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

PhD Student: Aniello Mungiello

Cycle: XXXVIII

Training and Research Activities Report

Year: First

Tutor: prof. Stefania Santini

Co-Tutor:

Date: December 12, 2023

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXVIII **Author: Aniello Mungiello**

1. Information:

- **PhD student: Aniello Mungiello**
- **DR number: 996969**
- **Date of birth: 22/08/1998**
- **Master Science degree: Autonomous Vehicle Engineering University: Federico II**
- **Doctoral Cycle: XXXVIII**
- **Scholarship type: *PNRR MOST SPOKE : CCAM e Smart Infra***
- **Tutor: Stefania Santini**
- **Co-tutor:**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Is control a solved problem for aerial robotics research?	Seminar	1	0.2	12/01/2023	Prof. Antonio Franchi	Y
Towards Occlusion-Aware Autonomy using People as Sensors	Seminar	1	0.2	07/02/2023	Prof. Katie Driggs-Campbell	Y
Learning Robot Super Autonomy	Seminar	1	0.2	14/02/2023	Prof. Giuseppe Loianno	Y
Multi-robot Control of Heterogeneous Herds	Seminar	1	0.2	16/02/2023	Prof. Eduardo Montijano	Y
Safe legged locomotion and navigation: robust motion planning and interactive decision-making	Seminar	1	0.2	21/02/2023	Prof. Ye Zhao	Y
Industry 4.0 Fundamentals in Bosch Applications	Seminar	8	2	23-26/01/2023	Eng. Martino Bruni	Y
Using Delay for Control	Seminar	1	0.2	01/03/2023	Prof. Emilia Fridman	Y
Analysis and control of functional brain networks	Seminar	1	0.2	09/03/2023	Prof. Fabio Pasqualetti	Y
One hundred years of wheel shimmy: Why is it still dangerous?	Seminar	1	0.2	15/03/2023	Prof. Gabor Stepan	Y
When quantum systems source gravity: how can we do physics without spacetime?	Seminar	1	0.2	27/04/2023	Prof.Flaminia Giacomini	Y
Distributed Kalman filtering for systems with spatiotemporal dynamics	Seminar	1	0.2	02/05/2023	Dr. Juncal Arbelaiz	Y

Data-driven complex dynamics	Seminar	1	0.2	03/05/2023	Prof. Bala Balachandran	Y
Intelligent Coordination for Sustainable Roadways – If Autonomous Vehicles are the Answer, then What is the Question?	Seminar	1	0.2	09/05/2023	Prof. Cathy Wu	Y
Ricerca e formazione nella società della transizione digitale	Seminar		1	22/09/2023	CINI	Y
Statistical data analysis for science and engineering research	course	12	4	06-08-10-13-15-16/02/2023	Prof. Roberto Pietrantuono	Y
Electronic Scan Antennas for Radar Signal Processing Applications	course	6	2	27-28/02 06/03/2023	Dr. Enzo Carpentieri	Y
The Linear Parameter Varying approach: theory and application	course	12	4	25-29-30/05 01/06/2023	Prof. Olivier SENAME	Y
Academic Entrepreneurship	course	17	4	29-31/05 - 05-15-20-22/06/2023	Prof. Pierluigi Rippa	Y
Percorso per il rafforzamento delle competenze sulla progettazione europea (Modulo 1-3-4)	course	8	1,6	14/09/2023 12-26/10/2023	Dr. Tommaso FOGLIA, Dr. Federico PORCEDDA. Dr. Veronica ROCCO	Y
Learning-based predictive control	PhD schools	22,5	4	26-27-28-29-30/06/2023	Professor Melanie ZEILINGER, Professor Lorenzo FAGIANO, Doctor Lukas HEWING	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**	**3**	**7**	**0**	**10**
Bimonth 2	**6**	**0.8**	**3.2**	**0**	**10**
Bimonth 3	**0**	**0.6**	**9.4**	**0**	**10**
Bimonth 4	**12**	**0**	**3**	**0**	**15**
Bimonth 5	**1.6**	**1**	**7.4**	**0**	**10**
Bimonth 6	**0**	**0**	**10**	**0**	**10**
Total	**19.6**	**5.4**	**40**	**0**	**65**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

3. Research activity:

Vehicle platooning composed of Connected and Automated Vehicles (CAVs) has been extensively studied since it is expected to mitigate traffic congestion while increasing road safety and traffic throughput [1]. A key element of platooning control strategies is the spacing policy. Its choice is not trivial: limited inter-vehicle distance may enhance traffic throughput but compromises safety; on the other hand, the optimization of traffic flow requires spacing policy to be adaptable to the prevailing traffic conditions. The policies employed the most in the technical literature, the Constant Spacing (CS) and the Constant Time Headway/Gap (CTH/CTG) [2], are not flexible enough, especially in rapidly changing speed situations, and they lead to a non-optimal utilization of road in terms of throughput [3]. To overcome these limitations, many nonlinear spacing policies have been proposed, although their usage for platooning applications has received less attention.

