Curriculum vitae et studiorum
Luigi Piroddi

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Contents

1 Brief résumé

1.1 Personal data

- Name: Luigi Piroddi
- Date and place of birth: November 26, 1966, London (UK)
- Nationality: Italian
- Current address: Piazza del Carmine, 1, 20121, Milano, Italy
- E-mail and phone: luigi.piroddi@polimi.it, +39-3471481792

1.2 Education and Studies

- July 1985: receives the "Maturità Classica" degree from the Liceo Classico statale "Tito Livio", Milano, Italy, with a mark of 58/60
- September 1985 – December 1990: studies Electronic Engineering at the Politecnico di Milano, Italy
- December 20, 1990: receives the "Laurea" (Master) degree in Electronic Engineering, with a mark of 100/100, defending the thesis "Metodi di identificazione per modelli ARMA a coefficienti periodici" ("Identification methods for ARMA models with periodic coefficients", advisor Prof. Sergio Bittanti, co-advisors Prof. Paolo Bolzern and Prof. Giuseppe De Nicolao)
- March 1991 – March 1992: works in the Civil Service (alternative to the compulsory military service)
- June 1991: passes the state examination required to enrol in the Professional Register of Engineers
- November 1991 – November 1994: attends the Ph.D. in Information and Automation Engineering at the Dipartimento di Elettronica e Informazione of the Politecnico di Milano
- October 1995: receives the Ph.D. degree, defending the thesis "Reti neurali per il controllo predittivo non lineare" ("Neural networks for nonlinear predictive control", advisor Prof. Sergio Bittanti)
- 2014: receives the National Academic Qualification ("Abilitazione Scientifica Nazionale") as Full Professor in the scientific-disciplinary area 09/G1 – Automatica

1.3 Academic career and current position

- 1994 – 1999: professor of "Elementi di Automatica" ("Elements of Automation") at the Università degli Studi di Bergamo, Italy
- 1999 – 2005: assistant professor ("ricercatore") at the Dipartimento di Elettronica e Informazione of the Politecnico di Milano, in the scientific-disciplinary area ING-INF/04 – Automatica (Systems and Control); he is confirmed in the role in 2002
- 2005 – 2015: associate professor ("professore associato") at the Dipartimento di Elettronica e Informazione of the Politecnico di Milano, in the scientific-disciplinary area ING-INF/04 – Automatica (Systems and Control); he is confirmed in the role in 2008
- From 2016: full professor ("professore ordinario") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano, in the scientific-disciplinary area ING-INF/04 – Automatica (Systems and Control)

2 Teaching activities and institutional duties

2.1 Full courses

Luigi Piroddi holds various courses in the systems and control area, among which Model Identification and Data Analysis, Fundamentals of Automation, Industrial Automation, and Active Control of Noise and Vibrations.

In detail, he has taught the following courses:

- "Elementi di Automatica" ("Elements of Automation"), 100 hours (10 credits), Corso di Laurea in Ing. Gestionale, V.O. (M.Sc. course in Management, Economics and Industrial Engineering), Università degli Studi di Bergamo
  academic years: 1994-95, 1995-96, 1996-97, 1997-98, 1998-99, 1999-00

- "Identificazione dei Modelli e Analisi dei Dati" ("Model Identification and Data Analysis") , 75 ore (7.5 credits), Corso di Laurea in Ing. Informatica, V.O. (M.Sc. course in Engineering of Computing systems), Politecnico di Milano (Como campus)
  academic years: 2000-01, 2001-02, 2002-03

- "Fondamenti di Automatica" ("Fundamentals of Automation"), 10 credits, Ing. Informatica / Ing. Elettronica / Ing. delle Telecomunicazioni, N.O., I liv. (degree course in Eng. of Computing systems / Electronic Eng. / Telecommunications Eng.), Politecnico di Milano (Milano Leonardo campus)
  academic years: 2001-02.

- "Automazione Industriale" ("Industrial Automation"), 5 credits, Corso di Laurea in Ing. Informatica, N.O., I liv. (degree course in Computer Science and Engineering), Politecnico di Milano (Como campus)
  academic years: 2002-03, 2003-04, 2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10, 2010-11, 2011-12, 2012-2013, 2013-14, 2014-15, 2015-16, 2016-17, 2017-18.

- "Fondamenti di Automatica I" ("Fundamentals of Automation I"), 5 credits, Corso di Laurea in Ing. Informatica, N.O., I liv. (degree course in Engineering of Computing systems), Politecnico di Milano (Como campus)
  academic years: 2003-04, 2004-05, 2005-06, 2006-07, 2007-08, 2008-09.

- "Progetto di Automatica" ("Automation Project"), 2.5 credits, Corso di Laurea in Ing. Informatica, N.O., I liv. (degree course in Engineering of Computing systems), Politecnico di Milano (Como campus)
  academic years: 2004-05, 2005-06, 2006-07, 2007-08, 2008-09.

- "Active control of noise and vibrations", 5 credits, Corso di Laurea in Ing. Informatica, N.O., II liv. (M.Sc. course in Engineering of Computing systems), Politecnico di Milano (Como campus)
  academic years: 2005-06, 2007-08, 2008-09, 2010-11, 2012-13.

- "Fondamenti di automatica (per il settore dell'Informazione)" ("Fundamentals of Automation (for the Information area)"), 10 credits, Corso di Laurea in Ing. Informatica On Line, N.O., I liv. (degree course in Engineering of Computing systems On Line), Politecnico di Milano
  academic years: 2006-07, 2007-08, 2008-09, 2009-10, 2010-11, 2011-12, 2012-13.

- "Active noise control" (2.5 credits), Ph.D. course, Department of Electronics and Information, Politecnico di Milano,
  academic years: 2008-09, 2011-12, 2014-15.

- "Fondamenti di Automatica" ("Fundamentals of Automation"), 10 credits, Corso di Laurea in Ing. Informatica, N.O., I liv. (degree course in Engineering of Computing systems), Politecnico di Milano (Como campus),
  academic years: 2009-10, 2010-11, 2011-12, 2012-13, 2013-14, 2016-17, 2017-18.

- "Model identification and adaptive systems", 5 credits, Corso di Laurea in Ing. Informatica, N.O., II liv. (M.Sc. course in Engineering of Computing systems), Politecnico di Milano (Como campus)
  academic years: 2013-14, 2014-15, 2015-16, 2016-17, 2017-18.

