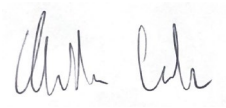
PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Mirko Casale

Cycle: XXXIX

Training and Research Activities Report

Academic year: 2023-24 - PhD Year: Second

Student: 

Tutor: prof.ssa Stefania Santini 

Co-Tutor:

Date: October 30, 2025

1. Information:

- **PhD student: Mirko Casale** **PhD Cycle: XXXIX**
- **DR number: DR997201**
- **Date of birth: 24/04/1992** **University: Federico II Napoli**
- **Master Science degree: Mechanical Engineering for Energy and Environment**
- **Scholarship type: no scholarship**
- **Tutor: Stefania Santini**
- **Co-tutor:**
- **Period abroad:**

2. Study and training activities:

Activity	Type	Hours	Credits	Dates	Organizer	Certificate
Perché l'Intelligenza Artificiale crede di fare a meno della teoria linguistica, ma in realtà non potrà farlo	Seminar	1	0,2	20/11/2024	Phil_AI Lab- prof. F. Cutugno	N
Phase transitions in the nucleus of cells	Seminar	1	0,2	21/11/2024	SSM	Y
Strutture basate su regole e strutture basate su approssimazioni	Seminar	2	0,4	10/12/2024	Phil_AI Lab- prof. F. Cutugno	Y
Stability Guarantees under Sampling for Retarded Nonlinear Systems	Seminar	1	0,2	06/12/2024	Dr. Gabor Orosz (TDS)	N
Solid State Transformers: Fundamentals, Insights and New Trends	Seminar	2	0,4	20/12/2024	Luigi Pio Di Noia	Y
Lunar Laser Retroreflectors for ESA-ASI's Moonlight	Seminar	1	0,2	16/01/2025	SSM	Y
Bridging Physics to Biomedical Sciences	Seminar	1	0,2	30/01/2025	SSM	N

Optimisation-based Control of Flexible Resources in Sustainable Energy Networks	Seminar	1	0,2	05/02/2025	Prof. Luigi Gliemo	Y
Emergent behaviors and collective decisions in cyber-physical-human systems	Seminar	1	0,2	13/02/2025	SSM	N
Explainable Scientific Machine Learning: Theoretical and Practical Perspectives	Seminar	1	0,2	20/02/2025	SSM	N
Dynamic Risk Assessment in Industrial Applications: Leveraging Bayesian Inference for Enhanced Decision-Making	Seminar	1	0,2	04/03/2025	Dr. Francesco Vitale	Y
Numerical bifurcation analysis for delay equations	Seminar	1	0,2	07/03/2025	Dr. Gabor Orosz (TDS)	N
Bridging Local and Global Universe via gravitational astrometry: The Milky Way paradigm	Seminar	1	0,2	20/03/2025	SSM	N
Safety Assessment for Autonomous vehicles: Approaches and Challenges	Seminar	1,5	0,3	24/03/2025	Prof. Stefano Russo	Y
ADVANCED CONTROL AND APPLICATIONS	Course	30	6	25/03/2025	Università del Sannio	Y
Robot Autonomy among Decision-Making Agents	Seminar	1	0,2	15/04/2025	Prof. Fabio Ruggiero (DIETI, UniNA)	Y
IEE ITSS Italian Chapter Annual Meeting and PhD Award 2025	Seminar	5	1	10/07/2025	IEEE ITSS Italian Chapter	Y

Control of multi-agent systems with time delays: theory and applications	Seminar	1	0,2	05/09/2024	Dr. Gabor Orosz (TDS)	N
Guardians or Threats? AI as the Frontlines of CyberSecurity	Seminar	4	0,8	17/10/2025	5G Academy (Prof. Antonia Tulino)	Y
TECNOLOGIE DEI SISTEMI DI AUTOMAZIONE	Course	30	6	23/09/2025	Università di Napoli FedericoII	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**	**1.4**	**8.6**	**0**	**10**
Bimonth 2	**0**	**1**	**9**	**0**	**10**
Bimonth 3	**6**	**1.1**	**2.9**	**0**	**10**
Bimonth 4	**0**	**0**	**10**	**0**	**10**
Bimonth 5	**0**	**1**	**9**	**0**	**10**
Bimonth 6	**6**	**1**	**3**	**0**	**10**
Total	**12**	**5.5**	**42.5**	**0**	**60**
Expected	**10 - 20**	**5 - 10**	**30 - 45**	**0 – 4.8**	

3. Research activity:

The second year of research activity focused on Advanced Driver Assistance Systems (ADAS), encompassing a wide spectrum of themes ranging from data processing to the modelling and simulation of complex systems, and extending to the exploration of innovative Artificial Intelligence (AI) techniques for data generation.

