I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Mobility and Autonomous Vehicles

Research themes

The main goal of the Mobility and Autonomous Vehicles curriculum is to train scientists and researchers capable of working in multidisciplinary teams on topics related to state-of-the-art solutions for mobility and intelligent vehicles on land, water or air. Specific areas of research include:

1. Development of control algorithms to allow, starting from sensory data, to plan and control vehicle dynamics, also in relation to the assignment of vehicles to transport service requests.

2. Development of sensors and sensor data processing algorithms for an accurate perception of the vehicle's surrounding environment, both fixed and dynamic.

3. Integration and coordination of human and artificial intelligence to facilitate coexistence both between driverless and human-guided vehicles, and between driverless vehicles and other users in the shared environment.

4. Development of a reference regulatory framework regarding the objectives to be optimized in emergency situations where the possibility of a complete solution without harm to people, animals or things does not eventually exist.

5. Study of how to ensure the safety of the vehicle, of its passengers (if any) and of the people, animals or things around it, in all conditions.

6. Development of technologies for autonomous freight, off-highway, unmanned vehicles for last-mile delivery and for agriculture.

The ideal candidates are students with a Master (or equivalent/higher) STEM (Science, Technology, Engineering, and Mathematics) degree and possibly a specific background in Robotics.

The students will perform their research project at the hosting institution (as described in the research project sheet). Interested applicants are encouraged to contact the tutors and/or the Unit's PI for clarifications before submitting their application.

International applications are encouraged and applicants will receive logistic support with visa issues, relocation, etc.

1. Innovative solutions for electric vehicles and connected, cooperative and automated mobility – Politecnico Bari

Curriculum: Mobility and autonomous vehicles

Hosting Institution: Politecnico di Bari

Department: Ingegneria Elettrica e dell'informazione

Tutor(s): Maria Pia Fanti

Description: the goal of the PhD program is to study, develop and test intelligent and innovative solutions for cooperative, connected and automated mobility (CCAM), based on artificial intelligence, in particular on machine learning and deep reinforcement learning.
The research is part of the vision of the Horizon Europe 2021-2027 framework program which illustrates the research priorities to support sustainable recovery, further accelerating the double green and digital transition. Furthermore, the research intends to support institutional planning also through the experimentation of innovative tools of the different governance models in a comparative key between policy sectors, between European, state and sub-state levels of government and between national cases, which adequately take into account the opportunities offered by new information and communication technologies (ICT). In fact, the research will propose innovative tools and efficient, effective and sustainable solutions in the areas of competence of public administrations as regards the issues of regulation and management of transport, logistics, mobility also with reference to the needs of accessibility and respect for 'environment.

Requirements: applicants must have computer science, automation and automatic control skills.

References:

1. L. Liang, H. Ye, and G. Ye Li, "Toward Intelligent Vehicular Networks: A Machine Learning Framework", IEEE Internet of Things Journal, Vol. 6, No. 1, February 2019.
2. Pompigna, R.Mauro, "Smart roads: A state of the art of highways innovations in the Smart Age", Engineering Science and Technology, an International Journal 25, 2022.
3. M. R. Bachute, J. M. Subhedar, "Autonomous Driving Architectures: Insights of Machine Learning and Deep Learning Algorithms", Machine Learning with Applications 6, 2021.
4. K. Tan , D. Bremner, J. Le Kernec, L. Zhang, M. Imran, "Machine learning in vehicular networking: An overview", Digital Communications and Networks 8, 2022 18–24.

Number of positions available: 1

Main Research Site: Politecnico di Bari, Dept. Ingegneria Elettrica e dell'informazione, via Orabona 4, 70125, Bari, Italy

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Funding Scheme: This doctorate grant is fully funded by the proponent research institution.

2. Perception and control in mobile intelligent robots – Univ Milano-Bicocca

Curriculum: Mobility and autonomous vehicles

Hosting Institution: Università degli Studi di Milano - Bicocca

Department: Informatica, Sistemistica e Comunicazione

Tutor(s): D. G. Sorrenti, D. Ognibene, E. Datteri

Description: the goal of this PhD position is to study, develop and test innovative solutions for intelligent in-road and off-road vehicles, based on artificial intelligence techniques. Intelligent road vehicles can enable a high level of service, even in low-demand conditions, for moving people or goods. Scientific research is quite active in modeling the world around the robot, and in planning of robot actions. In particular, building a model of the world in front of the vehicle as well as an overall model of the robot working space. These problems can be approached by aiming only at a purely geometric model, see e.g., [Fontana et al 2021], or they can be approached by relying on semantic segmentation of sensor data and matching sensor data to pre-existing data about the working space, see e.g., [Ballardini et al 2021], tracking in space and time the different components of the world model, etc. These problems are long standing problems in intelligent robots, see e.g., [Thrun et al 2005], although they are increasingly better handled by exploiting machine learning approaches, see e.g., [Cattaneo et al 2020], [Cattaneo et al 2019]. A more recent problem is the interaction between vehicles and humans, e.g., in order to make the human aware that the vehicle perceived her, an issue particularly significant for road vehicles.

Requirements: applicants are expected to have good knowledge of programming and machine learning techniques, and knowledge about typical problems in robotic perception and control in autonomous mobile robots, e.g., SLAM, Point Cloud Registration, semantic segmentation of images and point clouds, control and planning of mobile robots.