- "Automazione Industriale" ("Industrial Automation"), 5 credits, Corso di Laurea in Ing. Informatica, N.O., I liv. (degree course in Computer Science and Engineering), Politecnico di Milano (Milano Leonardo campus)
  academic years: 2014-15.

2.2 Collaborations as teaching assistant

- "Elementi di Automatica" ("Elements of Automation"), held by Prof. P. Bolzern, Corso di Laurea in Ingegneria Gestionale (M.Sc. course in Management, Economics and Industrial Engineering), Politecnico di Milano (Como campus)
  academic years: 1994-95 (20 hours), 1995-96 (20 hours).

- "Fondamenti di Automatica" ("Fundamentals of Automation"), held by Prof. P. Bolzern, Corso di Laurea in Ingegneria Gestionale (M.Sc. course in Management, Economics and Industrial Engineering), Politecnico di Milano (Milano Leonardo campus)
  academic years: 1996-97 (24 hours), 1997-98 (20 hours), 1998-99 (28 hours).

- "Fondamenti di Automatica" ("Fundamentals of Automation"), held by Prof. S. Bittanti, Corsi di Laurea in Ingegneria Elettrotecnica e Ingegneria delle Telecomunicazioni (M.Sc. courses in Electrical Eng. and Telecommunications Eng.), Politecnico di Milano (Milano Leonardo campus)
  academic years: 1996-97 (20 hours).

- "Fondamenti di Automatica" ("Fundamentals of Automation"), held by Prof. L. Ferrarini, Corso di Laurea in Ingegneria Gestionale (M.Sc. course in Management, Economics and Industrial Engineering), Politecnico di Milano (Milano Leonardo campus)
  academic years: 1997-98 (10 hours).

- "Fondamenti di Automatica" ("Fundamentals of Automation"), held by Prof. L. Ferrarini, Corsi di Laurea in Ingegneria Elettrica, Ingegneria Nucleare e Ingegneria Biomedica (M.Sc. courses in Electrical Eng., Nuclear Eng. and Biomedical Eng.), Politecnico di Milano (Milano Leonardo campus)
  academic years: 1998-99 (30 hours).

- "Automazione Industriale" ("Industrial Automation"), held by Prof. L. Ferrarini, Corso di Laurea in Ingegneria Informatica (M.Sc. course in Engineering of Computing systems), Politecnico di Milano (Milano Leonardo campus)
  academic years: 1999-00 (8 hours), 2000-01 (10 hours), 2001-02 (10 hours), 2002-03 (10 hours)

- "Automazione Industriale" ("Industrial Automation"), held by Prof. L. Ferrarini, Corso di Laurea in Ingegneria Informatica (M.Sc. course in Engineering of Computing systems), Politecnico di Milano (Como campus)
  academic years: 1999-00 (13 hours), 2000-01 (13 hours), 2001-02 (12 hours)

- "Modelli dei Sistemi di Produzione – Automazione Industriale" ("Models of Production Systems – Industrial Automation"), held by Prof.s F. Malucelli and L. Ferrarini, Corso di Diploma in Ingegneria Informatica (degree course in Engineering of Computing systems), Politecnico di Milano (Milano

Leonardo campus)
academic years: 2000-01 (6 hours)

2.3 Other teaching activities

- March – May 1994: Lectures of "Systems Theory" for Ph.D. students of the Università Commerciale "Luigi Bocconi" of Milano, Italy (16 hours)
- December 4–6, 1995: Lectures in the refresher course "World Wide Web: Applicazioni e Tecnologie" ("World Wide Web: Applications and Technologies"), organized by the Dipartimento di Elettronica e Informazione, Politecnico di Milano (6 hours)
- December 2–4, 1996: Lectures in the refresher course "Reti neurali per l'identificazione ed il controllo" ("Neural networks for identification and control"), organized by the Dipartimento di Elettronica e Informazione, Politecnico di Milano (10 hours)
- February – March 2000: Lectures in the refresher course "Corso di Trasferimento Tecnologico in Applicazioni di Automazione Industriale" ("Technological transfer course in Applications of Industrial Automation"), organized by Regione Lombardia (16 ore)
- Realization of a multimedia CD-ROM with teaching materials for the support of online courses of "Fondamenti di Automatica" ("Fundamentals of Automation"), in collaboration with Prof.s Paolo Bolzern and Giorgio Guariso, and Dr. Fabio Previdi
- Realization of a multimedia CD-ROM with teaching materials for the support of online courses of "Automazione Industriale" ("Industrial Automation"), in collaboration with Prof. Luca Ferrarini

2.4 PhD and student advising

Advisor of more than 35 Laurea (Bachelor) theses.

Advisor or co-advisor of more than 40 Laurea Magistrale (Master of Science) theses.

Academic tutor for 2 PhD theses:

- Aida Brankovic, "Distributed randomized model selection for nonlinear identification and supervised machine learning", 2016–18 (academic tutor)
- Federico Bianchi, "Identification of hybrid nonlinear systems", 2017-19 (academic tutor)

Advisor or co-advisor for PhD projects:

- William Spinelli, "Structure selection for polynomial NARX models based on simulation error minimization", minor project, 2003
- Tiziano Pulecchi, "Identification techniques based on polynomial NARX models for highly nonlinear systems with hysteresis", minor project, 2007
- Martina Maggio, "A geometric method for ATM complexity evaluation", minor project, 2010
- Fabio Della Rossa, "Active noise control of impulsive noise", minor project, 2011
- Marco Bergamasco, "Active noise control of impulsive noise", minor project, 2011
- Meysam Zareiee (visiting PhD student), "Reducing the size of PN supervisors", 2012

- Riccardo Vignali, “Approximate dynamic programming-based control of a building cooling system”, minor project, 2013
- Alessandro Falsone, “Randomized algorithms for NARX model identification”, minor project, 2013
- Roberto Quintana (visiting PhD student), “Virtual sensing for active noise control”, 2014
- Giorgio Manganini, “Policy search methods for the optimal control of MDPs”, 2014

Academic tutor for more than 20 stages.

