I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

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

Research themes

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 preventing the risk of injuries or professional pathologies. This curriculum addresses the following challenges:

1. New algorithms for human-robot interaction in application including diagnosis, therapy, rehabilitation, assistance, and support to healthcare personnel;
2. Increasing the role of robots in the overall process involving prevention, diagnosis, therapy, recovery and home assistance, to increase social participation and involvement of people, reducing social isolation, monitoring daily activities and identify emergencies;
3. New methods and techniques for human-machine interfaces, including bidirectional human-machine communication;
4. Innovative solutions per health, through integration of mechatronic devices, new materials and tissues;
5. Innovative solutions to improve the efficiency and safety of medical personnel to reduce healthcare costs;
6. Innovative solutions to foster the adoption of robotic solutions in the workplace, for prevention and reducing risks of work-related pathologies;
7. New methods for physical and social human-robot interaction, for the wellness of people in various contexts, including education and older adults' care.

Projects in the curriculum will develop and experimentally validate methods, conventional, biomimetic and bio-inspired models, components, subsystems, systems and intelligent strategies for information analysis and telemedicine for:

- 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 quality of research and its impact will be evaluated through specific indicators monitoring:

- Scientific Excellence;
- Industrial impact;
- Economic impact;
- Social Impact;
- Improvement to people health and wellbeing

The ideal candidates are students with a Master (or equivalent/higher) STEM (Science, Technology, Engineering, and Mathematics) degree and possibly a specific background in Robotics.

The students will perform 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 before submitting their application.

International applications are encouraged, and applicants will receive logistic support with visa issues, relocation, etc.

1. Social Robots for Behavioral Change – Università degli Studi di Genova

Curriculum: Healthcare and wellness of persons	
Hosting Institution UNIGE	
Department: DIBRIS, Department of Informatics, Bioengineering, Robotics and Systems Engineering	
Tutor(s): Antonio Sgorbissa	

Description:

This research theme will benefit of an ongoing collaboration with University of Naples Federico II (Prof. Silvia Rossi) and CNR-ISTC (Dr. Andrea Orlandini) within the project Fit4MedRob – subproject BEaCH, a Personal Robot for BEhavoral Change)

Mark is 54 years old and is trying to quit smoking. However, having a coffee and smoking a cigarette is a way to take a break from his very stressful job: it is difficult for him to find an equally gratifying substitute for smoking. **Lisa is 17 and would like to lose weight**. Unfortunately, her mother is not very sensitive to the subject because she believes that taking care of her little girl is her duty and continues to fill her plate and buy boxes of sweets that Lisa can't resist. **Philip is 85 years old and doesn't walk as well as he used to**. The doctor has prescribed him sessions of physical activity to do every day to keep moving, but he is very lazy and repeats to himself that at 85 he will certainly not become an athlete, much to the concern of his wife. **Elda is 5 and she attends kindergarten**, which she enjoys very much. Unfortunately, sometimes the teachers give her tasks that she finds very boring, and when this happens, she can become very upset. Last time, she bit another child, which created a big mess in the parents' WhatsApp group.

Changing one's behavior is complex [1], even when on a rational level people are aware that the change is necessary for their health.

Whether we consider a personal trainer who gives us positive feedback for our successes or negative feedback for our failures, or teachers who promise a student a reward for behaving correctly, the relationships we have with the people around us play a fundamental role in determining our ability to change our behaviors. It is a mechanism considered socially acceptable, within certain limits, and of which the person is often aware. For this reason, the ethical problems that "manipulating" [2] a person could raise are considered negligible in the common perception, given that the final goal is the person's well-being.

The Ph.D. candidate will work for the development of a personal robot that replicates the psychological and social mechanisms that make behavioral change easier [3, 4] while being aware of the **diversity of different target populations and their need**s. Through an

overview of the type of behavior that the person wants to change, the robot must be able to:

- Represent the knowledge already available in the literature in this area, as well as the additional knowledge that will be acquired during the project through specialists in the different fields of intervention [5]. This knowledge will include the necessary steps and the most common obstacles encountered along the way when trying to change one's behaviour, and the diversity-aware strategies that can be adopted to overcome them depending on the personal profile of each person.

