I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Hostile and Unstructured Environments (CODE 11660)

Research Themes

The main goal of the curriculum “Robotics and Intelligent Machines for Hostile and Unstructured Environments” is to address challenges related to the study and development of enabling technologies and complex systems that will allow robots and intelligent machines to operate in environments that are dynamic, partially or completely unknown, difficult to predict, and potentially very challenging.

The general objective of the curriculum is to train scientists and research technologists capable of working in multidisciplinary teams on projects where interaction with a complex environment plays a crucial role in technological development and design.

The research theme offered by the Italian Institute of Artificial Intelligence for Industry (AI4), the University of Trento, Fincantieri SpA, the Italian Institute of Technology (IIT), and the University of Genoa will be awarded to the top applicants selected for this theme.

Ideal candidates are students with a strong background in robotics and intelligent machines, from various perspectives. 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. Riemannian geometry in reinforcement learning – AI4I

Curriculum:

Hostile and hazardous environments

Hosting Institution:

AI4I – The Italian Institute of Artificial Intelligence for Industry

Department:

PHI Lab

Tutor(s):

Dr. Leonel Rozo

Description:

Reinforcement learning (RL) methods have been applied in a broad range of applications domains, and represent one of the most successful learning paradigms for fine-tuning modern foundational models. However, most of RL methods work under the assumption that the states, actions and policy belong to Euclidean spaces. This PhD thesis is aimed at exploring how non-Euclidean geometries can be leveraged into the representation of states and actions in RL algorithms, and how such geometries impact the policy learning formulation. The first objective is to relax the Euclidean assumption on the formulation of a general RL problem via a Riemannian perspective. Later, the thesis will explore how methods like policy gradient need to be reformulated accordingly, and which advantages and challenges this new perspective brings in. Moreover, from a top-down approach, the next objective will be to leverage the Riemannian geometry of the Wasserstein space to understand, analyze and formulation policy learning methods based on Riemannian gradient flows and Wasserstein metrics. The thesis will explore applications of the developed methods in the control of physical systems such as robots or quadrotors, as well as the fine-tuning of foundational models, among others.

Requirements:

Must have skills:

- Excellent Master's degree in computer science, physics, mathematics, electrical or mechatronics engineering, or a related field
- Strong background in machine learning and robotics
- Good programming skills in Python
- Fluent in spoken and written English
- A team player, but also can work autonomously
- Experience with scientific writing

Good to have skills:

- Background on (applied) differential geometry
- Publication of peer-reviewed research papers

References:

1. N. Jaquier, et al., "Geometry-aware Bayesian Optimization in Robotics using Riemannian Matern Kernels". CoRL, 2021.

2. H. Ziesche and L. Rozo, “Wasserstein Gradient Flows for Optimizing Gaussian Mixture Policies”, NeurIPS, 2023.
3. G. Tennenholtz and S. Mannor, “Uncertainty Estimation Using Riemannian Model Dynamics for Offline Reinforcement Learning”, NeurIPS, 2022.

Number of positions available:

1

Main Research Site:

AI4I - The Italian Institute of Artificial Intelligence for Industry., Corso Castelfidardo 22, 10129 Torino

Contacts:

Email: leonel.rozo@ai4i.it

Funding Scheme:

This doctorate grant is fully funded by the Italian Institute of Artificial Intelligence for Industry.

Scholarship Amount:

Fascia 4: 19,500 €/year

2. Geometry and physics-based inductive bias for robust and explainable foundational models– AI4I

Curriculum:

Hostile and hazardous environments

Hosting Institution:

AI4I – The Italian Institute of Artificial Intelligence for Industry

Department:

PHI Lab

Tutor(s):

Dr. Leonel Rozo

Description:

Recent research highlights the promising potential of geometry-aware and physics-informed attention mechanisms, as well as the power of differential

geometry in the analysis and refinement of foundational models. In this PhD thesis, we will study the properties of Riemannian embeddings in large multimodal models, and the role of different curvatures for accommodating and associating inter-connected tokens. We will design geometry-, physics- and control-based attention mechanisms to capture complex

underlying perception-action interactions. These advancements may help develop new models that leverage physics-aware and curved spaces to better abstract and disentangle the information coming from multimodal perception systems in foundational models. The developed methods will be applied to general foundational models, vision-action large models for robotics, among others.

