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

PhD Student:

Cycle: XXXVII

Training and Research Activities Report

Academic year: 2023-23 - PhD Year: Second

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Tutor: Prof. Stefania Santini :

Co-Tutor: Ing. Pietro Schipani

Date: October 21, 2023

1. Information:

- ➢ **PhD student: Giacomo Basile**
- ➢ **PhD Cycle: XXXVII**
- ➢ **DR number: DR995857**
- ➢ **Date of birth: 26/12/1995**
- ➢ **Master Science degree: Autmation Engineering**
- ➢ **University: University of Naples Federico II**
- ➢ **Scholarship type: INAF**
- ➢ **Tutor: Prof. Stefania Santini**
- ➢ **Co-tutor: Ing. Pietro Schipani**

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 (SSM)**	**Y**
Durability of Fuel Cell Systems	**Seminar**	**1.5**	**0.3**	**30/11/2022**	**Doc. Elodie Pahon (SSM)**	**Y**
Ginger, Gyroscpoes in general relativity	**Seminar**	**1.5**	**0.3**	**01/12/2022**	**Prof. Angeladi Virgilio**	**Y**
Back and forth between the infinite and the finite: a numerical view of time delay systems	**Seminar**	**1.5**	**0.3**	**01/12/2022**	**Prof. Dimitri Breda (ITEE-TDS)**	**N**
Progettazione di strategie di controllo in ambiente Simulink	**Seminar**	**3**	**0.6**	**03/12/2022**	**Ing. Gianfranco Fiore (Matworks)**	**Y**
Digital Forensics	**Seminar**	**2**	**0.4**	**06/12/2022**	**Prof. Vladimir Kurdin**	**N**
Threat Hunting & Incident Response	**Seminar**	**2**	**0.4**	**13/12/2022**	**Prof. Vladimir Kurdin**	**N**
From Cyber Situational	**Seminar**	**2**	**0.4**	**13/12/2022**	**Prof. M. Albanese**	**Y**

					(SSM)	
Awareness to adaptive cyber defense: levelling the cyber playing filed						
Entangled Relativity	**Seminar**	**2**	**0.4**	**15/12/2022**	**Prof. Oliver Minazzoli**	**Y**
Industry 4.0 Fundamental in Bosh Applications.	**Seminar**	**8**	**2**	**23-26/01/2023**	**Ing. Bruni Martino (Bosh)**	**Y**
Some free boundary problems in thermal insulation.	**Seminar**	**1.5**	**0.3**	**26/01/2023**	**Prof. Carlo Nitsh (SSM)**	**Y**
Multi-robot Control of Heterogeneous Herds	**Seminar**	**1.5**	**0.3**	**16/02/2023**	**Prof. Eduardo Montijano (SSM)**	**Y**
Discrete De Giorgi Theory: Analysis and Applications	**Seminar**	**1.5**	**0.3**	**24/02/2023**	**Prof. Endre Suli (SSM)**	**Y**
EECI phd School: "Nonlinear and data-driven model predictive control".	**Doctoral School**	**28**	**4**	**06-10/03/2023**	**EECI: Prof. Frank Allgower and Prof. Matthias A. Muller**	**Y**
Analysis and control of functional brain networks	**Seminar**	**1.5**	**0.3**	**09/03/2023**	**Prof. Fabio Pasqualetti (SSM)**	**Y**
Quantum gravity or shaking the foundations of physics and cosmology	**Seminar**	**1.5**	**0.3**	**23/03/2023**	**Prof. Daniele Oriti (SSM)**	**Y**
Phenomenology of Planck-scale Physics	**Seminar**	**1.5**	**0.3**	**30/03/2023**	**Prof. Giulia Gubitos (SSM)**	**Y**
Some advances in isogeometric analysis of coupled and complex problems	**Seminar**	**1.5**	**0.3**	**13/04/2023**	**Prof. Alessandro Reali (SSM)**	**Y**