2.5 Institutional duties

- 2004: Member of the Examination Board of the comparative evaluation procedure for a research assistant position in the scientific-disciplinary sector ING-INF/04 - Automatica at the 1^{st} Engineering Faculty of the Politecnico di Torino
- 2005–07: Member of the Committee for the revision of the web site of the Dipartimento di Elettronica e Informazione of the Politecnico di Milano
- 2005–07: Member of the Committee for the communication of the Dipartimento di Elettronica e Informazione of the Politecnico di Milano
- 2005–18: Member of the Committee for the revision of the rules and regulations of the Bachelor and Master of Science Programs in Engineering of Computing systems, Politecnico di Milano (Como campus)
- 2005–07: Member of the Committee for the approval of study plans of the Master of Science Program in Automation Engineering, Politecnico di Milano
- 2005–18: Member of the Committee for the approval of study plans of the Master of Science Program in Engineering of Computing systems, Politecnico di Milano (Como campus)
- 2006: Aggregate member of the Committee for the state examinations required to enrol in the Professional Register of Engineers
- 2008: Member of the Examination Board for the admission to the Ph.D. course in Engineering of Computing systems, Politecnico di Milano
- 2008: Member of the Examination Board for the assignment of the temporary research fellowship “Modellistica e controllo della diffusione di specie invasive” (“Modeling and control of the diffusion of invasive species”).
- 2009–10: Referee of joint German-Italian projects in the framework of the Vigoni Programme
- 2009–15: Member of the Examination Board for the assignment of the graduation award “prof. Giorgio Quazza”
- 2010: Member of the Examination Board for the assignment of two temporary research fellowships “Metodologie di sviluppo di sistemi di controllo e supervisione di sistemi energetici per usi finali” (“Design methodologies for control and supervision systems of energy systems for end uses”) at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2010: Member of the Examination Board for the assignment of a non-tenure-track research assistant position in the scientific-disciplinary sector ING-INF/04 - Automatica at the Engineering of Computing systems Faculty of the Politecnico di Milano

- 2010-2015: Vice-president of the Board of Professors of the Study Course in Engineering of Computing systems, Politecnico di Milano (Como campus)
- 2011: Referee for the national project "Valutazione Futuro in Ricerca 2010"
- 2012: Member of the Examination Board for the assignment of two temporary research fellowships "Supervisione e controllo di sistemi energetici per usi finali" ("Supervision and control of energy systems for end uses") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2013: Member of the Examination Board for the assignment of the temporary research fellowship "Sistemi di configurazione e simulazione per linee di produzioni automatizzate e analisi di algoritmi di controllo di isole robotizzate" ("Configuration and simulation systems for automatic production lines and analysis of control algorithms for automated production cells") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2013: Member of the Examination Board for the assignment of the temporary research fellowship "Sviluppo e validazione di tecniche di controllo per la gestione di reti elettriche di nuova generazione" ("Development and validation of control techniques for the management of new generation electric networks") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2013: Member of the Examination Board for the assignment of the temporary research fellowship "Progetto di sistemi di controllo per elicotteri quadrirotore a passo variabile" ("Control system design for variable pitch quadrotors") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2013: Member of the Examination Board for the assignment of the temporary research fellowship "Algoritmi randomizzati per l'identificazione di modelli non lineari" ("Randomized algorithms for the identification of nonlinear models") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2013: Member of the Examination Board for the assignment of the temporary research fellowship "Sviluppo di soluzioni innovative per il controllo e l'ottimizzazione di impianti e processi industriali" ("Development of innovative solutions for the control and optimization of indusrtial plants and processes") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2013: Member of the Examination Board for the assignment of the temporary research fellowship "Metodologie e tecnologie di modellazione e controllo di smart grids" ("Modeling and control methodologies and technologies for smart grids") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2015–18: Member of the Examination Board for the evaluation of teaching assistants at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2016: Member of the Examination Board for the assignment of the temporary research fellowship "Teleoperazione intelligente di manipolatori robotici" ("Smart teleoperation of robot manipulators") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2016: Member of the Examination Board for the assignment of the temporary research fellowship "Simulazione e controllo di sistemi produttivi e impianti automatizzati" ("Simulation and control of production systems and automated plants") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.

- 2016: Member of the Examination Board for the assignment of the temporary research fellowship "Controllo attivo delle vibrazioni negli elicotteri" ("Active Control of vibrations in helicopters") at the Dipartimento di Scienze e Tecnologie Aerospaziali of the Politecnico di Milano.
- 2016: Member of the Examination Board for the assignment of a non-tenure-track senior research assistant position in the scientific-disciplinary sector ING-INF/04 - Automatica at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2017: Member of the Examination Board for the assignment of the temporary research fellowship "Controllo predittivo distribuito con applicazione all'ambito energia e trasporti" ("Distributed predictive control with application to energy and transportation systems") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2017: Member of the Examination Board for the assignment of the temporary research fellowship "Sviluppo e validazione di modelli e algoritmi predittivi per la rilevazione di fenomeni associati a non productive time nelle attività di perforazione ENI" ("Development and validation of predictive models and algorithms for the detection of phenomena associated to non-productive time in ENI drilling operations") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2018: Member of the Examination Board for the assignment of the temporary research fellowship "Sviluppo di metodi per l'ottimizzazione del comfort e del consumo energetico" ("Development of optimization methods for comfort and energy consumption") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2018: Member of the Examination Board for the assignment of the temporary research fellowship "Sviluppo di un modello neurale per l'analisi di schemi progettuali" ("Development of a neural network model for the analysis of design diagrams") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2018: Member of the Examination Board for the assignment of the temporary research fellowship "Sviluppo di modelli predittivi online con tecniche di machine learning" ("Development of online predictive models with machine learning techniques") at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.
- 2018: Member of the Examination Board for the assignment of an associate professor position in the scientific-disciplinary sector ING-INF/04 - Automatica at the Dipartimento di Ingegneria dell'Informazione of the Università degli Studi di Brescia.
- 2018: Member of the Examination Board for the assignment of a non-tenure-track senior research assistant position in the scientific-disciplinary sector ING-INF/04 - Automatica at the Dipartimento di Elettronica, Informazione e Bioingegneria of the Politecnico di Milano.

