



PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Marco Coraggio

XXXII Cycle

Training and Research Activities Report – First Year

Tutor: Mario di Bernardo – co-Tutor: None

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PhD in Information Technology and Electrical Engineering – XXXII Cycle

Marco Coraggio

1. Information

Marco Coraggio, MSc in Ingegneria dell'Automazione – University of Naples Federico II
XXXII Cycle – ITEE – University of Naples Federico II
University of Naples Federico II ITEE fellowship
Tutored by Prof Mario di Bernardo

2. Credits summary

Credits year 1								
	1	2	3	4	5	6		
Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	
Modules	21	3	6	7,5	0	12	0	28,5
Seminars	6	1,8	0,8	0,2	0	0,7	0,4	3,9
Research	33	5	3,6	4	5	4	6	27,6
	60	9,8	10,4	11,7	5	16,7	6,4	60

3. Study and training activities

- Attended courses:
 - Ad hoc — Modeling, Simulation, and Control of Collective Behavior — Prof. Maurizio Porfiri.
 - Ad hoc — Introduction to Quantum Electrodynamics — Prof. Giovanni Miano.
 - Ad hoc — Ethical, legal and social aspects of ICT and Robotics — Prof. Guglielmo Tamburrini.
 - MSc — Analisi e Controllo di Reti Complesse — Prof. Pietro De Lellis.
 - Ad hoc — Analisi Funzionale: Fondamenti — Prof. Renato Fiorenza.
 - Ad hoc — Piecewise Smooth Dynamical Systems — Prof. John S. Hogan.
 - Informal course (0 credits) — Stochastic differential equations — Prof. Claudio Serpico.
 - MOOC online course (0 credits) — Computational Neuroscience — Prof. Adrienne Fairhall and Prof. Rajesh P. N. Rao.
- Attended seminars:
 - Plasma stability and dynamic events in tokamaks with a resistive wall — Dr. Vladimir Dmitrievich Pustovitov.
 - Electromechanical consequences of violent instabilities in tokamaks — Dr. Vladimir Dmitrievich Pustovitov.
 - IBM Cognitive computing: Challenges and opportunities in building an artificial intelligence platform for business — Dr. Pietro Leo.
 - How to organize and Write a Scientific Rebuttal — Prof. Pasquale Arpaia.
 - Fuzzy Logic, Genetic Algorithms and their Applications to Next Generation Networks — Prof. Leonard Barolli.
 - Exploiting Speech Production Knowledge for Deep Learning based Automatic Speech Recognition — Dr. Leonardo Badino.
 - Complex Dynamics in Memristor Networks: Flux-Charge Analysis Method and Bifurcations without Parameters — Prof. Fernando Corinto.
 - Power System Stability and Synchronization: Application to the lossy power grid system — Prof. Navdeep. M. Singh.
 - L' AIS ed il Sistema Nazionale per il Monitoraggio del Traffico Marittimo — Ing. Massimo Marrazzo.
 - Challenges and Opportunities for IT Innovation in the Space Business — Ing. Ernesto Doelling.
 - Optimal control of networks: energy scaling and open challenges — Prof. Francesco Sorrentino.

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- External courses:
 - 7th oCPS PhD School on Cyber-Physical Systems — IMT Scuola Alti Studi Lucca.
 - Course at Centro Linguistico di Ateneo — English C1 — Prof. Janet Parker.
 - Online course — Computation Neuroscience — Prof. Rajesh P. N. Rao, Prof. Adrienne Fairhall.

4. Research activity

Title of the whole research activity: Analysis and control of discontinuous dynamical systems and networks.