Atomistic and Mesoscopic Modeling of Structure -Property Relations in Polymers	**Seminar**	**1.5**	**0.3**	**20/04/2023**	**Prof. Doros N. Theodorou (SSM)**	**Y**
When quantum systems source gravity: how can we do physics without spacetime?	**Seminar**	**1.5**	**0.3**	**27/04/2023**	**Doc. Flaminia Giacomini (SSM)**	**Y**
Asymptotic Stability and Gamma-Stability of Linear Time Invariant Time Delays Systems (LTI-TDS) - Leveraging algebraic tools for analytical results.	**Seminar**	**1.5**	**0.3**	**26/05/2023**	**Prof. Rifat Sipahi (ITEE-TDS)**	**N**
Academic Entreprenuership	**Course**	**18**	**4**	**29-31/05 - 05-15-20-22/06/2023**	**Prof. Pierluigi Rippa**	**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	**0.0**	**4.4**	**6.6**	**0.0**	**10**
Bimonth 2	**0.0**	**2.9**	**7.1**	**0.0**	**10**
Bimonth 3	**4.0**	**1.8**	**4.2**	**0.0**	**10**
Bimonth 4	**0.0**	**0.2**	**9.8**	**0.0**	**10**
Bimonth 5	**4.0**	**0.0**	**6.0**	**0.0**	**10**
Bimonth 6	**6.0**	**0.0**	**4.0**	**0.0**	**10**
Total	**14.0**	**9.3**	**37.7**	**0.0**	**60**
Expected	**10 - 20**	**0 - 10**	**30 - 60**	**0 – 1.4**	

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3. Research activity:

During my second years the following activity have been carried out:

- TNG project: Nowadays, INAF, with the ESO research group, not only design and deploy new advanced telescopes such as the one in commissioning with the project ELT, but it requests the update of the old telescopes in oreder to improve their performance. Within this framework, I attended to the update project of the *"Telescopio Nazionale Galileo"* (TNG) located in las Palmas, Gran Canarias. The project aims to improve the axes motion control performance allowing the tracking, hence, to study of other celestial bodies which are used to studied by leveraging more sophisticate ESO's telescope such as the VLTs. The last update of the TNG has been implemented and reported in the 2000 [1]. To this end, by studying the current axes control loop and based advanced control strategy reported in the following books [2], [3], several new control algorithms for the axes control have been investigated. Specifically, before the investigation, designing of the new advanced control strategy, the identification of the telescope's dynamical behavior is carried out on real measurements by exploiting the identification strategy reported in [2]. Then, based on the control strategy reported in [3], i.e. an optimal double control loop, an Linear Quadratic Gaussian with Proportional and Integral action is designed in order to improve the tracking performance. The results obtained are still in proceeding to be published. Otherwise, more advanced control strategy, such as Model Predictive Controller and Deep Reinforcement Learning (DRL) based control strategies, will be investigated during the next year in order to deal with exogenous factor (wind disturbance) and model uncertainties [4].

- ELT project: during the first year, the preparation of the control loop for the adaptive optics system for the ELT program, especially, the Telemetry module has been deployed and test. During the second years, the focus has been the well manage of the measurement, rejecting as much as possible the measurement noise, while, on the other hand, the elaboration of the measurement data, preparing it for the control loop, has been deployed.

- Hybrid control strategy study: while during my first year I focused my sturdies to acquire knowledge and skills regarding the new DRL-based control strategy. During the second year, my focus was to study and understand the main challenges of the optimal control algorithm such as the MPC to combining the DRL approaches with this latter. Within this framework, I attended the ITEE EECI Phd school on the nonlinear and data driven MPC, where I could study and acquired the skills for the design and implementation of the optimal controller reported in [4], [5], [6].

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Reference

[1] Mancini, D., & Schipani, P. (2000, June). Tracking performance of the TNG Telescope. In *Advanced Telescope and Instrumentation Control Software* (Vol. 4009, pp. 355-365). SPIE.