2.6 Organization of scientific events

- 2006: Program Committee, 2006 IEEE International Conference on Intelligent Computing (ICIC'06), Harbour Plaza, Kunming, China, August 16–19, 2006
- 2011: National Organizing Committee, Young Authors' Support Committee, 18^{th} IFAC World Congress, Milan, Italy, August 28 – September 2, 2011
- 2017: Best Presentation Award Committee, National Conference of the Italian Society of Teachers and Researchers in Systems and Control (SIDRA 2017), Milan, Italy, September 11–13, 2017
- 2018: Best PhD Thesis Award Committee, National Conference of the Italian Society of Teachers and Researchers in Systems and Control (SIDRA 2018), Florence, Italy, September 12–14, 2018

2.7 Reviewing activities

Luigi Piroddi served as reviewer for many journals and conferences.
Among the journals, the most relevant ones are: IEEE Transactions on Automatic Control, IEEE Transactions on Control Systems Technology, IEEE Transactions on Automation Science and Engineering, Automatica, Computer Engineering Practice, IET Control Theory & Applications, Systems & Control Letters, International Journal of Adaptive Control and Signal Processing, European Journal of Control, IEEE Transactions on Systems, Man, and Cybernetics – Part A, Discrete Event Dynamic Systems, International Journal of Robotics and Automation, IEEE Transactions on Audio, Speech and Language Processing, Mechanical Systems and Signal Processing, IET Signal Processing, IEEE Signal Processing Letters, Signal Processing, Noise Control Engineering Journal, ACM Transactions on Embedded Computing Systems, IEEE Transactions on Industrial Informatics, Journal of Manufacturing Systems, International Journal of Production Research, IMA Journal of Mathematical Control and Information, Journal of Sound and Vibration, Archives of Acoustics.

He served as Associate Editor for the IEEE Transactions on Automation Science and Engineering from 2014 to 2017.

3 Participation in research projects

3.1 Industry sponsored research programs

- 1992-94 (ENEL C.R.A.): Extended Kalman Filter application for the estimation of the char mass in a fluidized bed combustor
- 1996-97 (GPS Standard): Development of neural network-based algorithms for signal detection by means of grounded pressure sensors
- 1997 (ISMES, research director): Development of algorithms and models for the dynamic monitoring of dams in the presence of seismic excitation (estimation of nonlinear black-box models of the NARX class use of generalized frequency response functions for the evaluation of nonlinear effects, experimental analysis on a laboratory model of a dam buttress, analysis of various experimental data of dams)
- 1998-00 (ENEL Ricerca): Cost optimization of a power plant using mixed fuels (oil and natural gas) with NOx emission constraints.
- 2000-01 (ENEL.Hydro, formerly ISMES, research director): Analysis and development of models and control algorithms for magneto-rheological dampers, in the framework of the SMART DAMPERS European project
- 2001 (ENEL.Hydro, formerly ISMES, research director): NARX modeling of radial crest displacements of the Schlegeis arch dam
- 2003-04 (Varian, research director): Development of a prototype control system for the vibration control of a turbomolecular vacuum pump
- 2004 (Whirlpool): Feasibility study concerning the control of temperature limit cycles in a freezer using on/off actuation and adaptive algorithms.
- 2004-05 (Technical): Study and design of an automatic machine for the placing of panels on highway tunnel walls
- 2005-06 (Varian, research director): Development of active control algorithms for vibration reduction in a turbomolecular vacuum pump
- 2005-06 (Varian, research director): Product engineering of an active control device for the attenuation of vibrations in turbomolecular vacuum pumps
- 2005-08 (Whirlpool): Modeling of refrigerators and temperature control
- 2006-07 (Bolton Manitoba): Production modeling and scheduling in a batch plant
- 2011-12 (E-lysis, research director): Development of a general purpose FPGA-based architecture for active noise control applications
- 2011-12 (SyES, research director): Analysis and development of a noise attenuation system for a high power transmitter of digital TV signals
- 2013 (Siemens): Condition monitoring of drive reducers of hot steel rolling mills
- 2013-15 (AddFor, research director): Analysis and development of estimation algorithms for vehicle dynamics

- 2015-2017 (SEL): Models for the prediction of the power produced by photovoltaic and hydroelectric plants
- 2017-2018 (ENI, research director): Development and validation of predictive models and algorithms for the detection of phenomena associated to non-productive time in Eni's drilling operations

3.2 Public sponsored research programs

- 1992-97: Italian Ministry of University and Scientific and Technological Research (MURST) 40% project "Identificazione dei modelli, Controllo dei sistemi, Elaborazione dei segnali" ("Model identification, Systems control, Signal processing")
- 1993-94: Italian Ministry of University and Scientific and Technological Research (MURST) 60% project "Sistemi robusti e sistemi adattativi per il filtraggio e il controllo" ("Robust and adaptive systems for filtering and control")
- 1998-01: Italian Ministry of University and Scientific and Technological Research (MURST) 40% project "Algoritmi e architetture per l'identificazione e il controllo di sistemi industriali" ("Algorithms and architectures for the identification and control of industrial systems")
- 2000-01: European Community project "IND DAMPERS (Industrial Novelty Dampers by Development of Advanced Materials with high Performance under Electromagnetic Stimulation)", in collaboration with ENEL.Hydro (formerly ISMES)
- 2001-02: Italian Ministry of University and Research (MIUR) project "PRIN 2000: Nuove tecniche per l'identi- ficazione e il controllo adattativo di sistemi industriali" ("Novel techniques for the identification and adaptive control of industrial systems")
- 2003-04: Italian Ministry of University and Research (MIUR) project "PRIN 2002: Tecniche innovative per l'identificazione e il controllo adattativo di sistemi industriali" ("Innovative techniques for the identification and adaptive control of industrial systems")
- 2005-06: Italian Ministry of University and Research (MIUR) project "PRIN 2004: Metodi e algoritmi innovativi per l'identificazione e il controllo adattativo di sistemi tecnologici" ("Methods and innovative algorithms for the identification and adaptive control of technological systems")
- 2007-08: Italian Ministry of University and Research (MIUR) project "PRIN 2006: Tecniche ed applicazioni innovative di identificazione e controllo adattativo" ("Innovative techniques and applications for identification and adaptive control")
- 2007-09: European Community STREP project "Safety, Complexity and Responsibility based design and validation of highly automated Air Traffic Management", study and development of complexity measures for air traffic management
- 2009-10: Italian Ministry of University and Research (MIUR) project "PRIN 2008: Nuovi algoritmi ed applicazioni di identificazione e controllo adattativo" ("Novel algorithms and applications for identification and adaptive control")
- 2010-13: European Community STREP project "Modeling, verification and control of complex systems: From foundations to power network applications"
- 2017-19 Regione Lombardia Smart Living project "Development of methods for the optimization of comfort and energy efficiency in housing units (OCCAM)" (research director)

4 Research activity

His main current research interests are:

- NARX model identification
- Randomized feature selection methods
- Modeling and control of FMS and batch processes
- Active control of noise and vibrations

Other topics in his research activity:

- Neural networks for model identification and control
- Estimation and optimization problems in power plants, microgrids and buildings

All the mentioned research topics are briefly described in the sequel.

