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

PhD Student: Sara Leccese

Cycle: XXXVIII

Training and Research Activities Report

Year: First

student signature 

Tutor: prof. Stefania Santini *tutor signature* 

Date: October 18, 2023

1. Information:

- **PhD student: Sara Leccese**
- **DR number: DR996621**
- **Date of birth: 17/05/1996**
- **Master Science degree: Automation and Robotics Engineering**
- **University: University of Naples Federico II**
- **Doctoral Cycle: XXXVIII**
- **Scholarship type: PNRR - DM 351 Ricerca**
- **Tutor: Stefania Santini**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
COMPLEX NETWORKS SYSTEMS: INTRODUCTION AND OPEN CHALLENGES	Seminar	1.5	0.3	17/11/2022	Prof. Pietro De Lellis	Y
GINGER, GYROSCOPES IN GENERAL RELATIVITY	Seminar	1.5	0.3	01/12/2022	Prof. Angeladi Virigilio	Y
Back and forth between the infinite and the finite: a numerical view of time delay systems.	Seminar	1.5	0.3	02/12/2022	Prof. Dimitri Breda,	Y
FROM CYBER SITUATIONAL AWARENESS TO ADAPTIVE CYBER DEFENSE: LEVELING THE CYBER PLAYING FIELD	Seminar	2	0.4	13/12/2022	Prof. M.Albanese,	Y
Progettazione di strategie di controllo in ambiente Simulink	Seminar	3	0.6	03/12/2022	Ing. Gianfranco Fiore	N
Is control a solved problem for aerial robotics research?	Seminar	1	0.2	12/01/2023	Prof. Fabio Ruggiero	Y

Multi-robot Control of Heterogeneous Herds.	**Seminar**	**1.5**	**0.3**	**16/02/2023**	**Prof. Eduardo Montijano**	**Y**
Industry 4.0 Fundamentals in Bosch Applications.	**Seminar**	**8**	**2.0**	**23-26/01/2023**	**Prof. Ing. Mariagrazia Dotoli, Eng. Martino Bruni**	**Y**
INTERNATIONAL GRADUATE SCHOOL ON CONTROL (IGSC)- Time-Delay and Sampled-Data System	**Doctoral School**	**25**	**4**	**11-14/04/2023**	**EECI 2020- International Graduate School on Control, Prof. Emilia Fridman; Prof. Pierdomenico Pepe**	**Y**
Using Delays for Control	**Seminar**	**1**	**0.2**	**01/03/2023**	**Prof. Emilia Fridman;**	**N**
Asymptotic Stability and Gamma-Stability of Linear Time Invariant Time Delays Systems (LTI-TDS) - Leveraging algebraic tools for analytical results.	**Seminar**	**1**	**0.2**	**26/05/2023**	**Prof. Rifat Sipahi**	**N**
Boundary feedback stabilization of freeway traffic networks: ISS control and experiments.	**Seminar**	**1.5**	**0.3**	**21/06/2023**	**Prof. Christophe Prieur**	**N**
Legendre polynomials for Delay Systems: Modelling and Stability	**Seminar**	**1**	**0.2**	**23/06/2023**	**Prof. Alexandre Seuret**	**N**
Let's Use Delays in Adaptive Control!	**Seminar**	**1.5**	**0.3**	**18/10/2023**	**Prof. Iasson Karafyllis**	**N**
Academic Entrepreneurship	**Ad hoc course**	**18**	**4**	**29-31/05 - 05-15-20-22/06/2023**	**prof. Pierluigi Rippa, Silvia Cosimato, Nadia Di Paola - DIE Unina**	**Y**

TEST MINING	**Course**	**40**	**6**	**29/09/2023**	**Prof. Flora Amato**	**Y**
INFORMATION SYSTEMS AND BUSINESS INTELLIGENCE	**Course**	**40**	**6**	**29/09/2023**	**Prof. Flora Amato**	**Y**

1) Courses, Seminar, Doctoral School, Research, Tutorship
2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	**0**	**1.9**	**8.1**	**0**	**10**
Bimonth 2	**0**	**2.5**	**7.5**	**0**	**10**
Bimonth 3	**4**	**0.2**	**5.8**	**0**	**10**
Bimonth 4	**0**	**0.7**	**0.3**	**0**	**10**
Bimonth 5	**4**	**0.3**	**5.7**	**0**	**10**
Bimonth 6	**12**	**0.3**	**1.7**	**0**	**14**
Total	**20**	**5.9**	**29.1**	**0**	**64**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

Cyber-Physical Systems (CPS) have revolutionized the way we interact with physical world. These systems, which combine computational elements with physical processes, have found applications in diverse domains such as smart transportation systems, smart grid, smart cities and Industry 4.0, (W. Bai, 2019) (Lai, 2021). As the intricacy and scale of CPS continue to grow, the need for efficient, robust, and adaptable control strategies becomes increasingly important (Hamzah M, 2023).

