I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Healthcare and wellness of persons

Research themes

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The main goal of the curriculum "Robotics and Intelligent Machines for Healthcare and Wellness of Persons" is to contribute to improving people's wellness and quality of life, as well as to prevent the risk of injuries and occupational diseases.

Projects within the curriculum will focus on the development and experimental validation of methods, conventional, biomimetic, and bio-inspired models, components, subsystems, systems, and intelligent strategies for information analysis and telemedicine in the following areas:

- Medical robotics with imaging support
- Rehabilitation robotics
- Assistive robotics and functional replacement
- Robotics for health and safety in the workplace
- Innovative medical devices
- Human-robot interaction

The research theme offered by the University of Genoa, the Italian Institute of Technology (IIT), the University of Palermo, and the University of Napoli Federico II 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 (Science, Technology, Engineering, and Mathematics) field, ideally with a background in Robotics.

Students will conduct 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 Principal Investigators for clarifications prior to submitting their application.

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

1. AI-Based Human Movement Analysis and Personalized Assessment

Curriculum: Healthcare and wellness of persons

Hosting Institution: Istituto Italiano di Tecnologia

Department:

Human-Robot Interfaces and Interaction https://hri.iit.it/

Tutor(s):

Drs. Arash Ajoudani, Marta Lorenzini

ISTITUTO ITALIANO DI TECNOLOGIA

Description:

This PhD research focuses on developing **advanced AI models for human movement analysis and anomaly detection**, with applications including gait assessment, functional movement evaluation, and rehabilitation monitoring. The project aims to detect, localize, and characterize deviations in keypoint and joint kinematics and intersegmental coordination through data-driven representations of human motion.

The research will explore **temporal Transformers, spatiotemporal graph neural networks, and generative models**, combined with self-supervised learning, to capture movement structure and variability from normative motion data. Particular attention will be given to **markerless motion capture**, accounting for measurement noise, occlusions, and uncertainty in pose estimation. A central objective is interpretable anomaly detection at joint, segment, and whole-body levels, distinguishing meaningful deviations from variability associated with task demands, movement speed, anthropometry, and individual strategies.

The project will also investigate **individualized reference motion generation**, producing plausible trajectories conditioned on personal characteristics, task constraints, and preserved movement capabilities. Biomechanical constraints and uncertainty-aware inference will guide the quantification of deviations and the analysis of compensatory strategies, without assuming that every departure from typical movement is detrimental.

The PhD aims to **develop and validate an AI-based framework for individualized movement assessment**. Validation will assess anomaly localization, robustness across subjects and acquisition conditions, biomechanical plausibility of generated references, and sensitivity to longitudinal changes. The resulting methods will support research in movement monitoring, assistive technologies, and personalized rehabilitation.

Requirements: The successful candidate must hold an MSc degree in Biomedical Engineering, Computer Science, Artificial Intelligence, or a related field, with a strong background in machine learning and/or computer vision.

The successful candidate should have:

- Strong Python programming skills; knowledge of C++ is a plus.
- Experience with deep learning frameworks such as PyTorch or TensorFlow.
- Familiarity with computer vision, human motion analysis, and/or time-series modeling.
- Confidence with version control tools, particularly Git.
- Good communication skills and willingness to work within a multidisciplinary, international research group.

- • Good command of written and spoken English.

References:

- Motta, Elisa, et al. "GenGait: A Transformer-Based Model for Human Gait Anomaly Detection and Normative Twin Generation." *arXiv preprint arXiv:2604.01997* (2026).
- Duan, Bingzhi, Xiaoyue Wan, and Xu Zhao. "FSGait: Fine-Grained Self-Supervised Gait Abnormality Detection." *Asian Conference on Computer Vision*. Singapore: Springer Nature Singapore, 2024.
- Shan, Wenkang, et al. "P-stmo: Pre-trained spatial temporal many-to-one model for 3d human pose estimation." *European conference on computer vision*. Cham: Springer Nature Switzerland, 2022.

