



PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Ricardo Cardona Rivera

XXXIV Cycle

Training and Research Activities Report - Third Year

Tutor: Prof. Mario di Bernardo - co-Tutor: Prof. Francesco Lo Iudice



1. Information:

I received a M. Sc. Degree in Automation Engineering in 2017 from the National University of Colombia. In December 2018 I became recipient of a PhD scholarship from the University of Naples – Federico II reserved to foreign students at the for the XXXIV cycle of the ITEE PhD under the direction from Mario di Bernardo as tutor and the co-direction of Francesco Lo Iudice. During this PhD, we have been working on modelling and control strategies for the power network.

2. Study and Training activities

a. Seminars

Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
Force and Visual Control for Safe Human Robot Interaction	0.4	Prof. Bruno Siciliano	UNINA	ITEE
Innate Immunity and Inflammation: from Cancer to COVID-19	0.3	Prof. Alberto Mantovani	University in Milan	CQB PHD
The Ohta-Kawasaki model for diblock copolymers: stability and minimality of critical points	0.3	Prof. Nicola Fusco	"Renato Caccioppoli" Department of Mathematics and Applications, UNINA	SSM
Network Systems, Kuramoto Oscillators and Synchronous Power Flow	0.3	Prof. Francesco Bullo	Department of mechanical engineering, University of California Santa Barbara- U.S.A.	SSM
Measuring the Expansion of the Universe with Quasars	0.3	Prof. Guido Risaliti	Department of Physics and Astronomy, University of Florence-Italy	SSM
Synchronization: A universal concept in Nonlinear Sciences	0.3	Prof. Jürgen Kurths	Department of Complexity Science, Postdam Institute for Climate Impact Research - Germany	SSM
Probing gravitational field: a fundamental viewpoint	0.3	Prof. Lorenzo Fatibene	"Giuseppe Peano" Department of Mathematics of University of Turin	SSM
Quantum Simulators	0.3	Prof. Rosario Fazio	International Center for Theoretical Physics ICTP, Trieste, Italy, and	SSM

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			Physics Department, University of Napoli Federico II, Napoli, Italy.	
Engineering the firearm ecosystem: research on media coverage and firearm acquisition in the aftermath of a mass shooting	0.3	Prof. Maurizio Porfiri	New York University Tandon School of Engineering, New York, NY, U.S.A.	SSM
Measuring the cosmological parameters with SNe-Ia and Gammaray Bursts	0.3	Prof. Massimo Della Valle	Astronomical Observatory of Capodimonte and Scuola Superiore Meridionale	SSM
Variational approximations of the Griffith functional	0.3	Prof. Francesco Solombrino	Renato Caccioppoli” Department of Mathematics and Applications, University of Naples Federico II – Italy	SSM
The SHiP project at CERN	0.3	Prof. Andrey Golutvin	Chair in Physics and Professor at Department of Physics, Imperial College London – U.K.	SSM
Astroparticle Physics in the Era of Multi-messenger Astronomy	0.3	Prof. Gennaro Miele	Scuola Superiore Meridionale and Department of Physics, University of Naples Federico II – Italy	SSM
Hierarchical Seismic Imaging	0.3	Prof. Jean Virieux	Professor at Laboratory in Earth Sciences: ISTerre, Université Grenoble Alpes – France	SSM
Additive Manufacturing. A world full of opportunities and challenges	0.3	Prof. Ferdinando Auricchio	Professor at Department of Civil Engineering and Architecture, University of Pavia – Italy	SSM
The coming revolution of data driven discovery (a fourth methodological paradigm of science)	0.3	Prof. Giuseppe Longo	Professor at “Ettore Pancini” Department of Physics, University of Naples Federico II – Italy	SSM

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Why do we cooperate? Understanding and modelling societies using reinforcement learning	0.3	Prof. Mirco Musolesi	Department of Computer Science, University College London - U.K.	SSM
Rheo-Engineering Microfluidics: how to exploit rheological properties of fluids to design microfluidic applications	0.3	Pier Luca Maffettone	Professor at Dept. of Chemical, Material and Production Engineering, University of Naples Federico II - Italy	SSM
Putting More PHYS into PSHA: Advancing Seismic Hazard Analysis with Physics-Based Modelling	0.3	Thomas H. Jordan	Professor of Earth Sciences, Southern California Earthquake Center, University of Southern California Dornsife – U.S.A.	SSM
Modelling the Complexity of Multiagent Activity for Human-AI Interaction using Dynamical Primitives	0.3	Michael Richardson	Professor at Department of Psychology; Centre for Elite performance, Expertise and Training; Faculty of Medical, Health and Human Sciences; Macquarie University - Australia	SSM
The Beat of Math	0.3	Alfio Quarteroni	Professor at Politecnico di Milano – Italy Professor emeritus at Ecole Polytechnique Fédérale de Lausanne (EPFL) – Switzerland	SSM
Synchronization in complex networks, hypergraphs and simplicial complexes	0.3	Stefano Boccalett	Director of Research at CNR - Institute of Complex Systems, Sesto Fiorentino - Italy	SSM
Dynamics of PDEs and recurrent motions	0.3	Pietro Baldi	Department of Mathematics and Applications “Renato Caccioppoli”, University of Naples	SSM