Requirements:

Must have skills:

- Excellent Master's degree in computer science, physics, mathematics, electrical or mechatronics engineering, or a related field
- Strong background in machine learning and robotics
- Good programming skills in Python
- Fluent in spoken and written English
- A team player, but also can work autonomously
- Experience with scientific writing

Good to have skills:

- Background on (applied) differential geometry
- Publication of peer-reviewed research papers

References:

1. A. Testa et al. "Geometric Contact Flows: Contactomorphisms for Dynamics and Control", ICML, 2025.

2. N. He, et al. “Beyond Euclidean: Foundation Models Should Embrace Non-Euclidean Geometries”, WWW, 2025.

3. H. Ding et al. “Fast and Robust Visuomotor Riemannian Flow Matching Policy”, Transactions on Robotics, 2025.

Number of positions available:

1

Main Research Site:

AI4I - The Italian Institute of Artificial Intelligence for Industry., Corso Castelfidardo 22, 10129 Torino

Contacts:

Email: leonel.rozo@ai4i.it

Funding Scheme:

This doctorate grant is fully funded by the Italian Institute of Artificial Intelligence for Industry.

Scholarship Amount:

Fascia 4: 19,500 €/year

3. Electrostatic zipping transducers for underwater operation - UNITN
Institution – University of Trento

Curriculum:

Hostile and hazardous environments

Hosting Institution:

University of Trento

Department:

Department of Industrial Engineering

Tutor:

Prof. Giacomo Moretti

Description:

While mechatronic systems are becoming increasingly pervasive, there are environments— such as outer space or the deep ocean— that remain difficult to access and exploit with conventional technologies. A major bottleneck lies in actuation and energy-generation technologies, which often struggle in unconventional conditions.

This PhD project aims to advance a new class of high-performance electrostatic polymer-based machines, known as zipping transducers, and adapt them for operation in unconventional applications. The focus will be on developing zipping transducers capable of functioning underwater, either as actuators for robotic systems or as generators for ocean wave energy harvesting.

The successful candidate will explore new concepts of zipping transducers, develop models and control algorithms to assess their performance, and design and carry out experimental validation campaigns in laboratory environments.

The position is funded in the framework of ERC StG project flEAP - Fluid gap Electro-Active-Polymer machines for a new generation of mechatronic systems.

Requirements:

The ideal candidate must hold:

- A Master's degree in Mechatronics/Mechanical/Systems Engineering or similar
- A solid background in one of the following areas: modelling, mechanics, electronics, systems engineering, engineering design.
- A track record of project works
- Strong interest towards problem solving and experimental activity
- Fluency in English (written and spoken)

Other preferred requirements include:

- Experience with experimental activity, mechanical design, and/or data processing
- Knowledge of robotics, electronics, control theory, electrostatics, or electromechanical drives.
- Experience with modelling and simulation

References:

1. Rothemund, P., Kellaris, N., Mitchell, S. K., Acome, E., & Keplinger, C. (2021). HASEL artificial muscles for a new generation of lifelike robots—recent progress and future opportunities. Advanced materials, 33(19), 2003375.

2. Sîrbu, I. D., Moretti, G., Bortolotti, G., Bolignari, M., Dirè, S., Fambri, L., ... & Fontana, M. (2021). Electrostatic bellow muscle actuators and energy harvesters that stack up. Science Robotics, 6(51), eaaz5796.

3. Duranti, M., Righi, M., Vertechy, R., & Fontana, M. (2017). A new class of variable capacitance generators based on the dielectric fluid transducer. Smart Materials and Structures, 26(11), 115014.