- Have a theory of mind (ToM) to represent the users' mental and emotional states as they evolve over time [8], which ensures the required social acuity for planning actions and personalize the robot's behavior based on inferred beliefs and intentions [17].
- Plan, depending on the person, their goals, physical and cognitive characteristics, and the cultural and social context that surrounds them, a personalized and diversity-aware strategy that leads to the achievement of the desired results [6, 7].
- Interact with the person verbally and non-verbally [9] in order to implement the strategies that the robot has planned.

The candidate will address these issues from a theoretical, implementation, and experimental perspective.

Requirements:

Applicants are expected to have an interest in multidisciplinary research. The ideal candidate is a robotic scientist with a strong motivation for social studies. Previous experiences in social robotics, robotic architectures, knowledge representation, planning will be positively evaluated.

References:

1. Bandura, A. Self-efficacy: Toward a unifying theory of behavioral change (1977) Psychological Review, 84 (2), pp. 191-215.
2. T. Paal and T. Bereczkei, "Adult theory of mind, cooperation, machiavellianism: The effect of mindreading on social relations," Pers. Individ. Differ., vol. 43, no. 3, pp. 541–551, 2007.
3. Wainer, J., Ferrari, E., Dautenhahn, K., Robins, B. The effectiveness of using a robotics class to foster collaboration among groups of children with autism in an exploratory study (2010) Personal and Ubiquitous Computing, 14 (5), pp. 445-455.
4. Da Silva, J.G.G., Kavanagh, D.J., Belpaeme, T., Taylor, L., Beeson, K., Andrade, J. Experiences of a motivational interview delivered by a robot: Qualitative study (2018) Journal of Medical Internet Research, 20 (5)
5. Bruno, B., Recchiuto, C.T., Papadopoulos, I., Saffiotti, A., Koulouglioti, C., Menicatti, R., Mastrogiovanni, F., Zaccaria, R., Sgorbissa, A. Knowledge Representation for Culturally Competent Personal Robots: Requirements, Design Principles, Implementation, and Assessment (2019) International Journal of Social Robotics, 11 (3), pp. 515-538.
6. Baroni, I., Nalin, M., Coti Zelati, M., Oleari, E., Sanna, A. Designing motivational robot: How robots might motivate children to eat fruits and vegetables (2014) IEEE RO-MAN

2014 - 23rd IEEE International Symposium on Robot and Human Interactive Communication
7. Mulas, F., Carta, S., Pilloni, P., Manca, M. Everywhere Run: A virtual personal trainer for supporting people in their running activity (2011) ACM International Conference Proceeding Series
8. B. Scassellati, "Theory of mind for a humanoid robot," Auton. Robots, vol. 12, no. 1, pp. 13–24, 2002.
9. Grassi, L., Recchiuto, C.T., Sgorbissa, A. Knowledge-Grounded Dialogue Flow Management for Social Robots and Conversational Agents (2022) International Journal of Social Robotics, 14 (5), pp. 1273-1293.

Number of positions available:
1

Main Research Site
DIBRIS Department, RICE lab (Robots and Intelligent systems for Citizens and the Environment), Via Opera Pia 13, Genova, Italy.

Contacts:
Email: antonio.sgorbissa@unige.it

Funding Scheme: This doctorate grant is funded by the University of Genova.

Scolarship Amount:
- Fascia 4: 19,500 €/year

2. Assistive Robots for Alzheimer's Disease – Università degli Studi di Genova

Curriculum: Healthcare and wellness of persons	
Hosting Institution Università degli Studi di Genova	
Department: DIBRIS: https://dibris.unige.it/ RICE lab: https://rice.dibris.unige.it/	
Tutor(s): Carmine Recchiuto	

Description:

May an opportunely programmed social robot be able to assist individuals with dementia and ease the burden of their caregivers, by a) showing emotional intelligence, b) providing practical help with Activities of Daily Life, and c) being extremely reliable so as to be used for long-term interaction?

The question, up to now only partially answered by related scientific literature [1, 2], comes with different technical issues to be addressed. Indeed, emotional intelligence, even when coupled with cutting-edge techniques in computer vision and language processing, is still a big challenge in social robotics, in particular, if the robot should behave autonomously and with adaptive capabilities. On the other hand, assistive robots able to practically help persons suffering from Alzheimer's to perform ADLs have received only limited attention, due to similar technical challenges and real-life complexity. Finally, long-term interaction requires autonomous robots that are able to deal with unexpected situations, are controlled by reliable software.

