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

PhD Student: Emanuele Carella

Cycle: XXXIX

Training and Research Activities Report

Year: First

Student: 

Tutor: prof. Stefania Santini 

Co-Tutor:

Date: October 31, 2024

Training and Research Activities Report

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Author: Emanuele Carella

1. Information:

- **PhD student:** Emanuele Carella
- **DR number:** DR997208
- **Date of birth:** 23/01/1996
- **Master Science degree:** Mechatronics Engineering
University: Politecnico di Torino
- **Doctoral Cycle:** XXXIX
- **Scholarship type:** no scholarship
- **Tutor:** Stefania Santini
- **Co-tutor:**

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
Control Systems for Autonomous ground Vehicles	Courses	48	6	21/12/2023	Prof. Stefania Santini	Y
Statistical Data Analysis for Science and Engineering research	Course	12	4	29/04/2024	Prof. Roberto Pietrantuono	Y
Smart Roads and Cooperative Driving	Courses	48	6	26/06/2024	Prof. Angelo Coppola	Y
Innovation and Entrepreneurship	Courses	12	4	03/07/2024	Prof. Pierluigi Rippa	Y
ACSA – Automotive Cyber Security Academy	Courses	16	3.2	01/07/2024	Prof. Christiancarmine Esposito	Y
Machine Learning for Science and Engineering Research	Courses	20	5	30/09/2024	Prof. Anna Corazza	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
Decentralized Bilevel Optimization	Seminar	1	0.2	12/02/2024	Dr. Shiqian Ma	Y
CSL'24 Conference	Seminar	5	1	23/02/2024	European Association for Computer Science Logic (EACSL)	Y
Analytic centre selection of optimization-based controllers for robot technology	Seminar	1	0.2	09/04/2024	Dr. Gennaro Notomista	Y
Dynamics with implicit state-dependent delay and post-Newtonian gravitational models	Seminar	1	0.2	05/04/2024	Dr. Erik Verriest	Y

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IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors	Seminar	1.5	0.3	07/05/2024	The IEEE Xplore Events Team	Y
REWIRE THE BRAIN: THE POTENTIAL OF NEUROPLASTICITY	Seminar	2	0.4	09/05/2024	Dr. Paola Marangolo	Y
5G & DIGITAL TRANSFORMATION: A VIEW FROM AN UNCONVENTIONAL PERSPECTIVE	Seminar	4	0.8	10/05/2024	Dr Maurizio Irlando	Y
INTELLIGENZA ARTIFICIALE E REGOLE DEL MERCATO	Seminar	1	0.2	14/05/2024	Dr Massimo Rubino De Ritis	Y
Superare le sfide della modellazione di sistemi grazie al Model-Based System Engineering	Seminar	1	0.2	21/05/2024	Mathworks team	Y
Optimization-Based Planning and Control for Multi-Limbed Walking Robots	Seminar	1	0.2	27/05/2024	Dr. Dario Bellicoso	Y
Accelerating Deep Neural Inferences on FPGAs	Seminar	0.5	0.1	27/05/2024	Prof. Alessandro Cilardo	Y
RISC-V and SoCs	Seminar	0.5	0.1	27/05/2024	Prof. Alessandro Cilardo	Y
Da Model-Based System Engineering a Model-Based Design: Progettazione di architetture software con System Composer	Seminar	1	0.2	29/05/2024	Mathworks team	Y
Social Network Analysis: Methods and Applications	Seminar	2	0.4	07/06/2024	Dr. Tanmoy Chakraborty	Y
Design and Analyze a Quadcopter with Model-Based Systems Engineering (MBSE)	Seminar	1	0.2	29/08/2024	Mathworks team	Y
Hopf bifurcation made simple for some scalar delay differential equations	Seminar	1	0.2	06/09/2024	Dr. Gabor Orosz	Y
From ACE Technologies to Sustainable, Accessible and Equitable Urban Mobility: An Optimization Journey	Seminar	2	0.4	16/08/2024	Prof. Mauro Salazar	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	0	1.2	8.8	0	10
Bimonth 3	4	0.4	5.6	0	10
Bimonth 4	6	2.9	1.1	0	10
Bimonth 5	7.2	0.2	2.0	0	9.4
Bimonth 6	5	0.6	5	0	10.6
Total	28.2	6.2	25.6	0	60
Expected	30 - 70	10 - 30	80 - 140	0 - 4.8	

3. Research activity:

One of the most significant technological breakthroughs in vehicle transportation is represented by the development of advanced driver assistance systems (ADAS) and Vehicle-to-Everything (V2X) communication.

