I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Agrifood

Research themes

1. AI FOR MARITIME SENSING, PERCEPTION, AND DECISION SUPPORT – UNIVERSITY OF PISA..... 3
2. MISSION PLANNING AND AI-ENHANCED AUTONOMY FOR UNDERWATER APPLICATIONS – FINCANTIERI S.P.A.... 5

Automation, together with robotics and artificial intelligence, is a key enabling technology for the digital and sustainable transition. It enables the development of autonomous systems capable of operating without direct human intervention, through the acquisition of environmental information, data processing and interpretation, action planning, and performance optimization, while ensuring reliability and safety.

The "Autonomous Systems" curriculum aims to train PhD graduates with advanced expertise in the design, management, and development of autonomous systems to improve efficiency, safety, and sustainability across various application sectors, including industry, mobility, logistics, agriculture, energy, biomedicine, and the environment.

The program adopts an integrated and multidisciplinary approach, offering methodological and technological pathways organized into three distinct yet complementary areas:

- Automation: Particularly relevant for sectors such as automation, logistics, agriculture, and transportation, this area focuses on the design of next-generation industrial systems. Topics covered include the control and supervision of complex systems composed of networks of sensors, actuators, and collaborative robots. The approach incorporates advanced modeling methodologies, optimization techniques, and simulation based on digital twins, alongside modern mathematical tools. Special attention is devoted to sustainable and green automation.
- Smart Environment: Dedicated to intelligent environments and cyber-physical systems, with applications in smart cities, autonomous vehicles and mobile robots, smart grids, sustainable mobility, smart buildings, and smart homes. The focus is on advanced control problems using consensus algorithms, predictive control, distributed identification, and networked control. Key areas include distributed optimization and the integration of technologies for the intelligent and sustainable management of spaces and resources.
- Monitoring and Security: Focused on the design and management of autonomous systems to ensure reliability, resilience, and security, even under uncertain conditions. Topics include fault monitoring and prediction, privacy protection, resilience against physical and cyber-attacks, and the design of safe processes in environments where humans and automated systems coexist. Security is considered a cross-cutting and

priority issue across multiple domains, including environmental, cyber, clinical-healthcare, network, and public administration sectors.

The research theme offered 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. AI for Maritime Sensing, Perception, and Decision Support – University of Pisa

Curriculum: Autonomous Systems	
Hosting Institution: University of Pisa	
Department: Department of Information Engineering	
Tutor(s): Andrea Munafo and Andrea Caiti	

Description:

The proposed research lies in the area of artificial intelligence for maritime sensing, perception, and data-driven decision support, with particular focus on the analysis of heterogeneous data, the interpretation of acoustic events, and the deployment of AI methods under operational and computational constraints.

The overall objective is to develop methods and models capable of extracting meaningful information from incomplete, indirect, or complex data in order to improve situational understanding, monitoring, and intelligent support for maritime applications. Within this framework, one research direction concerns the detection of anomalies in the motion behaviour of objects from partial observations or bearing-only data, including the possible use of publicly available AIS data to generate representative scenarios. A second direction concerns the application of advanced AI models, including foundation models, to sonar spectrograms for the detection and classification of acoustic events of interest (e.g., marine mammals).

A further line of research addresses low-power and computationally efficient AI approaches, suitable for embedded systems or sensor platforms with limited processing capabilities. This part of the work will investigate what level of performance can realistically be achieved under strict hardware, energy, and complexity constraints, and will explore the trade-offs between accuracy, robustness, latency, and deployability. It may also include system-level considerations, combining algorithm design with awareness of hardware and implementation requirements.

From a methodological perspective, the research may involve modelling, simulation, data analysis, algorithm development, and experimental validation. Comparisons may be carried out between data-driven approaches, compact models for edge AI, and more computationally demanding models used as references. Particular attention will be given to robustness under uncertainty, limited observability, transferability from simulated to real-world data, and the practical feasibility of the proposed solutions.

Overall, the project aims to contribute to the development of intelligent tools for maritime perception, acoustic monitoring, and data-informed decision support, with potential applications in environmental monitoring, vessel traffic analysis, and autonomous marine systems.

Requirements:

The ideal candidate would have a degree in Robotics Engineering or Computer Science.

References:

- Goodfellow, I., Bengio, Y., and Courville, A. (2016). Deep Learning. MIT Press.
- Gianluca Antonelli, Alessia Biondi, Andrea Caiti, Stefano Chiaverini, Riccardo Costanzi, Paolo Di Lillo, Alessandro Gentili, Andrea Munafò, Towards a multi-robot architecture for bearing-only tracking of underwater acoustic sources using vector sensors, Ocean Engineering, Volume 353, Part 2, 2026

Number of positions available: 1

Main Research Site

Department of Information Engineering, University of Pisa

Contacts:

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Funding Scheme:

This doctorate grant is funded by University of Pisa with financial support by ATLAS Elektronik

Scholarship Amount:

- Fascia 4: 19,500 €/year

2. Mission planning and ai-enhanced autonomy for underwater applications – Fincantieri S.p.A.

Curriculum: Autonomous Systems	FINCANTIERI UNIVERSITÀ DI PISA Università di Genova
Hosting Institution: University of Pisa	
Department: Department of Information Engineering (DII), University of Pisa	
Tutor(s): Prof. Andrea Munafò (University of Pisa) Scientific referents of the agreement: Prof. Giovanni Indiveri (University of Genoa – ISME); Mirko Stifani (Fincantieri S.p.A.)	