This PhD program project aims at tackling all or some of these aspects by developing a new generation of assistive robots able to provide emotional engagement with persons affected by Alzheimer's, by adapting to the user's identity and emotional state, expressing proper emotions in response to that state, while also helping the user to perform simple activities. In particular, the work performed during the PhD will allow for defining guidelines for social assistive robots interacting with people suffering from Alzheimer's and designing software architecture and modules able to interact with the user in the proper way, also adapting to the user's specific needs.

The project will be based on existing work in social robotics, psychology (e.g, affect theory, appraisal theory, existing cognitive architecture for robotics), but the student will also benefit from the experience acquired by the RICE lab in the CARESSES project [3] and its future evolutions, where cultural- and diversity-aware social robots have been developed for elderly care assistance and long-term interaction. Experimental tests with real end-users are also foreseen for the last phase of the project.

The project will be performed at the DIBRIS department in the "RICE Lab," a fully equipped facility for software development with different humanoid robots for socially assistive applications (Pepper, Nao, Navel, Buddy)

Requirements:
Applicants are expected to have good programming skills (C++, Java, or Python) and a profound interest in cutting-edge research in autonomous robotics and socially assistive robotics. Previous experience with Artificial Intelligence techniques and Human-Robot Interaction strategies will be considered.
When applying for the Ph.D. scholarship, the student will be encouraged to propose solutions to address one or more of the aspects described in the proposal.

References:

1. Góngora Alonso, Susel, et al. "Social robots for people with aging and dementia: a systematic review of literature." Telemedicine and e-Health 25.7 (2019): 533-540.
2. Ghafurian, Moojan, Jesse Hoey, and Kerstin Dautenhahn. "Social robots for the care of persons with dementia: a systematic review." ACM Transactions on Human-Robot Interaction (THRI) 10.4 (2021): 1-31.
3. Carmine T. Recchiuto, and Antonio Sgorbissa. "A feasibility study of culture-aware cloud services for conversational robots." IEEE Robotics and Automation Letters 5.4 (2020): 6559-6566.

Company name and link (for industrial projects):
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Number of positions available:
1

Main Research Site
Università degli Studi di Genova, DIBRIS, RICE lab, via all'Opera Pia 13, 16145, Genova

Contacts:

Email: carmine.recchiuto@dibris.unige.it

Funding Scheme: This doctorate grant is fully funded by the Alzheimer's Association Project ARIA, Proposal number: 24AARG-NTF-1200708. CUP

Scolarship Amount:
- Fascia 4: 19,500 €/year

3. Diversity-Aware Robotics – Università degli Studi di Genova

Curriculum: Healthcare and wellness of persons

Hosting Institution
Università degli Studi di Genova

Department:
DIBRIS: https://dibris.unige.it/
RICE lab: https://rice.dibris.unige.it/

Tutor(s):
Carmine Recchiuto

Description:

In recent years, starting from research in Transcultural Nursing and culturally competent Health Care, the EU-Japan project CARESSES [1] addressed for the first time the problem of developing culturally competent Socially Assistive Robots for elderly care. The concept of "culture" is complex, and there is no consensus among researchers on how to define it. Nevertheless, a simple yet effective definition holds that culture is a shared representation of the world of a group of people.

Said that, by "culturally competent," we mean a robot that can adapt its perceptions, plans, actions, and interaction style depending on the worldview of the person it is interacting with, including their beliefs, values, ideas, language, norms and visibly expressed forms such as customs, art, music, clothing, food, etc. The concept, however, can be further enlarged to "Diversity-Aware Robotics": diversity awareness will introduce a crucial innovation in social robotics [2,3]. It will produce robots that can reconfigure their behavior to recognize and value the uniqueness of the person they interact with to promote respect for diversity, inclusion, and equal opportunities, not only for health and social assistance but also cooperation in the workplace, education, welcoming visitors.