Number of positions available:

1

Main Research Site

Department of Industrial Engineering, University of Trento, Trento.

Contacts:

Email: giacomo.moretti@unitn.it

Funding Scheme:

This doctorate grant is funded by ERC Fluid gap Electro-Active-Polymer machines for a new generation of mechatronic systems - flEAP, CUP: E63C24001590006, Grant number: 101163668

Scholarship Amount:

Fascia 4: 18,500 €/year

4. Autonomous navigation and distributed perception for robotics in complex shipyard environments – Fincantieri S.p.A., Università di Genova

Curriculum:

Hostile and hazardous environments

Hosting Institution:

Fincantieri S.p.A.

University of Genoa (Università degli Studi di Genova)

Department:

Fincantieri SpA – Digital Lab Robotica

Department of Informatics, Bioengineering, Robotics, and Systems Engineering

Tutor(s):

Dr. Carlo Dentesano and Dr. Emma Romagnoli, Fincantieri SpA

Prof. Fulvio Mastrogiovanni and Prof. Giorgio Cannata, University of Genova

Description:

As part of the "Smart Shipyard" initiative, Fincantieri SpA is advancing a new generation of digital technologies for shipbuilding. The initiative aims to enhance communication, streamline logistics, support construction and maintenance processes, and deploy advanced robot solutions across Fincantieri's facilities.

Within this strategic framework, Fincantieri and the University of Genoa are opening a fully funded PhD position focused on the design, development and integration of advanced technologies for autonomous navigation and environmental perception in AI-powered robots operating in shipyard environments, that is, spaces that are narrow, dynamic, cluttered, and geometrically irregular, for example including stairs, beams, scaffolding, carpentry materials.

The research could address wheeled or legged platforms (rovers, quadrupeds, humanoids), with the goal of enabling robust navigation via novel forms of sensing, distributed perception, and multi-modal Simultaneous Localization and Mapping (SLAM). A key focus will be the integration of emerging technologies such as robot skin, thus enabling robots to perceive contact, proximity, and environmental irregularities with unprecedented level of detail.

In particular, the main objectives are as follows:

1. Design and develop robust SLAM algorithms tailored to narrow, unstructured, and complex shipyard environments.
2. Design, integrate, and evaluate innovative sensors, including distributed tactile and proximity robot skin systems.
3. Assess the performance, cost, and energy efficiency of robot-skin based perception compared to conventional sensors.
4. Integrate distributed tactile/proximity data with SLAM pipelines to improve autonomous movement and safety, particularly in human–robot shared spaces.

5. Demonstrate the developed technologies on real-world use cases.

The PhD student will be engaged in the following activities:

Year 1. (i) State-of-the-art analysis on SLAM in complex, cluttered, and constrained environments. (ii) Study and selection of innovative sensing technologies. (iii) Definition of application scenarios and use cases. (iv) Development of a simulation environment integrating novel sensors for preliminary testing.

Year 2. (i) Development and testing of integrated SLAM algorithms exploiting robot-skin data. (ii) Integration and evaluation of distributed perception techniques. (iii) Simulation and early prototyping in realistic shipyard-like conditions.

Year 3. (i) Validation of the developed technologies on real use cases within Fincantieri facilities. (ii) Comparative assessment against commercial perception solutions. (iii) Energy optimization and cost–benefit analysis for industrial deployment.

Requirements:

Candidates should have a degree in Robotics Engineering, Computer Engineering, or related study programs. Applicants are expected to be proficient in software design and development (software architectures for robots, C/C++, Python), artificial intelligence techniques for robots, sensing, motion planning and execution, and SLAM. The ideal candidate is proficient in computer vision, tactile sensing, and robot motion control.

References:

1. A. Thomas, F. Mastrogiovanni, M. Baglietto. Locally optimal solutions to constraint displacement problems via path-obstacle overlaps. Robotics and Autonomous Systems, *to appear*, 2025.