Number of positions available: 2

Main Research Site

Center for Robotics and Intelligent Systems (CRIS), IIT, Genova

Contacts: arash.ajoudani@iit.it, marta.lorenzini@iit.it

Funding Scheme: This open position is financed by Ministero dell'Università e della Ricerca (MUR) nell'ambito del "Bando FIS – Fondo Italiano per la Scienza – PROCEDURA COMPETITIVA PER LO SVILUPPO DELLE ATTIVITÀ DI RICERCA FONDAMENTALE, A VALERE SUL FONDO ITALIANO PER LA SCIENZA 2024–2025 (BANDO FIS 3)" – MACROSETTORE PE – Physical Sciences and Engineering, Decreto Direttoriale n. 1802 del 21/11/2024, e il Decreto "Approvazione delle Graduatorie Finali, Ammissione a Finanziamento – Disposizioni per l'avvio delle Attività Progettuali" prot. n. 18010 del 12/11/2025, within "The Ergonomics Embodied: Predictive and Inter-Causal Representation of Mind and Body in Robot-Assisted Occupational Ergonomics" project; Acronym: EPIC; Grant Agreement number: FIS-2024-026564; CUP: J53C25002230001

Scholarship Amount:

- Fascia 4: 19,500 €/year

2. Soft wearable robots for motion assistance – Università Campus Bio-Medico di Roma

Curriculum: Healthcare and wellness of persons	
Hosting Institution: Università Campus Bio-Medico di Roma	
Department: Departmental Faculty of Engineering – Research Unit of Advanced Robotics and Human-Centered Technologies	
Tutor(s): Nevio Luigi Tagliamonte and Loredana Zollo	

Description:

Wearable robotic technologies are playing an increasingly important role in supporting human movement, with applications ranging from exoskeleton-aided motor rehabilitation and functional assistance [1] to prosthetic systems [2]. These technologies offer new opportunities to improve or restore motor capabilities in individuals with upper limb impairments, both in clinical environments and in everyday activities. However, designing robotic devices that can effectively interact with the human body and the surrounding environment remains a significant challenge, particularly for the upper limb, where complex joint kinematics, multiple degrees of freedom, and highly coordinated movements must be accommodated or replicated.

Conventional wearable robotic systems often rely on rigid mechanical architectures, which provide effective force transmission, structural robustness, and accurate motion control. Despite these advantages, their limited adaptability and compliance may compromise long-term usability. Conversely, soft robotic technologies offer promising alternatives through compliant structures that can better conform to the human body and interacting objects and enable more comfortable and safer physical interaction [3]. Nevertheless, fully soft solutions may present limitations in terms of load-bearing capacity, mechanical robustness, and accurate motion tracking. An emerging research direction aims to bridge these two approaches by developing innovative structures that integrate rigid and soft features within a continuous mechanical architecture. Such solutions may enable wearable robotic devices capable of combining structural support, adaptability, and controlled motion, with potential applications in rehabilitation, assistive robotics, and prosthetic technologies.

Within this research framework, the PhD candidate will focus on the mechanical and mechatronic design, modeling, and prototyping of innovative wearable robotic systems for the upper limbs. The research will investigate novel structural concepts that address the mechanical, anatomical, and functional requirements of human movement, including their integration into assistive devices (e.g. exoskeletons and prostheses). Particular attention will be devoted to the development of soft or soft-rigid architectures and geometrically engineered compliant structures, aiming to achieve an effective balance between structural capabilities, flexibility, comfort, and biomechanical compatibility.

Specific research activities will include, but will not be limited to:

- Design and modeling of wearable robotic structures capable of accommodating or replicating natural upper limb movements.
- Investigation of deformable elements, shell-based components, and architected geometries to achieve controlled deformation, localized compliance, and tailored mechanical behavior.
- Structural and material optimization to improve force transmission, mechanical adaptability, and desired motion capabilities.
- Development and prototyping of selected solutions through additive manufacturing and conventional fabrication techniques, considering their applicability to exoskeletons and/or prosthetic systems.
- Experimental characterization and validation through mechanical testing, functional assessment, and human-centered evaluation.

The PhD candidate will work in a multidisciplinary research environment, with access to advanced design and prototyping facilities and opportunities for collaboration with researchers in robotics, biomechanics, and bioengineering. The project will provide opportunities to contribute to the development of novel wearable robots aimed at improving human mobility, functional independence, and quality of life.

