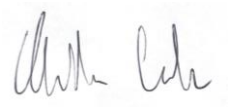
PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Mirko Casale

Cycle: XXXIX

Training and Research Activities Report

Academic year: 2023-24 - PhD Year: First

Student: 

Tutor: prof.ssa Stefania Santini 

Co-Tutor:

Date: October 31, 2024

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX **Author: Mirko Casale**

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[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Control Systems for Autonomous Ground Vehicles	Course	48	6	21/12/2023	Prof. Stefania Santini	Y
Balancing-based model reduction for delay systems	Seminar	1.5	0.3	01/12/2023	Dr. Nathan van de Wouw	Y
Ensemble optimal control problems governed by Boltzmann models	Seminar	1	0.2	07/12/2023	Dr. Alfio Borzi	Y
AI for RAILS – Deep Learning for Railway Safety and Maintenance: Methodologies and Applications	Seminar	2	0.4	27/11/2023	Dr. Lorenzo De Donato	N
Strategic Orientation for STEM Research & Writing	Course	24	5	Period: 12 2023 - 02 2024	Dr Chie Shin Fraser	Y
Decentralized Bilevel Optimization	Seminar	1	0.2	12/02/2024	Dr. Shiqian Ma	Y
Micro-to-macro variational analysis of lattice energies	Seminar	1	0.2	22/02/2024	Prof. Marco Cicalese	Y
CSL'24 Conference	Seminar	6	1	23/02/2024	EACSL	Y
Systems And Control Fundamentals	Course	72	9	06/03/2024	Prof. Stefania Santini	Y
Analytic center selection of optimization-based controllers for robot ecology	Seminar	1	0.2	09/04/2024	Dr. Gennaro Notomista	Y

Dynamics with implicit state-dependent delay and post-Newtonian gravitational models	Seminar	1.5	0.3	05/04/2024	Dr. Erik Verriest	Y
I pilastri della trasformazione digitale	Course	12	3	03/05/2024	Dr. Francesco Tortorelli	Y
Automotive Cyber Security Academy (ACSA)	Course	16	3.2	22/06/24	Prof. Christiancarmine Esposito	Y
IEEE Authorship and Open Access Symposium	Seminar	2	0.4	07/05/2024	IEEE	Y
Observing topological effects with infrared light	Seminar	1	0.2	08/05/2024	Dr. Paolo Fachin	Y
Rewire the brain: The potential of neuroplasticity	Seminar	2	0.4	09/05/2024	Prof. Paola Marangolo	Y
5G & Digital Transformation	Seminar	4	0.8	10/05/2024	Dr. Maurizio Irlando	Y
Regolazione in tema di intelligenza artificiale alla luce del'AI act	Seminar	5	1	13/05/2024	Dr. Elvira Raviele	Y
Some aspects of virtual medicine and human space science research	Seminar	1	0.2	16/05/2024	Dr. Paolo Russo	N
Innovation and Entrepreneurship	Course	12	4	11/07/2024	Prof. Pierluigi Rippa	Y
Strongly Stabilizing Controllers for Systems with Time Delay	Seminar	1	0.2	05/07/2024	Dr. Hitay Ozbay	Y
Hopf bifurcation made simple for some scalar delay differential equations	Seminar	1	0.2	06/09/2024	Dr. Gergely Röst	Y
How to write a scientific paper	Seminar	2	0.4	07/10/204	CRUI – Dr. Elisa Magistrelli	Y
Research lntegrity	Seminar	2	0.4	08/10/2024	CRUI – Dr. Elisa Magistrelli	Y
Author Journey - Transformative	Seminar	2	0.4	09/10/2024	CRUI – Dr. Elisa Magistrelli	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	**6**	**0.9**	**3.1**	**0**	**10**
Bimonth 2	**5**	**1.4**	**3.6**	**0**	**10**
Bimonth 3	**9**	**0.5**	**0.5**	**0**	**10**
Bimonth 4	**6.2**	**3**	**0.8**	**0**	**10**
Bimonth 5	**4**	**0.2**	**5.8**	**0**	**10**
Bimonth 6	**0**	**1.4**	**8.6**	**0**	**10**
Total	**30.2**	**7.4**	**22.4**	**0**	**60**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

The automotive industry is undergoing a transformative shift, driven by the rapid advancement of autonomous driving (AD) technologies. Central to this evolution is the accurate and efficient simulation of sensors, which play a crucial role in enabling vehicles to perceive and interact with their surroundings [1].

