Research theme title: Autonomous navigation systems

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Curriculum of DAUSY: C1 AS for Automation

Hosting University/Research Centre

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Brief Description:

The term autonomous navigation systems refers to systems that navigate with or without human intervention. Examples are Autonomous Vehicles (AVs), Unmanned Aerial Vehicles (UAVs or drones), Unmanned Combat Aerial Vehicles (UCAVs), Micro Aerial Vehicles (MAVs), and Unmanned Underwater Vehicles (UUVs).

To achieve complete autonomy, autonomous vehicles must be able to sense and react to their surroundings. Therefore, they must be equipped with a variety of sensors such as LIDARs, mmWave radar sensors, video cameras, event based cameras to be able to first observe and reconstruct the environment and then move and interact with the environment in autonomous decision-making using sophisticated algorithms and control systems.

Autonomous navigation systems can operate individually or in formation (fleets, swarms). The use of a swarm introduces needs for: intra-swarm and extra-swarm communication, formation control, data aggregation, collision avoidance also intra-swarm and extra-swarm.

Research fields involved in the development of such systems are: Automation using for example reinforcement learning control techniques, model predictive control, cooperative control; Localization with Simultaneous Localization and Mapping (SLAM) techniques, Aerial and Underwater Telecommunication, Artificial Intelligence, Mathematical Modelling, Sensors developments.

Fields of application:

Concerning UAVs: Security, Monitoring, and Surveillance, Disaster Management, Remote Sensing, Search and Rescue (SAR), Construction and Infrastructure Inspection, Precision Agriculture, Real-Time Monitoring of Road Traffic, UAVs for Inspection of Overhead Power Lines

Concerning AVs: Smart Mobility, Warehouse management.

Concerning UUVs: remote sensing, inspection of undersea infrastructure (Gas Pipelines, Undersea Telecommunication Cables, bridge foundations).

Open research issues:

Many research problems remain open in this area. From a methodological point of view, the control techniques based on Reinforcement Learning are of considerable interest but are not currently widely used in the industrial field as it is difficult to guarantee that the trained agents follow a safe behavior. For this purpose it is possible to consider more advanced approaches that consider directly safety in the training phase. In the field of communication, necessary in the case of robot swarm control, research

problems range from the design of ultra-low delay communication protocols to real-time transmission systems of video content (e.g. video acquired by cameras on board UAVs or UGV).

Specific Information:

Applicants must hold a master's degree, preferably in Automation Engineering or related fields. The applicants should have a solid background in the relevant areas of interest such as automatic control, and robotics. Candidates with a background on Reinforcement Learning are welcome. Knowledge about tools such as the Robot Operating System and Keras, Tensorflow, Pytorch are considered as a plus. The candidate is expected to be proficient in written and spoken English.

Type of scholarship:

DM 118/2023 – Project on PNRR (Italy's Recovery and Resilience Plan)

Study and research period outside the Hosting Institution:

Institution to be defined, minimum 6 months.

References

[1] Siegwart, Roland, Illah Reza Nourbakhsh, and Davide Scaramuzza. Introduction to autonomous mobile robots. MIT press, 2011.

[2] Garcıa, Javier, and Fernando Fernández. "A comprehensive survey on safe reinforcement learning." Journal of Machine Learning Research 16.1 (2015): 1437-1480.

[3] Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2018.

[4] Choset, Howie, et al. Principles of robot motion: theory, algorithms, and implementations. MIT press, 2005.