Description:

The research line concerns the development of artificial intelligence, optimisation and adaptive autonomy methods for the planning and conduct of missions with marine autonomous systems, with particular attention to underwater scenarios.

The goal of the PhD is to define an integrated framework supporting the planning, configuration and execution of missions in complex and variable scenarios. The framework shall assist the operator in defining the mission and, during execution, enable the autonomous systems to adapt their behaviour to the evolution of the scenario, to operational constraints and to mission priorities.

In the planning phase, the research will focus on the selection and combination of the available platforms, on task allocation and on the generation of mission plans compatible with operational constraints. The problem will be modelled taking into account coverage requirements, execution times, energy consumption, platform capabilities, operational risk and communication availability. Predictive models will be developed to estimate the performance, endurance and expected behaviour of the platforms in different scenarios. These models will be used within optimisation procedures to support task allocation, routing and the assessment of the main mission trade-offs.

In the execution phase, the research will address the development of adaptive task management and dynamic re-tasking logics. Platforms shall be able to update their contribution to the mission in the presence of unexpected events, environmental changes, loss or degradation of assets, energy constraints or changes in operational priorities. Multi-agent coordination strategies will be evaluated, with particular attention to scenarios in which communications are intermittent or limited, as is often the case in the underwater environment.

A key element of the research will be the development of reusable models, algorithms and software components that can be integrated into simulation environments, autonomous platforms and mission support systems. The expected result is a modular framework for the planning and adaptive reconfiguration of underwater missions, validated in simulation and progressively prepared for integration with representative platforms and systems.

The reference system for the activities will be DEEP (Dynamic Ecosystem for Enhanced Performance), a system for the monitoring and protection of critical underwater infrastructures and environments, orchestrated by the Underwater Management System (UMS) Toolbox. The activities will be carried out consistently with the progressive increase of the technology readiness level and with a possible integration into product systems.

Research plan

Year 1

- Definition of the operational use cases and of the main mission parameters.
- Problem modelling, with identification of the relevant constraints, objectives and variables.
- Development of the first predictive models, with particular reference to platform performance, consumption and behaviour.
- Development of the first optimisation models for task allocation and routing.
- Set-up of an integrated simulation environment supporting development and validation activities.

Year 2

- First prototype of an AI-based mission planning tool, integrating the predictive models and optimisation procedures developed in the first year, aimed at supporting mission configuration, platform selection and the generation of initial plans.
- Integration with simulation environments and with the Underwater Management System / UMS Toolbox. The research will be extended to the mission execution phase, with the development of adaptive task management and dynamic re-tasking logics. Multi-agent coordination mechanisms will also be studied, addressing communication constraints, unexpected events and degraded operating conditions.
- Progressive organisation of models and software libraries into reusable components, to ease their integration into mission support systems.

Year 3

- Validation in realistic and complex scenarios, including, where possible, integration with real platforms or representative operational environments; the validation will address mission plan quality, reconfiguration capability, robustness and scalability.
- Consolidation of the model library and of the developed methodology.
- Systematisation of the methodology, technical documentation and preparation of the framework for subsequent technology transfer and integration into operational or prototype systems.

Requirements:

The ideal candidate would have a Master's degree in Robotics, Automation Engineering, Computer Engineering, Computer Science, Artificial Intelligence, Electronic or Telecommunication Engineering, Applied Mathematics, or a closely related discipline. Familiarity with optimisation, machine learning, multi-agent systems and programming (Python and/or C++) is appreciated; experience with robotic middleware (e.g., ROS) and simulation environments is a plus.

References:

- G. Ferri, A. Munafò, K. D. LePage, “An Autonomous Underwater Vehicle Data-Driven Control Strategy for Target Tracking,” in IEEE Journal of Oceanic Engineering, vol. 43, no. 2, pp. 323–343, 2018.
- G. Ferri, A. Munafò, A. Tesei, P. Braca, F. Meyer, K. Pelekanakis, R. Petroccia, et al., “Cooperative Robotic Networks for Underwater Surveillance: an Overview,” in IET Radar, Sonar & Navigation, vol. 11, no. 12, pp. 1740–1761, 2017.
- A. Hamilton, S. Holdcroft, D. Fenucci, P. Mitchell, N. Morozs, A. Munafò, et al., “Adaptable Underwater Networks: The Relation between Autonomy and Communications,” in Remote Sensing, vol. 12, no. 20, 3290, 2020.

Company name and link (for industrial projects):

Fincantieri S.p.A., Trieste – https://www.fincantieri.com

Number of positions available: 1

Main Research Site

The research activities will be carried out at:

- University of Pisa – Department of Information Engineering (DII), Pisa (hosting institution);
- University of Genoa – ISME (Interuniversity Research Center on Integrated Systems for the Marine Environment), c/o DIBRIS, Genoa – administrative seat of the PhD programme;
- Fincantieri S.p.A. – company sites, according to the research programme agreed between the scientific referents.

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Scholarship Amount:

- Fascia 4: 19,500 €/year