2. H. Karami, A. Thomas, F. Mastrogiovanni. A task and motion planning framework using iteratively deepened AND/OR graph networks. Robotics and Autonomous Systems 189, 104943, 2025.

3. A. Ilachinski. Cellular Automata: A discrete universe. World Scientific, 2001.

Company name and link (for industrial projects):

Fincantieri SpA – Digital Lab Robotica

Web: https://www.fincantieri.com/en/

Number of positions available:

1

Main Research Site

Fincantieri SpA – Digital Lab Robotica, Via Maestri del Lavoro, 8 - 34123 Trieste

TheEngineRoom Lab, Department of Informatics, Bioengineering, Robotics, and Systems Engineering, University of Genoa.

MacLab, Department of Informatics, Bioengineering, Robotics, and Systems Engineering, University of Genoa.

Contacts:

Email: Emma.Romagnoli@fincantieri.it, Carlo.Dentesano@fincantieri.it, fulvio.mastrogiovanni@unige.it, giorgio.cannata@unige.it
Funding Scheme: This doctorate grant is funded by Fincantieri S.p.A. (Project IPCEI CIS PNRR "Important Project of Common European Interest on Cloud Infrastructure and Services" cofinanced by the European Union – NextGenerationEU and by the Italian Ministry of Enterprises and Made in Italy (MIMIT), Concession Decree No. 1566, CUP: B99J24001080005)
Scholarship Amount: Fascia 4: 19,500 €/year

5. Neuromorphic active exploration - IIT

Curriculum:

Hostile and unstructured environments

Hosting Institution:

Fondazione Istituto Italiano di Tecnologia

Department:

Event-Driven Perception for Robotics

Tutor(s):

Dr. Chiara Bartolozzi, Dr. Arren Glover

Description:

Neuromorphic computing is a key enabling technology for developing artificial agents that solve the same problems that animals solve, hence is promising for robots to act swiftly, robustly and efficiently in uncontrolled environment in a wide range of conditions and tasks. This potential can be fully developed when neuromorphic computing is embodied, through close-loop interaction of the robot with the environment. In this PhD project, we will develop end-to-end neuromorphic robots (from perception to decision making, to control) that exploit embodiment to endow them with the ability to continuously infer, predict and adapt to the state of the environment, of humans, and of the robotic platform itself and plan and execute appropriate actions.

We will focus on developing spiking neural networks on neuromorphic platforms for active sensing, starting from tactile exploration.

Requirements:

The ideal candidate would have a degree in physics, engineering, computer science, or related fields. Applicants are expected to enjoy coding, develop demos on robots and fruitfully collaborate with their peers. Background knowledge on computer vision, SNNs, computational neuroscience will make you shine.

References:

1. Bartolozzi, C., Indiveri, G., & Donati, E. (2022). Embodied neuromorphic intelligence. *Nature communications*, *13*(1), 1024.

2. N'dri, A. W., Gebhardt, W., Teulière, C., Zeldenrust, F., Rao, R. P., Triesch, J., & Ororbia, A. (2024). Predictive Coding with Spiking Neural Networks: a Survey. *arXiv preprint arXiv:2409.05386*.

3. Schürmann, L., D'Angelo, G., Grayver, L., Bartolozzi, C., & Indiveri, G. (2025). A neuromorphic electronic artist for robotic painting. *Scientific Reports*, *15*(1), 19561.