[2] Gawronski, W. K. (Ed.). (2004). *Advanced structural dynamics and active control of structures*. New York, NY: Springer New York.

[3] Gawronski, W. K. (2008). *Modeling and control of antennas and telescopes* (p. 43). Berlin, Germany: Springer.

[4] Allgöwer, F., & Zheng, A. (Eds.). (2012). *Nonlinear model predictive control* (Vol. 26). Birkhäuser.

[5] Chen, H., & Allgöwer, F. (1998). A quasi-infinite horizon nonlinear model predictive control scheme with guaranteed stability. *Automatica*, *34*(10), 1205-1217.

[6] Berberich, J., Köhler, J., Müller, M. A., & Allgöwer, F. (2022, December). Stability in data-driven MPC: an inherent robustness perspective. In *2022 IEEE 61st Conference on Decision and Control (CDC)* (pp. 1105-1110). IEEE.

4. Research products:

- Conference paper:
  - Basile, G., Lui, D. G., Petrillo, A., & Santini, S. (2022, December). Deep deterministic policy gradient-based virtual coupling control for high-speed train convoys. In 2022 IEEE International Conference on Networking, Sensing and Control (ICNSC) (pp. 1-6). IEEE. (**published:** December 15, 2022)

  - Basile, G., Leccese, S., Petrillo, A., Rizzo, R., & Santini, S. (2023, March). Sustainable DDPG-based Path Tracking For Connected Autonomous Electric Vehicles in extra-urban scenarios. In 2023 IEEE IAS Global Conference on Renewable Energy and Hydrogen Technologies (GlobConHT) (pp. 1-7). IEEE. (**published:** March 11, 2023)

  - Basile, G., Lui, D. G., Petrillo, A., & Santini, S. (2023, June). Adaptive Distributed PI-like Control Protocol for the Virtual Coupling of Connected Heterogeneous Uncertain Nonlinear High-Speed Trains. In 2023 31st Mediterranean Conference on Control and Automation (MED) (pp. 674-679). IEEE. (**published:** June 26, 2023)

- Journal Paper Published:
  - Basile, G., Napoletano, E., Petrillo, A., & Santini, S. (2022). Roadmap and challenges for reinforcement learning control in railway virtual coupling. Discover Artificial Intelligence, 2(1), 27. (**published:** December 29, 2022)

5. Conferences and seminars attended.

- 2022 IEEE International Conference on Networking, Sensing and Control (ICNSC)

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- o Date: 15-18 December 2022. Shangai, China (Going to virtual conference)
- o Presentation made: Presentation of the paper "Deep deterministic policy gradient-based virtual coupling control for high-speed train convoys" at 2022 IEEE International Conference on Networking, Sensing and Control (ICNSC).
- o
- **2023 31th Mediterranean Conference on Control and Automation (MED):**
  - o Date: 26-29 June 2023. Limassol, Cyprus
  - o Presentation made: Presentation of the paper "Adaptive Distributed PI-like Control Protocol for the Virtual Coupling of Connected Heterogeneous Uncertain Nonlinear High-Speed Trains" at 2023 31st Mediterranean Conference on Control and Automation (MED).

6. Periods abroad and/or in international research institutions

7. Tutorship

During my second PhD year, I did not make any tutorship activity.

8. Plan for year three

Activities planned for the third year include:

- Research activities
  - o The TNG project:
    - Design an advanced control strategy such as an MPC or an artificial intelligence-based controller.
    - Deployment of the designed advanced controller on the real TNG
  - o The ELT project:
    - Implementation of the adaptive optics control loop
  - o Advanced on the design of Multi-Agent Artificial Intelligence strategies for MAS system such as in VC control problem
- Draft topic of the thesis
  - o Deep reinforcement learning strategies for tracking control of the Telescope.
  - o Hybrid control strategy which combines the MPC benefits with the one of the DRL.