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**PhD in Information Technology and Electrical Engineering**  
Università degli Studi di Napoli Federico II

**PhD Student: Roberto Rizzello**

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Cycle: XL

**Training and Research Activities Report**

**Year: First**

Roberto Rizzello

**Tutor: Prof. Pietro De Lellis**

Pietro De Lellis

Date: October 31, 2025

# Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XL

Author: Roberto Rizzello

## 1. Information:

- **PhD student: Roberto Rizzello**
- **DR number: DR999881**
- **Date of birth: 22/09/1999**
- **Master Science degree: Ingegneria dell'Automazione e Robotica    University: Università degli Studi di Napoli Federico II**
- **Doctoral Cycle: XL**
- **Scholarship type: UNINA**
- **Tutor: Pietro De Lellis**
- **Co-tutor: N/A**

## 2. Study and training activities:

Activity	Type <sup>1</sup>	Hours	Credits	Dates	Organizer	Certificate <sub>2</sub>
How to boost your PhD	Courses	18	5	08/01/2025 15/01/2025 22/01/2025 28/01/2025 05/02/2025 12/02/2025	Prof. Antigone Marino	Y
Introduction to Python	Courses	12	2	14/01/2025 16/01/2025 21/01/2025 23/01/2025 28/01/2025 30/01/2025	Dott. Davide Salzano & Dott. Marco Coraggio	Y
Calculus of Probability and Elements of Stochastic Modeling	Courses	24	4	13/01/2025 17/01/2025 20/01/2025 24/01/2025 27/01/2025 31/01/2025 03/02/2025 07/02/2025 10/02/2025 14/02/2025 17/02/2025 21/02/2025	Dott. Giacomo Ascione & Dott. Caio Cesar Graciani Rodrigues	Y
Matrix Analysis for Signal Processing with MATLAB Examples	Courses	14	3	06/05/2025 08/05/2025 12/05/2025 19/05/2025 20/05/2025 29/05/2025	Dott. Massimo Rosamilia	Y

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				03/06/2025		
<b>The Linear Parameter Varying approach: theory and application</b>	<b>Courses</b>	<b>12</b>	<b>4</b>	24/04/2025 28/04/2025 29/04/2025 30/04/2025	<b>Prof. Olivier Sename</b>	<b>Y</b>
<b>System and Process Control</b>	<b>Courses</b>	<b>72</b>	<b>9</b>	09/2025-12/2025	<b>Prof. Francesco Lo Iudice</b>	<b>Y</b>
<b>SINCRO Research Seminars</b>	<b>Seminars</b>	<b>46</b>	<b>9.2</b>	6/11/2024 20/11/2024 4/12/2024 11/12/2024 5/02/2025 19/02/2025 26/02/2025 5/03/2025 19/03/2025 26/03/2025 2/04/2025 9/04/2025 16/04/2025 23/04/2025 7/05/2025 14/05/2025 21/05/2025 28/05/2025 4/06/2025 11/06/2025 02/07/2025 09/07/2025 16/07/2025	<b>SINCRO Group members</b>	<b>N</b>
<b>Optimisation-based Control of Flexible Resources in Sustainable Energy Networks</b>	<b>Seminars</b>	<b>1</b>	<b>0.2</b>	05/02/2025	<b>Prof. Luigi Glielmo</b>	<b>Y</b>
<b>Synchrony and synchrony-breaking as higher-order effects in hypernetwork systems</b>	<b>Seminars</b>	<b>2</b>	<b>0.4</b>	27/02/2025	<b>Dott. Eddie Nijholt</b>	<b>N</b>
<b>Incorporating human behavior into network epidemic models</b>	<b>Seminars</b>	<b>1</b>	<b>0.2</b>	5/12/2024	<b>Prof. Alessandro Rizzo</b>	<b>N</b>

1) Courses, Seminar, Doctoral School, Research, Tutorship

2) Choose: Y or N

## 2.1. Study and training activities - credits earned

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	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	9	1.8	8.2	0	19
Bimonth 2	5	1.8	3.2	0	10
Bimonth 3	2	2.8	5.2	0	10
Bimonth 4	11	2.4	1.6	0	15
Bimonth 5	0	1.2	3.8	0	5
Bimonth 6	0	0	10	0	10
<b>Total</b>	27	10	32	0	69
<b>Expected</b>	30 - 70	10 - 30	80 - 140	0 - 4.8	

### 3. Research activity:

During the current year, we faced and solved the problem of synchronizability in networks of nearly identical systems coupled through directed hypergraphs. We adopted a local Lyapunov-based approach to define a mathematically backed estimation methodology for the synchronization convergence bound. Such methodology can accurately predict the steady-state norm of the synchronization error between the dynamical agents composing the network. Given the strong correlation between the estimated and the actual convergence bound we observed, we defined our novel synchronizability metric as the reciprocal of the estimated bounds. We finally used it to compare the ability of different kinds of hypernetworks in synchronizing their dynamical units, and we used our methodology to identify the best topological configuration to control an opinion dynamics application by maximizing the synchronizability.

In addition, we designed a novel algorithm able to generate scale-free directed hypergraphs. We are currently working on the formal proof guaranteeing the scale-free property of the generated hypernetworks.

Finally, we identified a procedure to steer the dynamics of a slave hypernetwork towards a desired evolution exhibited by an exact copy of such hypernetwork, which acts as a master. We studied the linearized dynamics of the error between the state of each node of the slave and the corresponding node of the master and formulated sufficient conditions guaranteeing complete master-slave synchronization. The assumptions we identified are related to specific properties of the topology and coupling policy; they allowed us to identify the sub-set of nodes of the master hypernetwork that must be connected to the corresponding ones of the slave to guarantee complete master-slave synchronization.

### 4. Research products:

R. Rizzello, P. De Lellis "Pinning control in networks of nonidentical systems with many-body interactions", *IEEE Control Systems Letters*, vol. 8, pp. 1313-1318, 2024

R. Rizzello, P. De Lellis, F. Lo Iudice "Modeling and control of opinion dynamics in the presence of higher order interactions", *IEEE CompEng*, 2024

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*R. Rizzello, P. De Lellis “Synchronizability in networks with higher-order directed interactions”, submitted to Nature Communications, 2025.*

*R. Rizzello, P. De Lellis, E. Caroppo, M. Valentini, G. Sacco, C. Pianciamore, E. Marsili, R. Boccuzzi, G. Boccuzzi, F. Manganello “Effectiveness of artificial intelligence in supporting students in career decision making: a scoping review”, submitted to Human Resource Development International, 2025.*

## 5. Conferences and seminars attended

*63rd IEEE Conference on Decision and Control, CDC, Milan, Italy, 16/12/2024-19/12/2024 (Paper presented)*

*“Complex Networks beyond Pairwise Interactions: From Theory to Applications”, Natal, Brazil, 25/06/2025-3/07/2025 (Paper presented)*

*“Higher-order interactions: mechanisms, behaviors, and networks”, Erice, Italy, 25/08/2025-31/08/2025 (Paper presented)*

## 6. Activity abroad:

*N/A*

## 7. Activity in partner companies:

*N/A*

## 8. Tutorship

*N/A*