4.1 NARX model identification

Classical prediction error minimization approaches for the identification of polynomial NARX/NARMAX models do not yield satisfactory results for long term prediction or simulation purposes, because of regressor selection mechanisms that may include spurious or redundant terms in the model. In this research activity, alternative identification algorithms are studied for these models, with focus both on parameter estimation and model structure selection.

The main lines of research include:

- Model structure selection algorithms based on the minimization of the simulation error, [J14], [J21], [C14], [C27], [C34]
- Parameter estimation algorithms based on the minimization of the simulation error, employing prediction models with increasing horizon, [J30], [J33], [J37], [C42], [C48], [C50], [C55]
- Empirical methods for the reduction of the model size and regularization methods, [J31], [C13], [C51]
- Data pre-filtering for nonlinear identification, [J16], [C22], [C26], [C39]
- Use of higher order frequency response functions (HFRF) for the analysis of nonlinear models, [J7]
- Adaptive methods for model structure selection, [J32]

The developed algorithms have been tested on several application examples, such as:

- Monitoring of large size civil engineering structures (in collaboration with ISMES), [J7], [J8], [C11], [C16]
- Modeling of a Rolling-Ball Rubber-Layer anti-seismic isolator (in collaboration with ISMES and Università degli Studi di Brescia), [C10]
- Modeling of a magneto-rheological damping device (in collaboration with ISMES, in the framework of the European project IND DAMPERS “Industrial Novelty Dampers by Development of Advanced Materials with high Performance under Electromagnetic Stimulation”), [J11], [C23]
- Modeling of a nonlinear electronic system (international benchmark on nonlinear identification), [J39], [C47]
- Various hydrological and environmental models, [J23], [J26], [C59]

4.2 Randomized feature selection methods

We here introduce study a novel class of feature selection algorithms that can be employed both in classification problems and model structure selection problems (for nonlinear and hybrid models). The selection method progressively refines a probability distribution defined on the model structure space, by extracting sample models from the current distribution and using the aggregate information obtained from the evaluation of the population of models to reinforce the probability of extracting the most important terms.

The main results are listed below:

- Randomized methods for model structure selection in NARX identification problems, [J47], [J50], [J53], [C76]
- Randomized methods for feature selection and classification problems, [J54], [J55], [J57],
- Identification of hybrid models, [C88], [S1]

4.3 Modeling and control of FMS and batch processes

This research line investigates both modeling methodologies for flexible manufacturing systems and batch processes using Petri nets and Grafcet, and supervisory control techniques, particularly for deadlock prevention purposes. Regarding the first topic, a design methodology is proposed based on a hierarchical structure, where a Petri net supervisor regulates the process flow, while another control unit, realized in Grafcet/SFC, is in charge of commanding the various devices in the plant. This results in a particularly compact supervisor model, that can be obtained through the application of specific formal rules and that combines the advantages of the different formalisms used. As for supervisory control, a comparative study of different deadlock avoidance algorithms for Petri nets has been carried out, and different control techniques have been developed based on siphons or direct monitor optimization. An efficient algorithm for the enumeration of siphons in Petri nets has also been developed.

The main directions of the research in this area are listed below, with reference to the relevant publications:

- Formal approaches for the modeling of FMS and batch processes based on Petri nets, [J13], [J18], [J20], [C8], [C9], [C17], [C24]
- Analysis of deadlock avoidance algorithms, [BC2], [J5], [C52]
- Siphon enumeration algorithms for Petri net analysis, [J17], [C12], [C15], [C20]
- Siphon control-based deadlock avoidance algorithms for Petri nets, [J22], [J24], [J25], [C25], [C32], [C36], [C43]
- Deadlock avoidance algorithms for Petri nets based on direct monitor optimization, [J40], [J41], [J42], [J45], [C57], [C63], [C65], [C68], [C72], [C73]

4.4 Active control of noise and vibrations

Various projects, both experimental and methodological, have been carried out in this area of research. A prototype active damper has been developed for turbomolecular vacuum pumps, based on piezoelectric actuators. In this project a special emphasis has been placed on the implementation of adaptive notch filters on DSP- and FPGA-based architectures, and on the implementation issues related to finite precision arithmetic.
On the methodological side several extensions to the classical feedforward active control methods for acoustic noise attenuation have been proposed. These methods employ adaptive algorithms to generate a secondary acoustic signal capable of compensating the annoying noise by way of destructive interference. A

first extension is aimed at the development of novel active controllers capable of dealing with nonlinear effects commonly experienced in such applications, such as distortion or saturation of measurement and actuation devices. Specific nonlinear model classes must be introduced for this purpose, and suitable adaptive algorithms must be developed, dealing both with parameter estimation and model structure selection.
Specific algorithms designed for the attenuation of acoustic noise signals with impulsive characteristics have also been proposed.

Related publications:

- Identification and control of magneto-rheological dampers, [J11], [C23]
- Active vibration control of a turbomolecular vacuum pump, in collaboration with Varian Vacuum Technologies, [C28], [C29], [C31], [P1], [P2], [P3], [P4]
- Analysis of the effects of a finite precision implementation of an active control system, [C35], [C40]
- Development of FPGA-based architectures for active control, [J34], [C38]
- Nonlinear active noise control with NARX models, [J29], [J43], [J44], [C45], [C60], [C66], [C67]
- Methods for the active control of impulsive noise, [J36], [C56], [C58], [C64]
- Fault detection of bearings, [J46], [C75]
- Structural vibration reduction in helicopters, [C77], [C78]
- Virtual sensing for active noise control, [C80]
- Other, [J52]

4.5 Neural networks for model identification and control

Nonlinear model predictive control methodologies, based on simple and generalized minimum variance control, have been developed during the Ph.D. course. The designed controllers have an hybrid structure, in that they include both linear and nonlinear blocks, the latter implemented with neural networks. While the learning process of the neural networks is carried out off-line, the linear blocks can be easily tuned on-line, giving the control system designer an additional degree of freedom. The stability properties of the proposed control schemes have been studied, with particular reference to evaluating the performance degradation due to neural network approximation. The proposed methods have been applied to the outlet temperature control of a liquid – saturated steam heat exchanger.
Another research concerned with neural networks applications in control has investigated their usage as model structure classifiers, starting from simple open loop input–output data (*e.g.*, a step response), in order to improve the performance of autotuning regulators with model–specific design rules.