Initially, the research activities conducted in the preceding year were refined and validated with a view toward scientific publication. The main focus was the study and implementation of the Kalman filter in the context of object tracking. To ensure robust scientific validity, a rigorous comparison was performed between the results obtained and dynamic image tracking algorithms. This phase concluded with the collection of initial numerical outputs from the experiments conducted.

Subsequently, attention shifted to the application of the developed analytical tools. Work involved the acquisition and analysis of new real-world (on-road) driving scenarios. Following the selection of candidate

samples, they were processed and modelled in 3D. A key element was the extraction of useful data for a comparison between the Ground Truth (real data) and the generated 3D models. Simultaneously, the necessary simulations for the creation of these three-dimensional models were configured.

The third and fourth bimesters marked the beginning of a significant phase of study and modelling. An in-depth study was conducted on the application of Natural Language Processing (NLP) for the definition and verification of ADAS functional requirements. Subsequently, a speculative phase was initiated to set up a parametric model capable of emulating the behaviour of a neural network for vehicle recognition. Concurrently, the Model-Based Design (MBD) methodology for ADAS software development and verification was investigated, ensuring robust functionalities. This phase included learning how to create accurate Simulink models of automotive cameras for simulation and a thorough review of various Lidar technologies for automotive perception.

The final bimesters combined methodological refinement with the exploration of cutting-edge techniques. Following the continuation of Model-Based Design (MBD), the activity was enriched by speculating on new techniques for video input generation. Initial tests were conducted to create synthetic videos using AI video generation tools, with the aim of replacing traditional production processes, such as those based on simulation environments like CARLA. To support this phase, a literature review was completed on Model-Based Systems Engineering (MBSE) methodologies for the development of complex systems. Finally, the work focused on systems engineering and hardware. A study was conducted on the configuration of Vector platforms (standard tools in the automotive industry) for performing specific measurements on Ethernet architectures within in-vehicle ADAS systems.

In summary, the research year facilitated the acquisition of transversal skills, moving successfully from algorithmic optimisation and real-data analysis to the modelling of complex systems through MBD/MBSE, and culminating in the adoption of generative AI tools to address the challenges of data production and validation in the field of ADAS.

References:

[1] J. Chen, Z. Wang, et al., “HybridTrack: A Hybrid Approach for Robust 3D Multi-Object Tracking in Autonomous Vehicles” arXiv preprint (Jan 2025).

[2] M. Rossi, P. Bianchi, et al., " Developing Next-Generation Lidar with Model-Based Design" in MathWorks Automotive Conference Presentation (2024).

[3] C. Dubois, D. Martin, et al., " Automated Derivation and Consistency Checking of ADAS Requirements using Large Language Models" IEEE Transactions on Intelligent Vehicles (2024).

[4] A. Smith, B. Jones, et al. " Generative AI for Testing of Autonomous Driving Systems: A Survey" arXiv preprint (Aug 2025)

[5] E. Kim, F. Lee, et al. "Kalman Filter-Based Fusion of LiDAR and Camera Data in Bird's Eye View for Multi-Object Tracking in Autonomous Vehicles" Sensors (MDPI), Vol. 24, Issue 23 (2024).

4. Research products

5. Conferences and seminars attended

6. Periods abroad and/or in international research institutions

7. Tutorship

8. Plan for year three

The quarterly planning for the final year's activities is as follows:

Q1) Parametric Model Finalization Complete the optimization and calibration of the mathematical models. Define the key metrics for efficiency (computation time) and robustness (detection accuracy).

Q2) Intensive Experimental Validation Execute testing campaigns to systematically compare the model's output data with that of a real ADAS camera (Ground Truth), utilising complex driving scenarios.

Q3) Analysis and Thesis Demonstration Statistically elaborate the results to demonstrate functional equivalence and the reduction in testing costs/time. Draft the central chapters of the dissertation (Methodology and Results).

Q4) Writing and Publication Conclude the writing of the dissertation. Prepare and submit an article to a high