Number of positions available:

1

Main Research Site

Event-Driven perception for Robotics – IIT https://edpr.iit.it
Contacts: Email: chiara.bartolozzi@iit.it
Funding Scheme: This doctorate grant is funded by the Istituto Italiano di Tecnologia
Scholarship Amount: Fascia 4: 19,500 €/year

6. Learning Adaptive Robotic Behavior for Manipulation in Unstructured Environments – IIT

Curriculum:

Hostile and unstructured environments

Hosting Institution:

Istituto Italiano di Tecnologia

Department:

Humanoid Sensing and Perception (https://hsp.iit.it)

Tutor(s):

Dr. Lorenzo Natale

Description:

The deployment of robots in unstructured environments remains a central challenge in robotics and artificial intelligence. Recent advances — particularly the emergence of foundation models (LLMs and VLMs) – have enabled promising forms of robot programming through natural language and task planning. However, their utility is mostly limited to high-level instruction following, and an open problem remains how to ground pre-trained model to the robot action space. Imitation Learning (IL) and Reinforcement Learning (RL), on the other hand, have been widely used to train robots for complex tasks, yet they come with significant limitations: IL relies on human teleoperation and is labor-intensive, while RL demands extensive simulation and computational resources. Both approaches scale poorly and struggle to support autonomous adaptation in real-world deployment. While most existing approaches rely primarily on visual perception, the contribution of tactile sensing remains comparatively underexplored.

This PhD project aims to investigate learning frameworks that overcome these limitations and enable scalable, adaptive behavior in humanoid robots with a focus on generalization and physical interaction.

The following research directions may be pursued depending on the candidate's interest and background:

- Tactile and visuo-tactile integration for solving contact-rich manipulation tasks with IL or RL;
- Blending IL and RL techniques to enable robust policy transfer across embodiments and environments;
- Task learning and grounding through natural language interaction, including learning and adaptation of foundational multi-modal models.

The goal is to develop methods that enable robots to learn efficiently, adapt autonomously, and generalize across environments, embodiments, and tasks.

Requirements:

The ideal candidate would have a degree in Computer Science, Engineering or related disciplines, with a background in Robotics, Computer Vision and/or Machine Learning. They

would also be highly motivated to work on robotic platforms and have computer programming skills.

References:

1. Ceola, F., Rosasco, L., and Natale, L., *RESPRECT: Speeding-up Multi-fingered Grasping with Residual Reinforcement Learning*, IEEE Robotics & Automation Letters, vol. 9, no. 4, 2024.

2. Puang, E.Y., Ceola, F., Pasquale, G. and Natale, L. PCHands: PCA-based Hand Pose Synergy Representation on Manipulators with N-DoF, Humanoids 2025.

3. Rosasco, A., Ceola, F., Pasquale, G., and Natale, L., KDPE: A Kernel Density Estimation Strategy for Diffusion Policy Trajectory Selection, in Conference on Robot Learning, Seoul, Korea, 2025.

Number of positions available:

1

Main Research Site

Istituto Italiano di Tecnologia, Via Morego, 30 16163 Genova - Italy

Contacts:

Email: Lorenzo.natale@iit.it

Funding Scheme:

This doctorate grant is funded by the Istituto Italiano di Tecnologia

Scholarship Amount:

Fascia 4: 19,500 €/year

7. Mechatronic Design and End-Effector Development for Inspection and Maintenance Mobile Robots - IIT

Curriculum:

Hostile and unstructured environments

Hosting Institution

Istituto Italiano di Tecnologia

Department:

Humanoid and Human Centred Mechatronics Research line (https://hhcm.iit.it/)

Tutor(s):

Dr. Nikos Tsagarakis

Description:

This PhD will focus on advancing the mechatronic design, sensing, and manipulation capabilities of mobile robotic platforms aimed at inspection and maintenance (I&M) of complex energy infrastructures such as power distribution systems, renewable energy facilities, and industrial plants. The objective is to develop modular, high-performance mechatronic subsystems and end-effectors that enable robots to execute versatile, safe, and precise manipulation and inspection tasks in environments that are often unstructured, hazardous, or difficult for humans to access. The research will address the co-design of mechatronics, actuators, and sensing systems to achieve improved dexterity, adaptability, and resilience. Innovative multi-functional end-effectors will be developed to handle operations such as grasping, tool manipulation, valve turning, or surface inspection, supported by integrated force/torque and vision sensing. Emphasis will be placed on compact and efficient actuation, modular design principles, and sensor fusion strategies that enhance perception and control under uncertainty.

