005.
- Senior Member of the IEEE Control Systems Society (since July 2006)
- Best master thesis award "G. Barzilai", IEEE Centre and South Italy section, 4th edition.
- Best master thesis award "R. Mariani", AEI (Italian Electrotechnical Association) for year 1993.

## Language skills

- Italian: Mother tongue
- English: Fluent. TOEFL score 607 (August 1995). Graduate Record Examinations (GRE) score: 610 (verbal), 750 (quantitative), 710 (analytical) (December 1996).

## Research activities

In a nutshell, my research activities concern *embedded real-time optimization for control of dynamical processes*, with efforts covering the investigation of theoretical aspects, the development of numerical algorithms and software tools, and their application to real-life problems of industrial and economic interest, such as in the areas of automotive and aerospace systems, financial engineering, smart grids and energy markets, process control.

The research activities carried out starting in 1993 are summarized below. Such activities lead to about 250 scientific publications, detailed in the [publication list](#). The scientific impact of the results in terms of citations is quantified by the Hirsch number (H-number), to date (September 3, 2014) equal to 53, with the six most cited papers having 1900, 1654, 538, 536, 436, 406 citations (see [personal page](#) on Google Scholar).

- *Model predictive control*. Model Predictive Control (MPC) is widely adopted in industry as an effective means to control large multivariable constrained systems. The main idea of MPC is to choose the control action by solving an optimal control problem on line that minimizes a performance criterion over a future horizon, subject to constraints on process variables. Several issues in MPC were investigated: embedded optimization methods for linear MPC; stochastic MPC for constrained linear systems; decentralized MPC for spatially-distributed large-scale systems; MPC based on wireless sensor feedback and minimization of battery energy (experimental results obtained on a wireless automation laboratory process equipped with Telos wireless nodes), and to minimize the use of battery energy; reference governors that supervise conventional controller operations by "smoothing out" the reference trajectory for linear, nonlinear, uncertain systems, for systems teleoperated in the presence of arbitrarily large network delays, for robotic manipulators with constraints; robust MPC based on set-membership state

estimation and min-max MPC; explicit MPC for computing the control law off line and development of multiparametric solvers for linear, hybrid, uncertain, quantized systems, and anti-windup  $L_2$  synthesis.

- *Hybrid systems.* Hybrid models based on mixed-integer models for describing systems composed of both continuous and discrete dynamic components. Accomplished research results: modeling, predictive control, verification and reachability analysis, observability analysis, fault detection and state estimation, scheduling and optimal control, stochastic hybrid systems, event-based hybrid systems, identification of hybrid models based on randomized algorithms and on mixed-integer programming, solvers for mixed-integer quadratic optimization and suboptimal techniques.
- *Automotive applications.* Several case studies in automotive applications investigated using MPC and hybrid techniques in collaboration with industrial research centers (Ford Motor Company USA, Jaguar UK, Fiat Research Center Italy): adaptive cruise control, semiactive suspension, magnetic actuators, hybrid electrical vehicles, active steering, idle speed control, control of air-to-fuel ratio, traction control, control of direct injection engines, of dry-clutch engagement, of robotized gearbox for reduction of consumptions and emissions; Synthesis of sliding-mode controllers for anti-skid systems based on analog fuzzy chip implementation (in collaboration with the Microelectronics Dept. of the University of Bologna, Italy).
- *Aerospace applications.* MPC of satellite attitude (in collaboration with Thales Alenia Space, France), MPC of formations of unmanned air vehicles (quadcopters) with experimental realization of laboratory prototypes.
- *Financial engineering applications.* Stochastic MPC for dynamic option hedging (in collaboration with MPS Capital Services, Italy).
- *Energy systems.* Recent activities started in stochastic MPC for bidding on day-ahead/ancillary services/balancing electricity markets, and for power dispatch in smart microgrids (within the European project E-PRICE "Price-based control of electrical power systems" and in collaboration with Dolomiti Energia, Italy).
- *Wireless sensor networks.* MPC over wireless sensor feedback was tested experimentally in wireless automation laboratory activities. Wireless monitoring applications were also experimentally carried out in the laboratory for estimating environmental parameters in agricultural applications (temperature, humidity, speed and wind direction, leaf wetness, soil moisture, solar radiation), for vehicle detection through magnetoresistive sensors, human motion detection through pyroelectric sensors and accelerometers (testbed: Telos nodes and data acquisition directly in the Matlab environment).
- *Computational geometry.* Developed theory and algorithms for convexity recognition and computation of the union of polyhedra, for inner and outer approximation of polyhedra via unions of hyper-rectangles, for computing polyhedral invariant sets from invariant ellipsoidal sets using DC (difference of convex functions) optimization ideas.
- *Robotics.* Path planning for mobile robots. Investigated on-line path planners based on velocity fields for car-like mobile robots in the presence of obstacles. Navigation of mobile robots using sonar sensors, with experiments on two mobile robots constructed at the Dipartimento di Sistemi e Informatica, University of Florence, Italy; on-line trajectory planning for robotic manipulators with experiments on a PUMA 560 robot (Washington University, St.Louis). Design and construction of a mobile robot based on the Motorola 68HC11F1 microcontroller (during the military service).
- *Development of MATLAB/Simulink toolboxes.* Development of the [Hybrid Toolbox](#) for the analysis and design of hybrid systems and hybrid/explicit MPC controllers, which has been applied since 2003 to numerous control problems in industry and in academia; development of the [Model Predictive Control Toolbox](#) distributed by The Mathworks, Inc.; development of the MPCTOOL toolbox and of the MPCSoft toolbox for the European Space Agency.