Related publications:

- Neural networks for nonlinear model predictive control, minimum variance and generalized minimum variance methods, [J1], [J3], [J4], [J6], [J38], [C2], [C3], [IJ1], [T2]
- Structural identification techniques based on neural networks for intelligent autotuning of classical regulators, [J2], [J15], [J19], [C5], [C18], [C30], [C33]

4.6 Estimation and optimization problems in power plants, microgrids and buildings

Various energy-related problems have been addressed, concerning estimation, optimization and control aspects. In the first category, the estimation of the char mass (*i.e.*, the coal after the release of its volatile matter and water content) in bubbling fluidized bed plants has been pursued using an extended Kalman filter approach.
The estimation of NO_X emissions in power plants has also been addressed, both using accurate plant simulators and neural networks.
On the optimization side, the problem of optimizing the fuel mix in the management of a multi-fuel thermoelectric plant has been considered.
Finally, a method designed to improve both the food preservation and the energy consumption characteristics of household refrigerators and freezers has been developed. The core of the method is an adaptive algorithm that tunes the characteristics of the limit cycle induced by the relay controller.

Related publications:

- Estimation of the char mass in a fluidized bed combustor, in collaboration with ENEL Centro di Ricerche in Automatica, [C4]
- Estimation of NO_X emissions in power plants, in collaboration with CESI (former Research Center of ENEL) and Queen's University of Belfast, [J10], [C19], [C21]
- Fuel mix optimization in a combustion chamber, abiding by anti-emissions regulations, in collaboration with CESI (former Research Center of ENEL), [J9], [C7], [IJ2]
- Adaptive temperature control in household freezers, in collaboration with Whirlpool, [J28], [C37], [C44], [P5]
- Energy production estimation of a photovoltaic system, [C61]
- Control of microgrids and building cooling systems, [J49], [J51], [C62], [C69], [C70], [C71], [C74], [C79], [C81], [C82], [C83], [C85], [C86]

5 List of publications

5.1 International journal articles

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[C88] F. Bianchi, M. Prandini, and L. Piroddi, "A randomized approach to switched nonlinear systems identification," in 18^{th} *IFAC Symposium on System Identification*, Stockholm, Sweden, July 9-11, 2018.

5.4 Books

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5.6 Submitted articles

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[S2] A. Brumana and L. Piroddi, "A multi-tone central divided difference frequency tracker with adaptive process noise covariance tuning," 2018, submitted for journal publication.

[S3] R. Cordone, F. Basile, and L. Piroddi, "Computation of K-reachable paths in Petri nets," 2018, submitted for journal publication.

[S4] A. Casalino, A. M. Zanchettin, L. Piroddi, and P. Rocco, "Optimal scheduling of human-robot collaborative assembly operations with time Petri nets," 2019, submitted for journal publication.

[S5] F. Bianchi, S. Formentin, and L. Piroddi, "Process noise covariance estimation via stochastic approximation," 2019, submitted for journal publication.

[S6] ——, "Structure selection of noise covariance matrices for linear Kalman filter design," 2019, submitted for journal publication.

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[T2] L. Piroddi, "Reti neurali per il controllo predittivo non lineare (in italian)," Ph.D. dissertation, Information and Automation Engineering, Politecnico di Milano, 1995.

5.8 Patents

[P1] F. Casaro, A. Leva, and L. Piroddi, "Vacuum pump provided with vibration damper," 2004, US Patent US2005106043A1.

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[P5] A. Boer, R. Paganini, A. Leva, and L. Piroddi, "Method for self-tuning an on-off temperature control in domestic refrigerator and refrigerator using such method," 2009, European Patent EP2034260A1.

[P6] A. Zanchettin, A. Casalino, L. Piroddi, and P. Rocco, "Metodo di controllo predittivo di un robot e relativo sistema di controllo," 2018, Italian Patent (applicants: Politecnico di Milano and Smart Robots srl).

6 Brief presentation of the 15 most significant journal papers

[J53] M. Avellina, A. Brankovic, and L. Piroddi, "Distributed randomized model structure selection for NARX models," *International Journal of Adaptive Control and Signal Processing*, vol. 31, no. 12, pp. 1853–1870, December 2017.

Model Structure Selection (MSS) is a critical problem in the nonlinear identification field. In the framework of polynomial Nonlinear AutoRegressive [Moving Average] models with eXogenous input variables (NAR[MA]X), it is formulated as the combinatorial problem of finding the subset of regressors that yields optimal model accuracy. Increasing the set of potential model terms improves the flexibility of the model but results in a computational overload and may even jeopardize the ability of the MSS algorithm to find the optimal model. In this work, a distributed optimization scheme is developed to tackle the MSS task for large-sized candidate regressor sets. The regressor set is split among a group of independent processors and each of them executes an MSS routine on its local subset. Then, the processors exchange information regarding the selected models and the corresponding regressors are distributed among all the units for a new MSS round. The procedure is repeated until convergence of all processors to the same solution. Besides a drastic reduction in the computational time thanks to the inherent parallelizability of the algorithm execution, the proposed distributed optimization scheme can also be beneficial in terms of model accuracy, due to a more efficient exploration of the search space.

[J47] A. Falsone, L. Piroddi, and M. Prandini, "A randomized algorithm for nonlinear model structure selection," *Automatica*, vol. 60, pp. 227–238, 2015.

The identification of polynomial Nonlinear Autoregressive [Moving Average] models with eXogenous variables (NAR[MA]X) is typically carried out with incremental model building techniques that progressively select the terms to include in the model. The Model Structure Selection (MSS) turns out to be the hardest task of the identification process due to the difficulty of correctly evaluating the importance of a generic term. As a result, classical MSS methods sometimes yield unsatisfactory models, that are unreliable over long-range prediction horizons.
The MSS problem is here recast into a probabilistic framework based on which a randomized algorithm for MSS is derived, denoted RaMSS. The method introduces a tentative probability distribution over models and progressively updates it by extracting useful information on the importance of each term from sampled model structures. The proposed method is validated over models with different characteristics by means of Monte Carlo simulations, which show its advantages over classical and competitor probabilistic MSS methods in terms of both reliability and computational efficiency.

[J45] F. Basile, L. Piroddi, and R. Cordone, "A branch and bound approach for the design of decentralized supervisors in Petri net models," *Automatica*, vol. 52, pp. 322–333, Feb. 2015.