Within the framework of a new joint laboratory initiative, the PhD candidate will collaborate with both academic and industrial colleagues to validate the developed technologies on mobile robotic platforms, including wheeled, tracked, or legged systems, performing real-world I&M scenarios. The outcome will be a set of mechatronic and end-effector innovations that extend the functional autonomy, safety, and practical deployment of mobile robots in inspection and maintenance tasks.

Requirements:

We are seeking for highly motivated candidates with a background in Mechanical engineering, Physical Sciences or Robotics. Candidates should have competencies in CAD mechanical design and/or robot dynamics and control. (Mechanical design 50%, Dynamics/Control %50). The applicants should be fluent in English and team players.

References:

1. Rossini et. al,, “CONCERT: a Modular Reconfigurable Robot for Construction”, Journal of Field Robotics (2025).

Number of positions available: 1
Main Research Site Center for Robotics and Intelligent Systems (CRIS), Via Morego, 30 16163 Genova - Italy
Contacts: Email: nikos.tsagarakis@iit.it
Funding Scheme: This doctorate position is funded by the Italian Institute of Technology, this position is funded by the Miranda (CUP F83D24000430001) and Quantum Lab projects.
Scholarship Amount: Fascia 4: 19,500 €/year

8. Aerial Drones for Autonomous Inspection of Photovoltaic Plants – Università di Genova

Curriculum: Hostile and unstructured environments	UNIVERSITÀ DEGLI STUDI DI GENOVA
Hosting Institution University of Genova	
Department: DIBRIS, Department of Informatics, Bioengineering, Robotics and Systems Engineering	
Tutor(s): Prof. Antonio Sgorbissa	

This fully funded PhD position at the University of Genova will conduct research in parallel with the SOLARIS European project (https://solaris-heu.eu/), in which the University of Genova is a key partner. SOLARIS aims to advance the development and integration of Photovoltaic (PV) systems in Europe and beyond. The project focuses on developing and demonstrating a comprehensive set of physical and digital tools to improve forecasting, operational performance, and maintenance, ultimately achieving high performance indices (≈90%) and system availability (>98%) for PV plants.

Among its many functionalities, SOLARIS will provide operators with automated multispectral PV inspection using drones. The University of Genova will develop strategies to enable drones to perform these inspections more efficiently and reliably, with full autonomy. The University has already gained significant experience in this field through previous collaborations [1].

To address these challenges, the PhD candidate will explore GPS-based navigation as well as innovative real-time visual segmentation and servoing techniques for navigation and control, tackling current limitations in the state of the art [2]. This includes enabling drones to fly at variable altitudes (to capture higher-resolution images) and to operate effectively in scenarios where PV panels are not parallel to the terrain. Furthermore, the candidate will investigate path planning and optimization techniques [3] to ensure that the drone's trajectory maximizes the number of panels inspected on a single battery charge.

Specifically, for navigation and control, the candidate will develop solutions based on real-time visual segmentation and visual servoing, combined with GPS-based navigation for transitions between PV rows. The following steps are expected:

1. Real-time segmentation of PV panels from acquired images.
2. Fusion of visual data over time using filtering techniques (e.g., Extended Kalman Filter) to mitigate errors in image segmentation.
3. Visual servoing to maintain drone alignment along PV panel rows while ensuring forward motion.
4. GPS-based navigation to move from one row to the next one of the PV plant.

For path optimization, the candidate will explore innovative methods, with the following steps foreseen:

1. Satellite image acquisition – obtaining georeferenced satellite imagery (e.g., from Copernicus).
2. PV panel and row segmentation – using a machine learning tool trained on a large dataset of satellite images to accurately distinguish PV panels and rows from the background.
3. Subarea clustering – dividing the PV plant into manageable subareas by identifying groups of PV rows and waypoints that can be inspected within a single battery cycle.
4. Optimization – determine the most efficient inspection route, considering battery constraints and the presence of multiple drones.