### Teaching activities

- Undergraduate courses:
  - 2009/10 - 2010/11: "[Automatic Control](#)", University of Trento, Engineering School
  - 2001/02 - 2008/09: "[Digital Control](#)", University of Siena, Engineering School
  - 2001/02 - 2008/09: "[Control Systems Technology](#)", University of Siena, Engineering School
  - 2003/04 - 2008/09: "[Process Control](#)", University of Siena, Engineering School
  - 2001/02: "[Introduction to Linear Systems](#)", University of Siena, Engineering School
  - From 2001/02 to 2007/08: "Laboratory of Control Systems Technology and PLC", University of Siena, Engineering School
  - 2000/01: "[Linear Systems](#)", University of Siena, Engineering School
  - 1997–2002: "Model Predictive Control" ETH Zurich (lectures)
  - 1999–2000: "Control Systems II", ETH Zurich (lectures and assistance)
  - 1997: Teaching Assistant in "Optimization" (Prof. M.Amin), Washington University, St. Louis, MO
  - 1994: Teaching assistant in Automatic Control (Prof. A. Vicino), University of Siena
- PhD Schools:
  - 2013: "[5th HYCON2 PhD School on Control of Networked and Large-Scale Systems and EFFINET PhD School on Control of Drinking Water Networks](#)", Lucca, July 1-5, 2013
  - 2011: "[4th HYCON PhD School on Control of Networked and Large-Scale Systems](#)", organization and participation as a lecturer, Trento, June 21-24, 2011
  - 2009: "[3rd WIDE PhD School on Networked Control Systems](#)", organization and participation as a lecturer, Siena, July 7-9, 2009
  - 2007: "[2nd HYCON PhD School on Hybrid Systems](#)", organization and participation as a lecturer, Siena, July 16-19, 2007
  - 2005: "[1st HYCON PhD School on Hybrid Systems](#)", organization and participation as a lecturer, Siena, July 19-22, 2005
  - 2003: "DISC Summer School on Modeling and Control of Hybrid Systems", organization and participation as a lecturer, June 23-26, 2003