- **Title:** Design of improved control strategies for atomic force microscopes in intermittent contact mode.
Description: Atomic force microscopes have proved to be fundamental research tools in many situations and in a variety of environmental conditions, such as the study of biological samples. Among the possible modes of operation, intermittent contact mode is one that causes less wear to both the sample and the instrument; therefore, it is ideal when imaging soft samples. However, intermittent contact mode is not particularly fast when compared to other imaging strategies. As result of our research, we introduced three enhanced control approaches, designed to manoeuvre different actuators in the instrument, to address the limitations of existing control schemes. Our proposed practical strategies are able to eliminate different image artefacts, automatically adapt scan speed to the sample being scanned and predict its features in real time. The result is that both the image quality and the scan time are improved.
Collaboration: Martin Homer, Oliver Payton, and Mario di Bernardo. — M. Homer and O. Payton are with the University of Bristol (UK), M. di Bernardo is with both Universities.
- **Title:** Observer design for piecewise smooth and switched dynamical systems via contraction theory.
Description: The aim of this research was to test the application of a new approach to study contraction theory recently developed for piecewise smooth systems. The approach is based on the use of *regularization*, a procedure to make the vector field of interest differentiable before analysing its properties. We have shown that by using this extension of contraction theory to non-differentiable vector fields it is possible to design observers for a large class of piecewise smooth systems using not only Euclidean norms, as also done in previous literature, but also non-Euclidean norms. This allows greater flexibility in the design and encompasses the case of both piecewise-linear and piecewise-smooth (nonlinear) systems.
Collaboration: Davide Fiore and Mario di Bernardo. — D. Fiore and M. di Bernardo are with the University of Naples Federico II.
- **Title:** Study on the conditions for consensus/synchronization of complex networks of discontinuous dynamical systems.
Description: Both piecewise smooth (PWS) dynamical systems and complex networks are highly investigated topics with numerous applications. In practical scenarios, it may happen to find complex networks composed of PWS agents, then a complex network of PWS agents emerges (mechanical ensembles, power grids, cardiac and neuronal cells, etc.). In the framework of complex networks, one of the most studied and significant behaviours is synchronization, however, all existing approaches for studying it in network of PWS agents have some sort of limitation. Our aim was to find general conditions for global synchronizability. We started by studying systematically the case of two coupled one-dimensional piecewise-smooth system, finding a sufficient condition on the coupling gain. Then, we extended the analysis to the case a generic network, finding again a condition on the coupling gain, provided that a discontinuous coupling is also present and strong enough.
Collaboration: Mario di Bernardo, Pietro De Lellis and John S. Hogan. — P. De Lellis is with the University of Naples Federico II, J. Hogan is with the University of Bristol (UK), M. di Bernardo is with both Universities.
- **Title:** Adaptive and quasi-sliding control of shimmy in airplane landing gears.
Description: Shimmy is a dangerous phenomenon that occurs when aircraft's nose landing gears oscillate in a rapid and uncontrollable fashion. In our research we investigated and validated the use of two nonlinear control approaches (zero average control, and model reference adaptive control based on minimal control synthesis) as simple yet effective strategies to suppress undesired oscillations, even in the presence of uncertainties and partial state measurements.
Collaboration: with Daniel A. Burbano L., Mario di Bernardo, Franco Garofalo and Michele Pugliese. — D. Burbano is with the Northwestern University (USA), M. di Bernardo, F. Garofalo and M. Pugliese are with the University of Naples Federico II.

5. Products

- Journal papers:
 - M. Coraggio, M. Homer, O. Payton, M. di Bernardo — “Improved Control Strategies for Atomic Force Microscopes in Intermittent Contact Mode” — IEEE Transactions on Control Systems Technology, 2017
- Conference papers:
 - D. Fiore, M. Coraggio, M. di Bernardo — “Observer design for piecewise smooth and switched systems via contraction theory” — IFAC 2017 World Congress (International Federation on Automatic Control)
 - [Judgement pending] D. A. Burbano L., M. Coraggio, M. di Bernardo, F. Garofalo and M. Pugliese — “Adaptive and quasi-sliding control of shimmy in landing gears” – ECC 2018 (European Control Conference)
 - [Preparing] M. Coraggio, P. De Lellis, J. S. Hogan, and M. di Bernardo — Synchronization of Coupled Piecewise-Smooth Systems — CDC 2018 (Conference on Decision and Control)
- Keynotes:
 - [Accepted, to be delivered] M. Coraggio, P. De Lellis, S. J. Hogan, M. di Bernardo — “On Synchronization in coupled piecewise smooth systems” — Advances in Nonsmooth Dynamics 2018

6. Conferences and seminars

- IFAC 2017 World Congress, presentation of the paper “Observer design for piecewise smooth and switched systems via contraction theory”.
The 20th World Congress of the International Federation of Automatic Control, Toulouse, France, 9-14 July 2017, 1 paper submitted.
- “BEST Autumn Course 2017 — Analysis and Control of Complex Systems”, delivery of a 2 hours seminar on the simulation of dynamical systems using matlab/simulink.

7. Activity abroad

- PhD school: 7th oCPS PhD School on Cyber-Physical Systems — Lucca, Italy — 12-15 June 2017.
- Conference: IFAC 2017 World Congress — Toulouse, France — 9-14 July 2017.

8. Tutorship and teaching assistance

- Seminars:
 - 2,5 hours in “First steps in Matlab/Simulink and simulations of dynamical systems” in BEST course: Analysis and Control of Complex Systems
- Teaching assistance:
 - 7 hours in the course Dinamica e Controllo Non Lineare, in Ingegneria dell’Automazione.
 - 4 hours in the course Controlli Automatici, in Ingegneria Informatica.
 - 12 hours in the course Nonlinear Systems, in Mathematical Engineering.
- Tutorship:
 - Co-supervisor for the thesis of 5 bachelor students in Ingegneria Informatica.
 - Co-supervisor for the thesis of 2 master students in Ingegneria dell’Automazione.
 - Weekly 2 hours tutorship (“ricevimento”) for the course of Dinamica e Controllo Non Lineare in Ingegneria dell’Automazione.