I-RIM

PhD Course in ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Agrifood (CODE 11657)

Research Themes

Robotics plays a fundamental role in contributing to agriculture that is resilient to climate change and capable of meeting the growing demand.

The curriculum aims to achieve scientific and technological advancements in the following areas:

1. **Automation and integration of human and artificial intelligence** with mechanical capabilities to reduce fatigue and health issues related to labor and interaction with chemicals, while addressing the labor shortage in the agri-food sector.
2. **Intuitive and natural interfaces** that allow farmers, workers, and vendors to operate robots without advanced training.
3. **Precision agriculture** to provide sufficient agricultural goods for the growing population through clean, climate-neutral, sustainable, and responsible techniques.
4. **Greater stability and safety of robots** in their physical interaction with humans and the environment, in the production and sale of agri-food products.
5. **Robotic systems capable of manipulation and locomotion** in air, water, and on different types of terrain for the cultivation, harvesting, and transport of agri-food products.
6. **Energy autonomy, communication robustness, and eco-sustainable production**, through new forms of energy harvested from the environment and new materials.

The research theme offered by CNR STIIMA will be awarded to the top applicants selected for this theme.

Ideal candidates are students with a Master's degree (or equivalent/higher qualification) in a STEM field. Please consult the individual requirements for each research theme.

Students will conduct their research project at the hosting institution (as described in the research project sheet). Interested students are encouraged to contact the tutors and/or the Unit's Principal Investigators for further information prior to submitting their application.

International applications are welcome, and participants will receive logistical support for visa issues, relocation, and related matters.

1. Harnessing robotics and AI for in-field crop monitoring and assessment – CNR STIIMA

Curriculum:

Agrifood

Hosting Institution:

Sistemi e Tecnologie Industriali Intelligenti per il Manifatturiero Avanzato (STIIMA), Consiglio Nazionale delle Ricerche (CNR)

Department:

Dipartimento di Ingegneria, ICT e Tecnologie per l'Energia e i Trasporti

Tutor(s):

Dr. Annalisa Milella, PhD

Description:

Autonomous robotic vehicles are becoming increasingly important in agriculture, contributing to sustainable food production, labor efficiency, and environmental monitoring. However, agricultural environments present unique challenges: they are highly unstructured, dynamic, and variable in terms of terrain, vegetation, lighting, and weather conditions. To ensure safe and efficient operation, agricultural robots must perceive, interpret, and adapt to their surroundings with minimal human supervision.

This PhD project aims to develop a multi-sensor and AI-based perception framework for autonomous ground vehicles operating in outdoor agricultural environments. The research will focus on integrating heterogeneous sensing modalities with advanced artificial intelligence algorithms to enable robust environmental understanding. A modular, flexible on-board sensor system will be designed and implemented, combining both exteroceptive and proprioceptive sensing technologies. These may include: LIDAR for 3D mapping and obstacle detection; RGB and NIR cameras for crop and soil characterization; stereo vision for terrain profiling; encoders, accelerometers, and torque sensors to capture soil–wheel interactions and infer local mechanical soil properties.

The collected data will be processed using machine/deep learning methods to achieve three main research goals:

- Multimodal 3D Mapping: fusion of heterogeneous sensor data to generate detailed representations of the agricultural environment that include geometric, visual, and mechanical features.
- Semantic Scene Segmentation: real-time classification of the environment into relevant categories (e.g., traversable terrain, crop rows, obstacles, humans, animals) using AI-based edge computing.
- Crop characterization and assessment: in-field characterization of plants and fruits in high-value crops for early detection of potential growth defects, diseases, and pest infestations, estimation of crop yield, and identification of possible anomalies in production.

Experimental activities will involve the collection of real-world datasets in agricultural settings and the use of robotic simulation platforms such as ROS–Gazebo for algorithm development and validation.

The expected outcome is a robust perception framework that improves the autonomy, safety, and efficiency of agricultural robots. This research will contribute to the advancement of intelligent and sustainable agricultural automation, bridging robotics, artificial intelligence, and environmental sensing.

Requirements:

The ideal candidate would have a Master Degree in Computer Science, Engineering or related disciplines, with a background in Mobile Robotics, Computer Vision and/or Machine Learning. Applicants are expected to be highly motivated to work on robotic and sensing platforms with good computer programming skills.

References:

1. E. Anastasiou et al., Applications of robotics and extended reality in agriculture: A review, Smart Agricultural Technology, Volume 12, 2025, 101521, ISSN 2772-3755,

https://doi.org/10.1016/j.atech.2025.101521

2. A. Milella et al., In-field high throughput grapevine phenotyping with a consumer-grade depth camera, Computers and Electronics in Agriculture, Volume 156, 2019, Pages 293-306, ISSN 0168-1699, https://doi.org/10.1016/j.compag.2018.11.026

3. G. Reina et al., Ambient awareness for agricultural robotic vehicles, Biosystems Engineering, Volume 146, 2016, Pages 114-132, ISSN 1537-5110, https://doi.org/10.1016/j.biosystemseng.2015.12.010

Main Research Site

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Scholarship Amount:

- Fascia 1: 16,500 €/year