- Graduate courses & workshops:
  - 2012-13: PhD course "[Model Predictive Control](#)", IMT Institute for Advanced Studies Lucca.
  - 2008: Short course "[Modeling and Control of Hybrid Systems](#)", Summer School on Hybrid Simulation / E-Learning, Malignano (SI), September 1, 2008
  - 2008: Short course "[Optimization models and methods](#)", Danieli Automation, Buttrio (UD), April 17, 2008
  - 2008: PhD course "[Hybrid predictive control and wireless sensor network](#)", PhD School in Information Engineering, University of Naples "Federico II", February 25-29, 2008
  - 2006: PhD course "Model Predictive Control of Hybrid Systems", Escuela de doctorado en control predictivo de sistemas híbridos y con restricciones, UPC, Barcelona, Spain, July 17-21, 2006
  - 2005: Workshop on "Model Predictive Control of Hybrid Systems" at the joint Conference on Decision and Control and European Control Conference, Sevilla, Spain, December 11, 2005
  - 2004, 2005: "[Decision support systems – Mathematical programming models](#)", Master in Digital Economy and E-Business, University of Siena
  - 2004: Intensive course on "Model Predictive Control", Dept. of Electrical Engineering, University of Linköpings, Sweden, September 22-24, 2004
  - 2003: Short course on "Hybrid and Explicit Model Predictive Control", Ford Research Laboratories, Dearborn, MI, December 2-4, 2003
  - 2003-2008: Short course on "Advanced Robust and Optimal Control Techniques – Hybrid Systems", Fiat Research Center, Orbassano (TO), Italy. From 2003 to 2008 editions
  - 2003: PhD School on "Hybrid Systems", Bertinoro, Italy, July 16-19, 2003
  - 2003: Short course on "Model Predictive Control", University of Linköping, Sweden, September 2003
  - 2003: Short course on "[Model Predictive Control](#)", KTH Stockholm, Sweden, April 7-9, 2003
  - 2003: Short course on "[Modeling, Control, and Reachability Analysis of Hybrid Systems](#)", Dutch Institute of Systems and Control (DISC) School, March 31, 2003
  - 2001: Short course on [Hybrid Systems](#), University of Pisa, December 11-12, 2001
  - 2001: Short course on Hybrid Systems, University of Florence, May 10-11, 2001
  - 2001: PhD School on "[Hybrid and Explicit Model Predictive Control](#)", Bertinoro, Italy, July 18-21, 2001
  - 2001: short course "Model Predictive Control", Ford Research Laboratories, Dearborn, MI, June 21-22, 2001

### Industrial collaborations

- The Mathworks, Inc. (Natick, MA): development of the Model Predictive Control Toolbox.
- Ford Research Laboratories (Dearborn, MI): several automotive case studies carried out since year 2000.
- ABB Corporate Research (Baden, Switzerland): Model predictive control of gas turbines, hybrid MPC for scheduling cement mill production
- Centro Ricerche Fiat (Orbassano, Turin, Italy): hybrid control of the gearbox
- Kawasaki Steel (Japan): control of a gas supply system.
- Danieli Automation (Italy): Optimization-based feedback control of flatness in a cold tandem rolling
- ENEL (Italy): Optimal control of investments for quality of supply improvement in electrical energy distribution networks
- United Technologies Research Center (East Hartford, CT).
- Thales Alenia Space (France): MPC of satellite attitude.
- MPS Capital Services (Italy): stochastic model predictive control for hedging of financial options.
- DENSO Automotive GmbH (Munich, Germany)

### Scientific collaborations

- UC Berkeley (USA), UC Santa Barbara (USA), KTH Stockholm (Sweden), University of Linköpings (Sweden), Washington University (USA), Georgia Institute of Technology (USA), University of Pennsylvania (USA), ETH Zurich (Switzerland), CalTech (USA), Instituto Superior Técnico (Portugal), Eindhoven University of Technology (The Netherlands), Delft University of Technology (The Netherlands), University of Trondheim (Norway), University of Sevilla (Spain), University of Zaragoza (Spain), UPC Barcelona (Spain), University of Florence (Italy), University of Pisa (Italy), University of Roma II "Tor Vergata" (Italy), University of Cagliari (Italy), University of Padova (Italy).