My research has focused on developing and refining a robust framework for sensor simulation, particularly for cameras. This framework aims to provide a computationally efficient, mathematically complete, and geometrically exact representation of these sensors, addressing key challenges such as field of view (FOV) and occlusion [2]. By leveraging state-of-the-art sensor models and virtual testing strategies, I aim to accelerate the development and validation of ADAS and AD functions.

A fundamental aspect of this research has been the in-depth study of sensor modeling techniques. I have explored various levels of model fidelity, from high-fidelity representations that capture intricate sensor details to lower-fidelity models that prioritize computational efficiency. Additionally, I have investigated the use of software tools for data analysis, such as MATLAB/Simulink and the Automated Driving Toolbox, to gain valuable insights into sensor behavior and performance.

To create realistic virtual environments for sensor testing, I have utilized the CARLA simulator [3]. This powerful tool enables the generation of diverse driving scenarios, ranging from urban streets to highway conditions. By leveraging CARLA, it is possible to digitalize a real environment, obtaining a fully manipulable 3D scenario capable of accommodating testing that can benefit from the perfect repeatability of simulations.

To ensure the reliability and accuracy of virtual tests, I aim to develop a comprehensive verification and validation protocol. This protocol outlines the steps involved in setting up test benches, defining test cases, and evaluating the results, favoring a model-based systems engineering (MBSE) approach [4] to identify alternative solutions for the installation, tuning, and maintenance of the virtual validation platform.

To improve the realism of simulations, I have investigated test automation techniques for generating realistic vehicular maneuvers and explored neural network training techniques for image analysis, enabling our simulated sensors to accurately perceive and interpret visual information. The goal of this part of my study is entirely focused on verifying the ability of the simulated environment to deceive the detection mechanisms underlying the sensors. By conducting a series of case studies that compare the results of real and simulated

cameras [5] and acquiring valuable information on the accuracy and limitations of our sensor models, it is emerging that the use of pre-trained neural networks, such as YOLO4 [6], for object detection and tracking [7], can extract data that confirms that synthetic representations of real environments, and specifically the 3D representation of vehicles from which sensor virtualization is derived, represent a sufficient input to obtain results similar to ADAS systems with real sensors.

In conclusion, after the first year of research, significant progress has been made in understanding the field of sensor simulation for ADAS and AD. I hope to formalize this work by describing a robust framework that, by combining accurate sensor modeling and realistic virtual environments, can facilitate and accelerate the development of these technologies.

References:

[1] Schlager, B., Muckenhuber, S., Schmidt, S., Holzer, H. et al., “State-of- the-Art Sensor Models for Virtual Testing of Advanced Driver Assistance Systems/ Autonomous Driving Functions,” SAE Int. J. of AV 3(3):233–261, 2020.

[2] S. Genser, S. Muckenhuber, C. Gaisberger, S. Haas and T. Haid, "Occlusion Model—A Geometric Sensor Modeling Approach for Virtual Testing of ADAS/AD Functions," in IEEE Open Journal of Intelligent Transportation Systems, vol. 4, pp. 439-455, 2023.

[3] P. Kaur, S. Taghavi, Z. Tian and W. Shi, "A Survey on Simulators for Testing Self-Driving Cars," 2021 Fourth International Conference on Connected and Autonomous Driving (MetroCAD), Detroit, MI, USA, 2021, pp. 62-70,

[4] Annunziata, M., De Cristofaro, F., Di Giuseppe, C., Natale, A. et al., "A Model For Electronic Control Units Software Requirements Specification," SAE Technical Paper 2004-01-0704, 2004.

[5] Albarella, N.; Masuccio, F.; Novella, L.; Tufo, M.; Fiengo, G. A Forward-Collision Warning System for Electric Vehicles: Experimental Validation in Virtual and Real Environment. Energies 2021, 14, 4872.

[6] Alexey Bochkovskiy, Chien-Yao Wang, and Hong-Yuan Mark Liao. “YOLOv4: Optimal Speed and Accuracy of Object Detection.” 2020, arXiv:2004.10934. https://arxiv.org/abs/2004.10934.

[7] Bewley, Alex, Zongyuan Ge, Lionel Ott, Fabio Ramos, and Ben Upcroft. "Simple online and realtime tracking." In 2016 IEEE international conference on image processing (ICIP), pp. 3464-3468. IEEE, 2016.

4. Research products

5. Conferences and seminars attended

6. Periods abroad and/or in international research institutions

7. Tutorship