

## **STUDENTS' ANNUAL ACTIVITY REPORT CYCLE XXXIV YEAR 2019/2020**

- Name and Surname            **Stefano FERACO**
- Dottorato in                    **Mechanical Engineering (Ciclo XXXIV – Anno di corso II)**
- Department                    **Department of Mechanical and Aerospace Engineering (DIMEAS)**
- Coordinator                   **Prof. Luca GOGLIO**
- Tutor                            **Prof. Nicola AMATI**
- Macroarea

### **Autonomous and intelligent vehicles: modeling, design and control**

- Short description of research activity (maximum 20 lines)

The rapid evolution of technologies in the automotive field allows the development and realization of transport systems that are increasingly intelligent, safe, connected, and with a higher level of autonomy. Similarly, electric or hybrid propulsion systems are increasingly adopted in the automotive field. Consequently, a great research effort is needed to develop innovative approaches in the control, modeling and design strategies of these vehicles, exploiting capabilities of Artificial Intelligence. Moreover, the future scenario of intelligent and connected mobility is an opportunity for the design of novel control strategies and algorithms for estimating vehicle's parameters, in order to develop safer and more accurate on-board vehicle systems. The design of sensors architecture, computing system and actuators for a sport electric vehicle (Formula Student) is providing a robust test bench for algorithms developed for autonomous driving. Lastly, the research for novel algorithms monitoring the batteries used in the automotive industry is still an interesting scientific topic.

#### **Research goals:**

1. **Autonomous vehicles modeling**
2. **Autonomous vehicles design**
3. **Autonomous vehicles control**
4. **Design of intelligent algorithms for the estimation of vehicle dynamics parameters**
5. **Design of intelligent algorithms for the estimation of the state of charge and state of health for**

#### **Lithium batteries**

- Training activities carried out during the year (courses, seminars, etc.); for each activity specify the nature, duration, and location

**01LCPRV - Experimental modeling: costruzione di modelli da dati sperimentali (33h – hard skills, Politecnico di Torino)**

**01SCSIU – Machine learning for pattern recognition (20h – hard skills, Politecnico di Torino)**

**FSG Formula Driverless Waymo Academy (15h, webinar)**

- Possible participation in further research activities during the year (research projects and agreements)

**Instrumentation and testing of an electric racing vehicle participating in the Formula Student championship for the Driverless category to test the developed algorithms on the race track.**

**Design and implementation of steering and braking actuation systems for an electric racecar participating in the Formula Student championship for the Driverless category.**

**Design and implementation of a monitoring system for the state of charge and health of lithium batteries for the automotive industry.**

**Design of an algorithm to monitor the state of climbing ropes with artificial intelligence.**

**Participation in research activities developed by the Interdisciplinary Laboratory of Mechatronics (LIM) on the analysis and**

- Possible participation in internal activities to support teaching during the year (specify on which courses, named as “subject expert”)

**Suitable for teaching assignments for the following SSDs (tutors and collaborators):**

**ING-IND/14 - PROGETTAZIONE MECCANICA E COSTRUZIONE DI MACCHINE - da A.A. 2020/21 a A.A. 2022/23**

- Stays at other research institutions during the year

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- Collaborations with companies during the year

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- List of accepted papers

1. Bonfitto, A., Feraco, S., Tonoli, A., Amati, N., & Monti, F. (2019). “Estimation Accuracy and Computational Cost Analysis of Artificial Neural Networks for State of Charge Estimation in Lithium Batteries.” *Batteries*, 5(2), 47.

2. Bonfitto, A., Tonoli, A., Feraco, S., Zenerino, E. C., & Galluzzi, R. (2019). “Pattern recognition neural classifier for fall detection in rock climbing.” *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, 1754337119850927.

3. Bonfitto, A., Feraco, S., Tonoli, A., & Amati, N. (2019). “Combined regression and classification artificial neural networks for sideslip angle estimation and road condition identification.” *Vehicle System Dynamics*, 1-22.

4. Bonfitto, A., Ezemobi, E., Amati, N., Feraco, S., Tonoli, A., & Hegde, S. (2019, July). “State of Health Estimation of Lithium Batteries for Automotive Applications with Artificial Neural Networks.” In *2019 AEIT International Conference of Electrical and Electronic Technologies for Automotive (AEIT AUTOMOTIVE)* (pp. 1-5). IEEE.

5. Bonfitto, A., Feraco, S., Amati, N., & Tonoli, A. (2019, August). Virtual Sensing in High-Performance Vehicles With Artificial Intelligence. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. 59216, p. V003T01A005). American Society of Mechanical Engineers.

6. Feraco, S., Bonfitto, A., Amati, N., & Tonoli, A. (2019, August). Combined Lane Keeping and Longitudinal Speed Control for Autonomous Driving. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. 59216, p. V003T01A018). American Society of Mechanical Engineers.

7. Galluzzi, R., Feraco, S., Zenerino, E. C., Tonoli, A., Bonfitto, A., & Hegde, S. (2020). Fatigue monitoring of climbing ropes. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology*, 1754337120905674.

8. Feraco S., Bonfitto, A., Amati, N., Tonoli A. (2020, August). “A Lidar-based Clustering Technique for Obstacles and Lane Boundaries Detection in Assisted and Autonomous Driving”. In *Proceedings of the ASME 2020 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference (IDETC-CIE 2020)*, 22nd International Conference on Advanced Vehicle Technologies (AVT). (accepted for publication)

9. Feraco S., Bonfitto, A., Amati, N., Tonoli A. (2020, August). "Optimal Trajectory Generation Using an Improved Probabilistic Road Map Algorithm for Autonomous Driving". In Proceedings of the ASME 2020 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference (IDETC-CIE 2020), 22nd International Conference on Advanced Vehicle Technologies (AVT). (accepted for publication)

10. Khan I., Feraco, S., Bonfitto, A., Amati N. (2020, August). "A Model Predictive Control Strategy for Lateral and Longitudinal Dynamics in Autonomous Driving". In Proceedings of the ASME 2020 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference (IDETC-CIE 2020), 22nd International Conference on Advanced Vehicle Technologies (AVT). (accepted for publication)

11. Filomeno G., Feraco, S. (2020), "Economic, Technical and Environmental Aspects of Recycling Lithium Batteries: A Literature Review". Global Journal of Researches in Engineering. (accepted for publication)

under peer-review process:

12. Feraco S., Luciani S., Bonfitto, A., Amati, N., Tonoli A. (2020, November). "A local trajectory planning and control method for autonomous vehicles based on the RRT algorithm". 2020 AEIT International Conference of Electrical and Electronic Technologies for Automotive - Track 3 Advanced driver assistance systems and autonomous driving, safety and connectivity. IEEE.

13. Bonfitto A., Feraco S., Rossini M., Carlomagno F. (2020) "Fuzzy Logic Method for the Speed Estimation in All-Wheel Drive Electric Racing Vehicles", Communications - Scientific letters of the University of Zilina.

Torino, 15/09/2020

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Signature of Tutor

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Signature of the Phd student

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The Coordinator