The paper addresses the design of compact and maximally permissive decentralized supervisors for Petri nets, based on generalized mutual exclusion constraints. Decentralization constraints are formulated with respect to the net transitions, instructing each local supervisor to detect and disable transitions of its own control site only. A solution is characterized in terms of the states it allows and its feasibility is assessed by means of two separate tests, one checking the required behavioral properties (*e.g.*, liveness, reversibility and controllability) of the induced reachability subgraph and the other ensuring the existence of a decentralized supervisor enforcing exactly the considered set of allowed states. The second test employs an integer linear programming formulation. Maximal permissivity is ensured by efficiently exploring the solution space using a branch and bound method that operates on the reachable states. Particular emphasis is posed on the obtainment of the controllability property, both in the structural and the behavioral interpretation.

[J42] F. Basile, R. Cordone, and L. Piroddi, "Integrated design of optimal supervisors for the enforcement

of static and behavioral specifications in Petri net models,"*Automatica*, vol. 49, no. 11, pp. 3432–3439, November 2013.

Petri net (PN) supervisory control is often performed through a sequential procedure that introduces additional constraint layers over an initial unconstrained PN model, using generalized mutual exclusion constraints (GMECs) implemented as monitor places. This is typical, *e.g.*, in the context of flexible manufacturing systems, where the initial model represents the production sequences and the constraints are used to express *static* specifications, such as job limitations or the usage of resources, and *behavioral* ones, as liveness, controllability, etc. This sequential procedure may yield a redundant model, that is not easily reduced *a posteriori*. Also, it is difficult to ensure maximal permissiveness with respect to multiple behavioral specifications.
This paper, building on recent results regarding optimal supervisor design with branch & bound methods, proposes an integrated modeling approach that can be used to derive a minimal supervisor guaranteeing the attainment of an arbitrary set of static and behavioral specifications in a maximally permissive way. Among behavioral specifications, deadlock-freeness, liveness, reversibility and behavioral controllability are considered in the paper. The supervisor comes in the form of a simple set of GMECs or of a disjunction of sets of GMECs. Some examples emphasize the potential model size reductions that can be achieved.

[J41] R. Cordone, A. Nazeem, L. Piroddi, and S. Reveliotis, "Designing optimal deadlock avoidance policies for sequential resource allocation systems through classification theory: existence results and customized algorithms,"*IEEE Transactions on Automatic Control*, vol. 58, no. 11, pp. 1–16, November 2013.

A recent line of work has sought the implementation of the maximally permissive deadlock avoidance policy (DAP) for a broad class of complex resource allocation systems (RAS) as a classifier that gives effective and parsimonious representation to the dichotomy of the underlying behavioral space into the admissible and inadmissible subspaces defined by that policy. The work presented in this paper complements the past developments in this area by providing (i) succinct conditions regarding the possibility of expressing the aforementioned classifier as a set of linear inequalities in the RAS state variables, and (ii) an efficient customized algorithm for the synthesis of pertinent non-linear classifiers that implement the target DAP with minimum run-time computational overhead, in the case that a linear-classifier-based representation of this policy is not possible.

[J40] R. Cordone and L. Piroddi, "Parsimonious monitor control of Petri net models of FMS,"*IEEE Transactions on Systems, Man and Cybernetics, Part A*, vol. 43, no. 1, pp. 215–221, Jan. 2013.

Most approaches for deadlock prevention and liveness enforcement in Petri nets rely on siphon control methods or the theory of regions to derive monitor-based supervisors. These techniques raise methodological and computational issues, from the existence of feasible solutions to the hardness of guaranteeing maximal permissivity and optimality in the size and cost of the control subnet. Recently, the supervisor design problem has also been reformulated as a direct monitor optimization task based on integer linear programming, which can more effectively deal with the mentioned issues and objectives. This paper introduces an efficient branch-and-bound scheme for the exploration of the solution space of the direct monitor optimization problem. An extensive computational analysis on a set of benchmark instances demonstrates the efficiency of the approach.

[J35] M. Prandini, L. Piroddi, S. Puechmorel, and S. L. Brázdilová, "Towards air traffic complexity assessment in new generation air traffic management systems," *IEEE Transactions on Intelligent Transportation Systems*, vol. 12, no. 3, pp. 809–818, September 2011.

The characterization of complex air traffic situations is an important issue in air traffic management (ATM). Within the current ground-based ATM system, complexity metrics have been introduced with

the goal of evaluating the difficulty experienced by air traffic controllers in guaranteeing the appropriate aircraft separation in a sector. The rapid increase in air travel demand calls for new generation ATM systems that can safely and efficiently handle higher levels of traffic. To this purpose, part of the responsibility for separation maintenance will be delegated to the aircraft, and trajectory management functions will be further automated and distributed. The evolution toward an autonomous aircraft framework envisages new tasks where assessing complexity may be valuable and requires a whole new perspective in the definition of suitable complexity metrics. This paper presents a critical analysis of the existing approaches for modeling and predicting air traffic complexity, examining their portability to autonomous ATM systems. Possible applications and related requirements are discussed.

[J33] M. Farina and L. Piroddi, "Simulation error minimization identification based on multi-stage prediction," *International Journal of Adaptive Control and Signal Processing*, vol. 25, no. 5, pp. 389–406, 2011.

Classical prediction error minimization (PEM) methods are widely used for model identification, but they are also known to provide satisfactory results only in specific identification conditions, *e.g.* disturbance model matching. If these conditions are not met, the obtained model may have quite different dynamical behavior compared with the original system, resulting in poor long range prediction or simulation performance, which is a critical factor for model analysis, simulation, model-based control design. In the mentioned non-ideal conditions a robust and reliable alternative is based on the minimization of the simulation error. Unfortunately, direct optimization of a simulation error minimization (SEM) criterion is an intrinsically complex and computationally intensive task.
In this paper a low-complexity approximate SEM approach is discussed, based on the iteration of multi-step PEM methods. The soundness of the proposed approach is demonstrated by showing that, for sufficiently high prediction horizons, the k-steps ahead (single- or multi-step) PEM criteria converge to the SEM one. Identifiability issues and convergence properties of the algorithm are also discussed. Some examples are provided to illustrate the mentioned properties of the algorithm.

[J32] C. Cantelmo and L. Piroddi, "Adaptive model selection for polynomial NARX models," *IET Control Theory & Applications*, vol. 4, no. 12, pp. 2693–2706, 2010.