Requirements:

The ideal candidate would have a MS degree in Mechanical Engineering, Biomedical Engineering, Mechatronics Engineering, Aerospace Engineering, Automation Engineering or related fields. Applicants are expected to have (or willing to get) advanced knowledge of CAD/FEM software for mechanical design, additive manufacturing technologies, generative and optimization-based design processes, and Matlab programming. An appreciated plus is a previous experience in robotics for bioengineering, compliant mechanisms and soft robotics, smart materials, wearable robotics, optimization algorithms for mechanical design.

References:

[1] Bardi, E. et al., 2022. Upper limb soft robotic wearable devices: a systematic review. Journal of NeuroEngineering and Rehabilitation.

[2] Mohammadi, A., Lavranos, J., Zhou, H., Mutlu, R., Alici, G., Tan, Y., ... & Oetomo, D. (2020). A practical 3D-printed soft robotic prosthetic hand with multi-articulating capabilities. PloS one, 15(5), e0232766.

[3] Cianchetti, M., Laschi, C., Menciassi, A., & Dario, P. (2018). Biomedical applications of soft robotics. Nature Reviews Materials, 3(6), 143-153.

Number of positions available: 1

Main Research Site

Università Campus Bio-Medico di Roma – Via Álvaro del Portillo 21, 00128 Roma (RM).

Contacts:

Email: n.tagliamonte@unicampus.it; l.zollo@unicampus.it

Funding Scheme: This doctorate grant is funded by INAIL within the project BioARMnext (Esoscheletro portatile per la riabilitazione e l'assistenza del paziente plesso-leso: follow-up),

CUP: E57G23000260005, and by Università Campus Bio-Medico di Roma.
Scholarship Amount: • Fascia 4: 19,500 €/year

3. Intelligent and Safe Robotic Systems for Healthcare and Medical Applications – The Italian Institute of Artificial Intelligence (AI4I)

Curriculum: Healthcare and wellness of persons	AI FOR INDUSTRY The Italian Institute of Artificial Intelligence
Hosting Institution: The Italian Institute of Artificial Intelligence (AI4I), Turin	
Department: **Laboratory:** IDeaLS Lab – Intelligent Development and Large-Scale Systems Lab	
Tutor(s): Sebastiano Panichella	

Description:

The PhD project focuses on the development of intelligent, adaptive, and trustworthy robotic systems for healthcare and medical applications. The research will investigate how Artificial Intelligence, Machine Learning, and advanced robotic control can be integrated to enable robots to operate reliably in complex, uncertain, and partially observable environments, with particular attention to applications involving interaction with humans and biological materials.

The research activities will explore AI-based perception, learning and decision-making, simulation-based training, human-robot interaction, shared autonomy, uncertainty-aware control, and safety mechanisms for intelligent robotic systems. Particular emphasis will be placed on developing methods that allow robotic systems to adapt their level of autonomy according to the reliability of sensory information, the state of the environment, the task context, and the interaction with human operators.

The candidate will contribute to the development and experimental evaluation of novel AI-enabled robotic approaches, combining simulation and physical robotic platforms to investigate robustness, adaptability, safety, and transfer from simulated to real-world environments. The research may involve the integration of multiple sensing modalities, learning-based control, uncertainty estimation, and safety-aware mechanisms for robotic manipulation and interaction.

The project will contribute to the broader development of trustworthy intelligent machines for healthcare, with potential applications in medical robotics, assistive robotics, and other scenarios where robots must operate safely and effectively in collaboration with humans.

Requirements:

The ideal candidate would have a degree in Computer Science, Artificial Intelligence, Robotics, Computer Engineering, Electrical Engineering, Mechanical Engineering, Biomedical Engineering, or a closely related discipline.

References:

- S. Panichella, C. Birchler, S. Khatiri, P. Rani, T. Kehrer, "A Roadmap for Simulation-Based Testing of Autonomous Cyber-Physical Systems: Challenges and Future Direction," in *ACM Transactions on Software Engineering and Methodology*, 2025.

- S. Khatiri, S. Panichella, P. Tonella, "Simulation-based Test Case Generation for Unmanned Aerial Vehicles in the Neighborhood of Real Flights," in *IEEE International Conference on Software Testing, Verification and Validation*, 2023.
- C. Birchler, T. Kombarabettu Mohammed, P. Rani, T. Nechita, T. Kehrer, S. Panichella, "How does Simulation-based Testing for Self-driving Cars match Human Perception?" in *ACM International Conference on the Foundations of Software Engineering*, 2024.