In particular, one of the most used ADAS services, in present days, is the Adaptive Cruise Control, that enables vehicle, exploiting the local sensor embedded in the vehicle (radar, LIDAR, etc...), to follow a leading vehicle at a predetermined distance. It is a well-studied and developed technology so that it belongs to level 2 of the SAE's LOAD (Levels of Automation).

Although perfectly integrated in the standard, ACC systems face challenges in maintaining a consistent time headway while avoiding the risk of rear-end collision during sudden speed changes in traffic (shockwave effect) [1]. These can occur when sudden braking in one vehicle creates a "ripple" in velocity that affects the vehicle behind it, often leading to abrupt speed adjustment. These limitations hinder the use of low-time headway values, leading to potential string instability.

Moreover, traffic with medium-to-high penetration of ACC-equipped vehicles is more susceptible to the formation of self-organized Phantom traffic jam induced by perturbation in vehicular demographics ("Congestion-Aware Cooperative Adaptive Cruise Control for Mitigation of Self-Organized Traffic Jams").

To tackle these challenges and more others, in recent years a new technology known as Cooperative Adaptive Cruise Control (CACC) has been introduced. It leverages the V2X technologies in the context of vehicle transportation and CAV (Connected Automated Vehicle), whose is a service that enables vehicles to continuously exchange information about their position, speed, and acceleration/deceleration. CACC uses this shared information together with local data to properly tune the control actuation for longitudinal dynamic and to achieve improved efficiency without compromising string stability, marking a significant advancement in intelligent transportation systems.

It results that CACC service improves performances in terms of shock wave attenuation [2] vehicle platooning [3], and traffic jam mitigation [4].

My work focuses on making the CAVs "aware" of the presence and/or formation of self-organized traffic jam. In particular, how to model such an awareness and how it affects the control algorithm of my CACC vehicle are the problems. So, the objective is to increase the performances of control algorithms mentioned above for CACC-enabled vehicles introducing such element in the logics and investigates what are the obstacles, in terms of communication delays and computing load, I had to face.

I treat the problem at several levels of detail, each one corresponding to a different way of modelling vehicular traffic. Since I am interested on both the presence/formation of traffic congestion and on CAVs speed control, it is necessary to model the traffic and the control structure at a Mesoscopic level, where I can capture the information at the Cell level (macro) and change the vehicle dynamics, that could be controlled by a car-following model (micro). So, my objective is to

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create an innovative control strategy that could improve the performances of the control algorithms that have to deal with the Issues exposed above leveraging on the congestion awareness, that will tune the control parameters for the strategy at both macro and micro levels.

Reference:

- [1] Michiel M., Piet H.L., “Impact of Intelligent Cruise Control on Motorway Capacity” Transportation Research Record: Journal of the Transportation Research Board, 1999.
- [2] Marco Di Vaio, Giovanni Fiengo, Alberto Petrillo, Alessandro Salvi, Stefania Santini, and Manuela Tufo, “Cooperative Shock Waves Mitigation in Mixed Traffic Flow Environment”, IEEE Transactions on Intelligent Transportation Systems, Vol. 20, No 12, December 2019.
- [3] Anca Maxim, Ovidiu Pauca, Constantin F. Caruntu and Corneliu Lazar “Distributed Model Predictive Control Algorithm with Time-Varying Communication Delays for a CACC Vehicle Platoon”, 24th International Conference on System Theory, Control and Computing (ICSTCC), 2020.
- [4] T. Kim and K. Jerath, “Mitigation of self-organized traffic jams using cooperative adaptive cruise control,” in Proc. Int. Conf. Connected Vehicles Expo (ICCVE), pp. 7–12, Sep. 2016.

4. Research products:

5. Conferences and seminars attended

6. Activity abroad:

7. Activity in partner companies:

8. Tutorship