In this perspective, one of this year's objectives can be divided into. Firstly, I design a novel nonlinear spacing policy covering the full speed range so to ensure a smooth transition between fixed distance at standstill and the desired time gap at high speeds. Then, in order to follow the desired variable spacing policy while guaranteeing a robust and resilient tracking of a desired speed profile, the CAVs platoon control is recast as a formation control problem. A robust delayed distributed controller is, hence, implemented to ensure that CAVs platoon safely moves in formation.

To enable this platoon behavior, however, it is also essential to address another aspect, V2X communication. Indeed, Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications, implemented via Dedicate Short Range Communication (DSRC) networks, are key features of future Intelligent Transportation Systems (ITS) and they are expected to improve safety, efficiency and reliability of road transportation [4]. Hence, compared with individual driving, a platoon-based vehicular network can be regarded as a Cyber-Physical System (CPS), able to improve traffic throughput and road capacity on the basis of data exchanges and distributed control algorithm [5]. Besides the above merits, it should be pointed out possible compromised data exchanges in connected vehicles networks can lead to packed dropouts, network delays and cyber-attacks, which can adversely affect cooperative control performance, even leading to hazardous traffic situation. The occurrence of such phenomena cannot be neglected in control design phase in order to avoid fatal disaster, especially during high-speed driving. Among different cybersecurity threats, Denial of Service (DoS) attacks are the most powerful weapons of malevolent fiddlers [6]. Under DoS attack, an adversary aims at overwhelming a vehicle by overloading its communication devices so that it cannot exchange information with neighboring vehicles, thus making the service unusable for a chunk of time. Hence, from a control-view-point, the design of secure and resilient control protocols plays a vital role in enhancing the reliability of the vehicular networks subject to DoS attacks and network induced delays.

So another objective of this year is to address both the presence of DoS attacks and communication network delays. With this view, a distributed controller based on sampled data and predictors was proposed to achieve a resilient platoon formation. Most notably, the approach has the potential of compensating large input delays which accounts for communication/computational latencies and paralyzed time intervals due to attack occurrence.

References

[1] Q. Li, Z. Chen, and X. Li, "A review of connected and automated vehicle platoon merging and splitting operations," IEEE Transactions on Intelligent Transportation Systems, 2022
2] C. Wu, Z. Xu, Y. Liu, C. Fu, K. Li, and M. Hu, "Spacing policies for adaptive cruise control: A survey," IEEE Access, vol. 8, pp. 50 149–50 162, 2020.
[3] S. Darbha and K. Rajagopal, "Intelligent cruise control systems and traffic flow stability," Transportation Research Part C: Emerging Technologies, vol. 7, no. 6, pp. 329–352, 1999
[4] S. Xiao, X. Ge, Q.-L. Han, and Y. Zhang, "Secure distributed adaptive platooning control of automated vehicles over vehicular ad-hoc networks under denial-of-service attacks," IEEE Transactions on Cybernetics, vol. 52, no. 11, pp. 12 003–12 015, 202
[5] B. Caiazzo, D. G. Lui, A. Petrillo, and S. Santini, "Distributed double-layer control for coordination of multiplatoons approaching road restriction in the presence of iov communication delays," IEEE Internet of Things Journal, vol. 9, no. 6, pp. 4090–4109, 2021
[6] S. Malik, P. Bandi, and W. Sun, "An experimental study of denial of service attack against platoon of smart vehicles," in 2021 Fourth International Conference on Connected and Autonomous Driving (MetroCAD). IEEE, 2021, pp. 23–30

4. Research products:

[1] B.Caizzo, D. G. Lui, A. Mungiello, A. Petrillo, S. Santini "On the resilience of Autonomous Connected Vehicles Platoon Under DoS Attacks: a predictorbased sampled data control", IEEE Intelligent Transportation Systems Conference (ITSC) Bilbao 26-30/09/2023, To appear.

5. Conferences and seminars attended

IEEE Intelligent Transportation Systems Conference (ITSC) Bilbao 26-30/09/2023 - Presentation of the paper:
"On the resilience of Autonomous Connected Vehicles Platoon Under DoS Attacks: a predictorbased sampled data control"

2023 IEEE ITSS R8 Chapters Meeting in Berlin 30/11 – 1/12/2023 – Presentation of two posters:

- *On the resilience of Autonomous Connected Vehicles Platoon Under DoS Attacks: a predictorbased sampled data control*
- *The full Autonomous Racing Car of UniNa Corse: Design and Validation*

6. Activity abroad:

7. Tutorship