### Research projects

- European Commission
  - 2012-2014: European project *EFFINET - Efficient Integrated Real-time Monitoring and Control of Drinking Water Networks*, 7th framework programme (422K euro)
  - 2008-2011: European project *WIDE - Decentralized and Wireless Control of Large-Scale Systems*, 7th framework programme (490K euro, project coordinator, total budget 1.8M euro)
  - 2010-2013: European Network of Excellence *HYCON2 - Highly Complex and Networked Control Systems*, European Commission, FP7-ICT Network of Excellence (280K euro)
  - 2009-2012: European project *E-PRICE - Price-based Control of Electrical Power Systems*, 7th framework programme (371K euro)
  - 2009-2012: European project *MOBY-DIC - Model-based synthesis of digital electronic circuits for embedded control*, 7th framework programme (322K euro)
  - 2004-2008: European network of excellence, *HYCON - Hybrid Control: Taming Heterogeneity and Complexity of Networked Embedded Systems*, 6th framework programme (340K euro)
  - 2003: European project *CC - Control and computation*, fifth framework programme (100K euro)
  - 2002-2005: Marie Curie *Control Training Site*, fifth framework programme, for hosting three visiting researchers (10K euro, 10K euro, 5K euro).
  - 1998-2000: European project, *VHS - Verification of Hybrid Systems*, fourth framework programme (co-responsible for the ETH unit) (150K euro)
- European Agencies
  - 2010-2012: Research project *NICE - Nonlinear innovative control designs and evaluation*, European Defence Agency (155K euro)

- 2010-2012: Research project *ROBMPC - Robust model predictive control of space constrained systems*, European Space Agency (132K euro)
- 2009-2010: Research project *ORCSAT - On-line Reconfiguration Control System and Avionics Technologies*, European Space Agency (80K euro)
- National and local funding
  - 2005-2006: PRIN project *MACSI - Advanced control methodologies for hybrid dynamical systems* (37K euro)
  - 2003-2004: PRIN project *Models for optimization, control and coordination of distributed manufacturing systems* (50K euro)
  - 2007: National Research Council project within the FIRB project *Public debt management for the application of advanced mathematical models, MPC, and stochastic optimization* (10K euro)
  - 2003: Research project *Optimization methods for hybrid systems*, University of Siena (14K euro)
  - 2005-2006: Research project *Optimization-based decision-making algorithms for heterogeneous networked cooperative systems*, University of Siena, 23K euro (project coordinator).
- Industrial funding: several research collaborations funded by different companies.
- Reviewer of research projects for several funding agencies: European Commission (V and VI framework programme), Italian Ministry of "Attività Produttive", Italian Ministry of Education, Research and University, Dutch Science Foundation, Irish Science Foundation, Swedish Science Foundation, INRIA (France), Veneto Region, Emilia Romagna Region, Marche Region.

### Services to the scientific community

- Associate Editor, IEEE Transactions on Automatic Control (2001-2005)
- Chair of the IEEE Control Systems Society [Technical Committee on Hybrid Systems](#) (2002-2010)
- Member of the Technical Activities Board, Control Systems Society. Served on the Program Committee of the IEEE CDC [2002](#), [2004](#), [2008](#).
- Program Committee member of the "Hybrid Systems Computation and Control" workshops [2003](#), [2004](#), [2005](#), [2006](#), [2007](#), [2008](#), [2009](#), [2010](#)
- International Program Committee member of the "1st IFAC Workshop on Estimation and Control of Networked Systems (NecSys'09)", 24-26 September, 2009, Venice, Italy.
- International Program Committee member of the IFAC Conference on the Analysis and Design of Hybrid Systems (ADHS), 2006 and 2009 editions.
- Program Committee member of the Int. Conf. on Informatics in Control, Automation and Robotics, 2004, 2005 editions.
- Reviewer for several international journals and conferences, reviewer of research projects.
- PhD examiner of F. Borrelli (ETH Zurich), D. Muñoz de la Peña (University of Sevilla, Spain), M. Silva (Instituto Superior Tecnico, Lisbon), M. Lazar (TU Eindhoven), L. Pina (Instituto Superior Tecnico, Lisbon), C. Ocampo (UPC, Barcelona), J. Spjøtvold (University of Trondheim, Norway), J.A. Larsen (University of Aalborg, Denmark), A. Micchi (University of Pisa).