Multi-agent CPS often involve a network of interconnected components working together towards a common goal. Novel distributed control strategies can optimize resource allocation, reduce latency, and enhance overall system performance. For example, in autonomous transportation systems, efficient traffic management can minimize congestion, lower fuel consumption, and improve transportation logistics. By designing control strategies that enable agents to communicate and coordinate effectively, the efficiency of multi-agent CPS can be significantly enhanced.

However, CPS are subject to various uncertainties, including sensor noise, hardware failures, and environmental disturbances (Nateghi, 2023). By developing distributed control methods that incorporate redundancy, fault tolerance, and self-healing capabilities, multi-agent CPS can continue to operate reliably under adverse conditions. In industrial automation, for instance, a robust multi-agent CPS can adapt to equipment failures and reconfigure its components to prevent production interruptions.

Moreover, in multi-agent CPS, communication networks enables the exchange of data, commands, and information among agents. These networks are subject to various impairments, such as latency bandwidth limitations network congestion and communications delays. The communication or interaction topology between these agents is not fixed but changes over time (D. Wang). This can be due to factors like network failures, mobility of agents, or dynamic requirements of the system. It is crucial to design novel distributed control strategies that specifically address these impairments to ensure the efficiency, robustness, and adaptability of communication networks within multi-agent CPS while meeting control specifications.

The most common instance to properly design the architecture for Multi-agent CPS is based on Multi Agent System (MAS) framework, which guarantee the implementation of distributed cooperative control strategies to better meet the highly dynamic behaviour of CPSs. In so doing the Multi-agent CPS is often described by a graphical model while the physical systems are often modelled through dynamical systems governed by physical laws and constraints.

In this context, my study during this year focuses on the problem of design distributed cooperative control strategies for multi-agents CPS to reach a specific goal with respect to the application considered. Specifically, over the past year of my PhD research, I mainly focused on the voltage regulation problem for an islanded Micro-Grid under and switched communication topology, and more recently, on the tracking control of heterogeneous trains under a time-varying communication topology subject to communication time-delays. In both cases, the stability of the proposed approach is provided by leveraging the Lyapunov-

Krasovskii theory for time-delay system (Fridman, Introduction to time-delay systems: Analysis and control, 2014).

References

D. Wang, N. Z. (2016). A pd-like protocol with a time delay to average consensus control for multi-agent systems under an arbitrarily fast switching topology. *IEEE transactions on cybernetics*, vol. 47, no. 4, pp. 898–907.

Fridman, E. (2014). *Introduction to time-delay systems: Analysis and control.*

Hamzah M, I. M. (2023). Distributed Control of Cyber Physical System on Various Domains: A Critical Review. *Systems*.

Lai, J. L. (2021). Resilient distributed multiagent control for AC microgrid networks subject to disturbances. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 43-53.

Nateghi, S. S. (2023). Resilient control of cyber-physical systems using adaptive super-twisting observer. *Asian Journal of Control*, 1775-1790.

W. Bai, Z. L. (2019). Distributed cooperative cruise control of multiple high-speed trains under a state-dependent information transmission topology. *IEEE Transactions on Intelligent Transportation Systems*, vol. 20, no. 7, pp. 2750–2763.

Wang, Y. G. (2009). Consensus of multi-agent systems in directed networks with nonuniform time-varying delays. *IEEE Transactions on Automatic Control*, 1607–1613.

4. Research products:

[1] B. Caiazzo, E. Fridman, S. Leccese, A. Petrillo, S. Santini " Voltage Recovery in SOA-based Virtual Microgrids via Time-Delay Approach to Averaging", IFAC, 22nd World Congress 2023 of the International Federation of Automatic Control, Yokohama, JAPAN, To appear.

[2] G. Basile, S. Leccese, A. Petrillo, R. Rizzo and S. Santini, "Sustainable DDPG-based Path Tracking For Connected Autonomous Electric Vehicles in extra-urban scenarios," 2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT), Male, Maldives, 2023, pp. 1-7,
doi: 10.1109/GlobConHT56829.2023.10087542.

5. Conferences and seminars attended

a. Details:
2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT),11-12 March 2023, Male, Maldives, attended on line.

b. Presentation made:
Presentation of the paper "Sustainable DDPG-based Path Tracking For Connected Autonomous Electric Vehicles in extra-urban scenarios" at *2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT),11-12 March 2023, online conference.*

6. Activity abroad:

7. Tutorship