Number of positions available: 1

Main Research Site

Italian Institute of Artificial Intelligence for Industry (AI4I), Turin

Contacts:

Email: sebastiano.panichella@ai4i.it

Funding Scheme:

This doctorate grant is funded by the Italian Institute of Artificial Intelligence for Industry (AI4I), Turin

Scholarship Amount:

- Fascia 4: 19,500 €/year

4. Intelligent and Safe Robotic Systems for Humanoid and Legged Robots – The Italian Institute of Artificial Intelligence (AI4I)

Curriculum: Healthcare and wellness of persons	AI FOR INDUSTRY The Italian Institute of Artificial Intelligence
Hosting Institution: The Italian Institute of Artificial Intelligence (AI4I), Turin	
Department: **Laboratory:** IDeaLS Lab – Intelligent Development and Large-Scale Systems Lab	
Tutor(s): Sebastiano Panichella	

Description:

The PhD project focuses on the development of intelligent, adaptive, and trustworthy robotic systems for humanoid and legged robots operating in complex and dynamic environments. The research will investigate how Artificial Intelligence, Machine Learning, robotics, and advanced software technologies can enable robots to perceive their surroundings, navigate safely, interact with humans, and adapt to changing conditions.

The research activities will explore AI-based perception and decision-making, autonomous navigation and locomotion, human-robot interaction, and methods for improving the safety, reliability, and adaptability of intelligent robotic systems. Particular attention will be given to understanding how uncertainty, environmental conditions, and interactions with humans influence robotic behaviour.

The candidate will contribute to the development and experimental evaluation of AI-enabled robotic approaches, using simulation environments and robotic platforms. The research may also investigate methods for monitoring robotic behaviour and addressing unexpected or potentially unsafe situations, with the aim of improving the robustness and dependability of autonomous systems.

Potential applications include humanoid and quadrupedal robots operating alongside humans in environments such as logistics, manufacturing, healthcare, and other real-world settings. The project may also involve collaboration on other robotic platforms and intelligent cyber-physical systems.

The project will contribute to the development of trustworthy intelligent machines by bringing together Artificial Intelligence, Robotics, and Software Engineering to support the safe and reliable operation of autonomous robots in real-world environments.

Requirements:

The ideal candidate would have a degree in Computer Science, Artificial Intelligence, Robotics, Computer Engineering, Electrical Engineering, Mechanical Engineering, Biomedical Engineering, or a closely related discipline.

A strong interest in Artificial Intelligence, Machine Learning, Robotics, Autonomous Systems, Human-Robot Interaction, or Cyber-Physical Systems is expected. Experience with programming, machine learning, robotics, simulation environments, computer vision, reinforcement learning, or experimental research is considered an advantage.

References:

- S. Panichella, C. Birchler, S. Khatiri, P. Rani, T. Kehrer, "A Roadmap for Simulation-Based Testing of Autonomous Cyber-Physical Systems: Challenges and Future Direction," in *ACM Transactions on Software Engineering and Methodology*, 2025.
- S. Khatiri, S. Panichella, P. Tonella, "Simulation-based Test Case Generation for Unmanned Aerial Vehicles in the Neighborhood of Real Flights," in *IEEE International Conference on Software Testing, Verification and Validation*, 2023.
- S. Khatiri, S. Panichella, P. Tonella, "Simulation-based Testing of Unmanned Aerial Vehicles with Aerialist," in *IEEE/ACM International Conference on Software Engineering – Demonstrations*, 2024.
- S. Khatiri, S. Panichella, P. Rani, T. Kehrer, "When Uncertainty Leads to Unsafety: Empirical Insights into the Role of Uncertainty in UAV Safety," in *Empirical Software Engineering*, 2025.
- • S. Panichella et al., "Bridging Research and Practice in Simulation-based Testing of Industrial Robot Navigation," in *ACM/IEEE International Conference on Automated Software Engineering – Industry Showcase*, 2025.

Number of positions available: 1

Main Research Site

Italian Institute of Artificial Intelligence for Industry (AI4I), Turin

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Funding Scheme:

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Scholarship Amount:

- Fascia 4: 19,500 €/year