Two algorithms are proposed for the adaptive model selection of polynomial non-linear autoregressive with exogenous variable (NARX) models. The recursive forward regression with pruning (RFRP) algorithm is based on a recursive orthogonal least-squares (ROLS) procedure and efficiently integrates model augmentation and pruning to reduce processing time whenever new data are available. The algorithm provides excellent model structure tracking compared to different OLS-based model selection policies.
A less accurate but much faster algorithm that can be used for time-critical applications is the ROLS-LASSO. This algorithm uses a recursive version of the least absolute shrinkage and selection operator (LASSO) regularisation approach for structure selection. It features a recursive standardisation of the regressors and performs parameter estimation with ROLS. A sliding window data updating is here adopted for both algorithms, although the methods seamlessly generalise to exponential windowing with forgetting factor. Some simulation examples are provided to demonstrate the model tracking capabilities of the algorithms.

[J29] R. Napoli and L. Piroddi, "Nonlinear active noise control with NARX models," *IEEE Transactions on Audio, Speech and Language Processing*, vol. 18, no. 2, pp. 286–295, February 2010.

The extension of active noise control (ANC) techniques to deal with nonlinear effects such as distortion and saturation requires the introduction of suitable nonlinear model classes and adaptive algorithms. Large sized models are typically used, resulting in an increased computational load, delayed convergence (and sometimes even algorithm instability), and other unwanted dynamical effects due

to overparametrization.
This paper discusses the usage of polynomial Nonlinear AutoRegressive models with eXogenous variables (NARX) models and model selection techniques to reduce the model size and increase its robustness, for more efficient and reliable ANC. An offline procedure is devised to identify the controller model structure, and the controller parameters are successively updated with an adaptive algorithm based on the error gradient and on the residual noise. Simulation experiments show the effectiveness of the proposed approach. A brief analysis of the involved computational complexity is also provided.

[J25] L. Piroddi, R. Cordone, and I. Fumagalli, "Combined siphon and marking generation for deadlock prevention in Petri nets," *IEEE Transactions on Systems, Man and Cybernetics, Part A*, vol. 39, no. 3, pp. 650–661, May 2009.

In Petri-net (PN) modeling of flexible manufacturing systems, deadlock prevention is often addressed by means of siphon-control methods. Constraints that avoid the emptying of siphons can be easily implemented using additional places suitably connected to the PN transitions. Efficient siphon-based techniques achieve highly permissive solutions using as few control places as possible. One such technique employs a set-covering approach to optimally match emptiable siphons to critical markings. In this paper, a modified version of the method is proposed that achieves the same results in terms of permissivity and size of the control subnet but avoids full siphon enumeration. This greatly reduces the overall computational time and memory requirements and allows the applicability of the method to large-size models.

[J22] L. Piroddi, R. Cordone, and I. Fumagalli, "Selective siphon control for deadlock prevention in Petri nets," *IEEE Transactions on Systems, Man and Cybernetics, Part A*, vol. 38, no. 6, pp. 1337–1348, November 2008.

Deadlock prevention is a crucial step in the modeling of flexible manufacturing systems. In the Petri net framework, deadlock prevention policies based on siphon control are often employed, since it is easy to specify generalized mutual exclusion constraints that avoid the emptying of siphons. However, such policies may require an excessive computational load and result in impractical oversized control subnets. This is often a consequence of the redundancy in the control conditions derived from siphons. In this paper, a novel method is proposed that provides small size controllers, based on a set covering approach that conveniently relates siphons and markings. Some examples are provided to demonstrate the feasibility of the approach and to compare it with other methods proposed in the literature.

[J17] R. Cordone, L. Ferrarini, and L. Piroddi, "Enumeration algorithms for minimal siphons in Petri nets based on place constraints," *IEEE Transactions on Systems, Man and Cybernetics, Part A*, vol. 35, no. 6, pp. 844–854, November 2005.

The paper addresses the problem of enumerating minimal siphons in an ordinary Petri net. The algorithms developed in this work recursively use a problem partitioning procedure to reduce the original search problem to multiple simpler search subproblems. Each subproblem has specific additional place constraints with respect to the original problem. Some results on algorithm correctness, convergence, and computational complexity are provided, as well as an experimental evaluation of performance. The algorithms can be applied to enumerate minimal, place-minimal siphons, or even siphons that are minimal with respect to given subsets of places.

[J16] W. Spinelli, L. Piroddi, and M. Lovera, "On the role of pre-filtering in nonlinear system identification," *IEEE Transactions on Automatic Control*, vol. 50, no. 10, pp. 1597–1602, October 2005.

Data prefiltering is often used in linear system identification to increase model accuracy in a specified frequency band, as prefiltering is equivalent to a frequency weighting on the prediction error function. However, this interpretation applies only to a strictly linear setting of the identification problem. In

this note, the role of data and error prefiltering in nonlinear system identification is analyzed and a frequency domain interpretation is provided, based on the Volterra series representation of nonlinear systems.Simulation results illustrate the conclusions of the analysis.

[J14] L. Piroddi and W. Spinelli, "An identification algorithm for polynomial NARX models based on simulation error minimization," *International Journal of Control*, vol. 76, no. 17, pp. 1767–1781, 2003.

Classical prediction error approaches for the identification of non-linear polynomial NARX/NARMAX models often yield unsatisfactory results for long-range prediction or simulation purposes, mainly due to incorrect or redundant model structure selection. The paper discusses some limitations of the standard approach and suggests two modifications: namely, a new index, based on the simulation error, is employed as the regressor selection criterion and a pruning mechanism is introduced in the model selection algorithm. The resulting algorithm is shown to be effective in the identification of compact and robust models, generally yielding model structures closer to the correct ones. Computational issues are also discussed. Finally, the identification algorithm is tested on a long-range prediction benchmark application.

7 Concise CV in numbers

- Age (years): 51
- Academic age (from date of first publication) (years): 28
- Years working in academic institutions: 20
- Papers in international journals: 55 (36 from 2008)
- Papers in international conferences: 88
- Chapters in international books: 2
- Total number of citations: Web of Science 1101 (1074 from 2003), Scopus 1551 (1519 from 2003), Google Scholar 2324
- H-index: Web of Science 16 (16 from 2003), Scopus 19 (19 from 2003), Google Scholar 24

Table 1: Ten most cited papers: number of citations according to Web of Science (WoS), Scopus (S) and Google Scholar (GS).

paper	WoS	S	GS
[J22]	151	163	190
[J14]	94	136	170
[J25]	123	130	151
[J27]	38	55	93
[J3]	45	50	81
[J26]	37	49	74
[J35]	27	45	80
[J11]	42	44	61
[J17]	39	43	58
[J42]	31	35	41