References:

- S. Thrun, W. Burgard, and D. Fox, "Probabilistic Robotics", MIT Press, 2005
- S. Fontana, D. Cattaneo, A. L. Ballardini, M. Vaghi, D. G. Sorrenti, "A benchmark for point clouds registration algorithms", Robotics and Autonomous Systems, 2021
- A. L. Ballardini, S. Fontana, D. Cattaneo, M. Matteucci, D. G. Sorrenti, "Vehicle Localization Using 3D Building Models and Point Cloud Matching", Sensors, 2021
- D. Cattaneo, M. Vaghi, A. L. Ballardini, S. Fontana, D. G. Sorrenti, W. Burgard, "CMRnet: Camera to lidar-map registration" IEEE Intelligent Transportation Systems Conference (ITSC), 2019
- D. Cattaneo, M. Vaghi, S. Fontana, A. L. Ballardini, D. G. Sorrenti, "Global visual localization in LiDAR-maps through shared 2D-3D embedding space", IEEE International Conference on Robotics and Automation (ICRA), 2020

Number of positions available:

1

Main Research Site: Università degli Studi di Milano - Bicocca, Dept. Informatica, Sistemistica e Comunicazione, viale Sarca 336, 20126, Milano, Italy

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Funding Scheme: This doctorate grant is co-funded by the proponent research institutions and by the Italian Ministry of Research, under law D.M. 351/2022 (PNRR).

3. Control and Coordination of Mobile Etherogeneous Robots for Surveillance Operations – LEONARDO-Univ. Genova

Curriculum: Mobility and autonomous vehicles

Hosting Institution
Università di Genova

Department:
Department of Informatics, Bioengineering, Robotics and Systems Engineering, University of Genova.

Tutor(s):
Marco Baglietto, Giorgio Cannata, Giovanni Indiveri, Antonio Sgorbissa

Description:
Leonardo is launching an industrial doctoral scholarship - in collaboration with DIBRIS - to develop patrolling robots for its Genova Headquarters in Torre Fiumara.
Leonardo is a global high-tech player in Aerospace, Defence and Security, protecting institutions, enterprises and citizens, through services and platforms for constantly monitoring and responding to both physical and cyber threats.

Patrolling robots [1] are autonomous mobile robots developed for security purposes. Like any other autonomous systems, they must be capable of exhibiting a high degree of autonomy and intelligence, while performing complex tasks in challenging real-world environments.

This PhD research has the main objective of developing coordination and control strategies for a team of heterogeneous robots. This team will have to move around the Leonardo offices - without direct operator supervision – coordinate their actions [2] in order to efficiently conduct periodic monitoring, and detect anomalies in different scenarios [3] by collecting data through sensors. While patrolling, if a security sensor is triggered, the single robot should be able to change its route moving to the location of the possible alert, and send an alarm to the central security center of Torre Fiumara, in order to ask for a human intervention.
To accelerate the behaviour development of such robots, the candidate will adopt a Digital Twin methodology [4]: in a 3D rendering of the Leonardo spaces, he will be able to train and optimize machine learning models by randomizing a wide variety of domain parameters in the simulation. This will help the ML model to generalize well when it encounters real-world scenarios. Hence, the behaviour policy can be verified in the simulator and lastly deployed on the real robots.
To conduct the research activities, the candidate will use state-of-the-art machine learning and software engineering methodologies, commercial simulation platforms and robots. All the robots mount cameras and 3D Lidars, though other off-the-shelf sensors might be added for improving situational awareness of the environment. A robotic arm could be integrated to the platforms, as well, in order to perform simple manipulation tasks, such as pressing elevator buttons, for autonomous multi-floor navigation.

The candidate will have access to the resources of the Leonardo Cyber and Security Solution Laboratory and the DIBRIS Department of University of Genova.

A period of research abroad in a foreign branch of the Company - ranging from 6 to 12 months - may be explored depending on the candidate availability.

Requirements:
Applicants are expected to have good programming skills (possibly including Python, C/C++), confidence with electronic hardware and be capable to conduct experiments, and a strong attitude to problem solving.

References:
[1] P. P. Kulkarni, S. R. Kutre, S. S. Muchandi, P. Patil and S. Patil, "Unmanned Ground Vehicle for Security and Surveillance," 2020 IEEE International Conference for Innovation in Technology (INOCON), pp. 1-5, 2020
[2] M. Schranz, M. Umlauft, M. Sende and W. Elmenreich, "Swarm Robotic Behaviors and Current Applications", in Frontiers in Robotics and AI, vol. 7, 2020
[3] C. S. Regazzoni, L. Marcenaro, D. Campo and B. Rinner, "Multisensorial Generative and Descriptive Self-Awareness Models for Autonomous Systems," in Proceedings of the IEEE, vol. 108, no. 7, pp. 987-1010, 2020
[4] A. Fuller, Z. Fan, C. Day and C. Barlow, "Digital Twin: Enabling Technologies, Challenges and Open Research," in IEEE Access, vol. 8, pp. 108952-108971, 2020

Company name and link (for industrial projects):

LEONARDO s.p.a., Genova – www.leonardo.com

Number of positions available:

1

Main Research Site
LEONARDO s.p.a., Torre Fiumara, Genova

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