Requirements:

The ideal candidate is a robotic scientist or a computer engineer with a strong background in programming and control. Previous experience with aerial drones will be positively considered.

References:

1. Morando, L., Recchiuto, C.T., Calla, J., Scuteri, P., Sgorbissa, A. Thermal and Visual Tracking of Photovoltaic Plants for Autonomous UAV Inspection, (2022) Drones, 6 (11).

2. Aghaei, M.; Dolara, A.; Leva, S.; Grimaccia, F. Image resolution and defects detection in PV inspection by unmanned technologies. In Proceedings of the 2016 IEEE Power and Energy Society General Meeting (PESGM), Boston, MA, USA, 17–21 July 2016; pp. 1–5. 15.

3. X. Luo, et al., "Optimal path planning for UAV based inspection system of large-scale photovoltaic farm," in Proc. of the CAC. Jinan, PRC: IEEE, Oct. 2017, pp. 4495–4500.

Number of positions available:

1

Main Research Sites

RICE laboratory, DIBRIS Department, Via all'Opera Pia 13, Genova, Italy.

Contacts:

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Funding Scheme:

This doctorate grant is funded by Università di Genova.

Scholarship Amount:

Fascia 4: 19,500 €/year

9. Advanced navigation and guidance systems for autonomous marine robots – University of Genoa

Curriculum:

Hostile and unstructured environments

Hosting Institution

University of Genoa (Università degli Studi di Genova)

Department:

DIBRIS, Department of Informatics, Bioengineering, Robotics and Systems Engineering https://dibris.unige.it/

Tutor(s):

Prof. Giovanni Indiveri

Description:

Autonomous marine robots are playing an increasingly critical role in underwater inspection and maintenance, environmental monitoring, and the exploration of unstructured and uninstrumented underwater environments. Ensuring precise and reliable navigation in such conditions—often characterized by limited or degraded access to external positioning systems (e.g., LBL, SBL, USBL), low-speed operations, complex maneuvers, and variable seafloor geometries—requires the development of advanced navigation and guidance strategies [1].

This PhD project aims to investigate, design, and implement next-generation navigation algorithms for underwater vehicles, with a particular emphasis on fusing sophisticated hydrodynamic modeling [2] with inertial navigation systems (INS). The modelling of underwater vehicles should account for many factors that are often neglected, such as the impact of the direction of the fluid with respect to the thruster. The research will explore both classical modeling approaches (e.g., rigid-body mechanics, lumped parameter models) and high-fidelity numerical techniques such as Computational Fluid Dynamics (CFD), seeking to combine them into hybrid estimation frameworks. These models will be used to augment the accuracy and robustness of navigation filters under uncertain and dynamically changing operating conditions. The use of AI-based estimation (e.g., neural networks, transformers, LSTM) to recover unmeasured quantities or compensate for faulty/missing data could also be envisaged.

Requirements:

Applicants are expected to have good programming skills (including Python, C/C++), a good background in control systems and software development.

References:

1. Zhang, B., Ji, D., Liu, S., Zhu, X., & Xu, W. (2023). Autonomous underwater vehicle navigation: A review. Ocean Engineering, 273, 113861.
2. Simetti, E., & Indiveri, G. (2022). Control oriented modeling of a twin thruster autonomous surface vehicle. Ocean Engineering, 243, 110260.

Number of positions available: 1
Main Research Sites GRAAL laboratory (https://graal.dibris.unige.it/), DIBRIS Department, University of Genoa, Via all'Opera Pia 13, Genova, Italy.
Contacts: Email: giovanni.indiveri@unige.it
Funding Scheme: This doctorate grant is funded by the DIBRIS Department (project INTERREG IF Marittimo00226 FABBISOGNI E SOLUZIONI PER L'INTEGRAZIONE DELLE COMPETENZE SUBACQUEE – FABIS)
Scholarship Amount: Fascia 4: 19,500 €/year