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			Federico II – Italy	
Seismic risk assessment and management: the Groningen gas field case	0.3	Annemarie Muntendam-Bos	Senior Specialist at the State Supervision of Mines, the Dutch safety authority for mining activities – The Netherlands Associate Professor on Induced Seismicity (part time) at the Delft University of Technology – The Netherlands	SSM
The pandemic playbook, a physicist tale	0.3	Francesco Sannino	Professor at the Department of Physics, Federico II University Director of the Centre for Cosmology and Particle Physics Phenomenology (CP ³ -Origins) SPACE Board of the Scuola Superiore Meridionale, Napoli	SSM
Weekly participation in internal lab meetings (48 hours) of SINCRO group research.	1.2	Different Group members and speakers		Mario di Bernardo, SINCRO

b. External courses

Module Title	Type	Credits	Lecturer	Organization
Numerical Methods in Complex Systems	External Module	6	Prof. Konstantinos Siettos	Scuola Superiore Meridionale
Numerical Methods for Optimal Control	External Module	6	Prof. Mario Zanon	Scuola IMT Alti Studi Lucca
Model Predictive Control	External Module	4	Prof. Alberto Bemporad	Scuola IMT Alti Studi Lucca

3. Research activity:

Modelling and Advanced Network Control of Future Smart Grids

The power network is a key critical infrastructure for our everyday life. While there is a wide range of studies dealing with the modelling and control of the power network components and their coordination for power generation, the links among the different modelling approaches and control strategies are still not clear enough in the literature. For this reason, To this aim we provide a review of the different dynamical models of the components of the power grid from a network perspective, the control specifications needed for their functioning and the control layers that fulfill them. As this detailed modelling of the power network can be cumbersome to handle for control design, we introduce the Swing Equation as a simplification of the frequency dynamics of the power network and provide a comprehensible framework to map each of the components of the power network into a set of parameters of the Swing Equation. This simpler model allows us to introduce additional control problems on the power network such as the secondary frequency control problem and the set-point scheduling problem and we frame these problems into a hierarchical description of the power network control. As the control architecture of the power network cannot always compensate the different disturbances it is subject to, we also discuss last resort strategies to contain failures. Specifically, we introduce the power network islanding problem and the Intentional Controlled Islanding (ICI) strategies found in literature. After this, we provide a self-organizing solution to the islanding problem based on the migration of nodes among islands defined by an initial partition of the network. This method uses a power balance estimator based on virtual consensus dynamics and a distributed migration strategy that uses this estimate to decide the migration. Our method finds, under some assumptions on the network structure and in a finite number of migration steps, a partition of the power network such that the average absolute power imbalance remains within a certain bound from the total power imbalance of the power network and we give an analytical expression for this bound.

4. Products:

- Lo Iudice F.*, Cardona-Rivera R.*, Grotta A., Coraggio M., di Bernardo M. Utilizing synchronization to partition power networks into microgrids, In preparation.
- Della Rossa F.*, Salzano D.*, Di Meglio A.*, De Lellis F.*, Coraggio M., Calabrese C., Guarino A., Cardona-Rivera R., De Lellis P., Liuzza D., Lo Iudice F., Russo G., di Bernardo M. (2020). A network model of Italy shows that intermittent regional strategies can alleviate the COVID-19 epidemic. Nature communications, 11(1), 1-9

5. **Activity abroad:** No period abroad was proposed due to the COVID-19 pandemic.

6. Conferences and seminars:

- a. Weekly participation in internal lab meetings (48 hours) of SINCRO group research.

7. Tutorship

- a. Support on exams preparation and grading for the course “Sistemi di Controllo per la Bioingegneria”.
- b. Support on exam grading for the course “Dinamica e Controllo Nonlineare”.

8. Summary of Credits.

Note that the three-month extension of the PhD is included as an additional entry, as requested.

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	Credits year 1							Credits year 2							Credits year 3							Total	Check				
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth			5 bimonth	6 bimonth	3-month Extension	Summary
Modules	0			6		2	6	14	12				6		3	9	7		6	6	4				16	39	30-70
Seminars	0	0,2	0,2	1,2	2	0,2	0,2	4	8	0,2	0,2	0,2	0,2	0,2	0,2	1,2	5	1,1	1,7	3,5	2	0,2	0,2	0,2	8,9	14,1	10-30
Research	0	9,8	9,8	2,8	8	7,8	3,8	42	40	9,8	9,8	9,8	3,8	9,8	6,8	49,8	48	8,9	2,3	0,5	4	9,8	9,8	9,8	45,1	137	80-140
	0	10	10	10	10	10	10	60	60	10	10	10	10	10	10	60	60	10	10	10	10	10	10	10	70	190	180

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