### Organization of scientific events

- Organizer of the "[Workshop on Embedded Optimization \(EMBOPT'14\)](#)", Lucca, September 8-10, 2014 (with S. Di Cairano and P. Patrino)
- Organizer of the "[5th HYCON2 PhD School on Control of Networked and Large-Scale Systems and EFFINET PhD School on Control of Drinking Water Networks](#)", Lucca, July 1-5, 2013 (with M. Heemels and M. Johansson)
- Organizer of the "[4th HYCON2 PhD School on Control of Networked and Large-Scale Systems](#)", Trento, June 21-24, 2011 (with M. Heemels)
- Technical program committee co-chair of the "[1st International Workshop on Networks of Cooperating Object](#)" (CONET 2010), April 12, 2010, Stockholm, Sweden.
- Organizer of the workshop "[Beyond the financial crisis: risk control and pricing methods](#)", Siena, September 7, 2009 (with A. Agnetis)
- Organizer of the "[3rd WIDE PhD School on Networked Control Systems](#)", Siena, July 7-9, 2009 (with M. Heemels and M. Johansson)
- Organizer of the kick-off meeting of the WIDE "Wireless and Decentralized Control of Large-Scale Systems" project, Siena, September 26-27, 2008.
- Organizer of the "[2nd HYCON PhD School on Hybrid Systems](#)", Siena, July 16-19, 2007 (with M. Heemels)
- Program Chair of the "[10th Conference on Hybrid Systems: Computation and Control](#)", April 2-4, 2007 (with A. Bicchi and G. Buttazzo)
- Organizer of the workshop "Model Predictive Control of Hybrid Systems", joint Conference on Decision and Control and European Control Conference, Sevilla, Spain, December 11, 2005.
- Organizer of the "[1st HYCON PhD School on Hybrid Systems](#)", Siena, July 19-22, 2005 (with M. Heemels)  
<http://www.dii.unisi.it/hybrid/school>
- Organizer of the "DISC International PhD School on Hybrid Systems", June 23-26, 2003 (with M. Heemels and B. de Schutter)  
[http://lcewww.et.tudelft.nl/~disc\\_hs/](http://lcewww.et.tudelft.nl/~disc_hs/)
- Organizer of the workshop "Optimization and control of supply chains", Siena, October 23-25, 2005 (with A. Agnetis and D. Giglio)
- Organizer of the meeting for the EU project "Computation and Control", Siena, September 2003.  
<http://www.dii.unisi.it/cohes/cc/meetings/siena03/>
- Organizer of invited sessions at the American Control Conference, at the Conference on Decision and Control, and at the Conference on Analysis and Design of Hybrid Systems.

### Plenary lectures

- "Simple and Certifiable QP Algorithms for Embedded Linear MPC", [4th IFAC Conference on Nonlinear Model Predictive Control](#) (NMPC'12), Noordwijkerhout, The Netherlands, August 23, 2012 (semi-plenary)
- "Hybrid modelling, analysis, and optimization-based control", [4th IFAC Conference on Analysis and Design of Hybrid Systems](#) (ADHS'12), Eindhoven, The Netherlands, June 8, 2012 (plenary)
- "Modelling and Optimization-based Control of Hybrid Dynamical Systems", 6th Vienna International Conference on Mathematical Modelling ([MATHMOD 2009](#)), February 13, 2009 (plenary)
- "Explicit Model Predictive Control: A Survey", Int. Workshop on Assessment and Future Directions of Nonlinear Model Predictive Control ([NMPC'08](#)), September 5-9, 2008 (plenary)

- "Model Predictive Control of Hybrid Systems", Advanced Process Control Applications for Industry Workshop ([APC2007](#)), May 14-16, 2007 (invited half-day tutorial)
- "Optimization-based Control of Hybrid Dynamical Systems", 7th Portuguese Conference on Automatic Control ([CONTROLO'2006](#)), September 11, 2006 (plenary)
- "Modeling and Control of Hybrid Systems", 16th Mathematical Theory of Networks and Systems Conference ([MTNS2004](#)), July 8, 2004 (semi-plenary)

### **Student supervision**

Supervisor of 7 postdoctoral fellows, 17 PhD students, 11 visiting students, 15 research collaborators, around 70 master thesis students.

Lucca, September 3, 2014

Alberto Bemporad