To implement the concept of diversity-aware robotics, the work performed in this PhD will develop a novel model based on two core components: an Ontology encoded in Description Logics and implemented in OWL 2, which stores a rich vocabulary to represent all the relevant concepts and relations for all the individuals considered (including beliefs, values, practices, customs, traditions, and systems' functionalities), as well as all the multiple worlds/worldviews corresponding to different groups of users, through proper instances and property assertions (also referred to as Assertional Box). The model will also benefit from a probability distribution in the ontology described through a Bayesian Network whose hierarchical structure mimics the ontology. The Bayesian Network relates assertions that hold for a certain group with assertions that may hold or not hold for an individual self-identifying with that group and is updated whenever new evidence is acquired through dialogue, observation, or other sources of information.

The developed architecture will be possibly tested in different scenarios (in schools with kids coming from different cultures, kids with Autism Spectrum Disorders, elderly people,…) and it will be possibly complemented with foundation models, emotional intelligence approaches, multilanguage capabilities.

The project will be performed at the DIBRIS department in the "RICE Lab," a fully equipped facility for software development with different humanoid robots for socially assistive applications (Pepper, Nao, Navel, Buddy)

Requirements:
Applicants are expected to have good programming skills (C++, Java, or Python) and a profound interest in cutting-edge research in autonomous robotics and social robotics. Previous experience with Artificial Intelligence techniques and Human-Robot Interaction strategies will be considered.
When applying for the Ph.D. scholarship, the student will be encouraged to propose solutions to address one or more of the aspects described in the proposal.

References:

1. Carmine T. Recchiuto, and Antonio Sgorbissa. "A feasibility study of culture-aware cloud services for conversational robots." IEEE Robotics and Automation Letters 5.4 (2020): 6559-6566.
2. Martín, A., Pulido, J. C., González, J. C., García-Olaya, Á., & Suárez, C. (2020). A framework for user adaptation and profiling for social robotics in rehabilitation. Sensors, 20(17), 4792.
3. Kim, Y., Marx, S., Pham, H. V., & Nguyen, T. (2021). Designing for robot-mediated interaction among culturally and linguistically diverse children. Educational Technology Research and Development, 69, 3233-3254.

Company name and link (for industrial projects):
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Number of positions available:
1

Main Research Site
Università degli Studi di Genova, DIBRIS, RICE lab, via all'Opera Pia 13, 16145, Genova

Contacts:

Email: carmine.recchiuto@dibris.unige.it

Funding Scheme: This doctorate grant is funded by the University of Genova.

Scolarship Amount:
- Fascia 4: 19,500 €/year

4. Innovative AI-based system to enhance Robot-Assisted Sensorimotor Rehabilitation – Università di Genova

Curriculum: Healthcare and wellness of persons	
Hosting Institution Università di Genova	
Department: DIBRIS	
Tutor(s): Casadio Maura (DIBRIS UNIGE), Matteo Moro (DIBRIS UNIGE), Jacopo Zenzeri (REWING SRL)	

Description:

People with neurological and/or orthopedic conditions often experience motor dysfunctions and sensory impairments in the upper limbs, impairments that are crucial to accomplishing most activities of daily living. Traditional rehabilitation techniques typically rely on subjective and qualitative measures to support clinical decisions for rehabilitation treatments. To enhance the effectiveness and personalization of therapy, it is essential to use the data collected from robotic technology sensors during each session, enabling continuous improvement and adaptation of individual treatment plans.

This PhD project aims to develop advanced AI and machine learning algorithms to enhance the personalization and efficacy of robotic rehabilitation treatments. The core objective is to create algorithms that can dynamically tailor rehabilitation protocols based on the assessment of patient performance. Using large datasets made of kinematic and dynamic data from past treatments and patient progress, the algorithms to be developed will be able to adapt treatment plans in real-time, ensuring that each patient receives the most effective therapy tailored to their unique needs.

The research will focus on developing machine learning algorithms to analyze patient data and provide personalized rehabilitation recommendations. These algorithms will be integrated into the software of existing robotic rehabilitation products, allowing for smooth application in clinical settings. Extensive testing with human participants will be conducted to validate the personalized approach and clinical efficacy of the proposed system. Moreover, close collaboration with clinicians will be essential to ensure the decision support tool is practical, reliable, and enhances clinical workflows.

The expected outcome is a decision support system that provides clinicians with data-driven, personalized recommendations, optimizing the rehabilitation process and improving patient outcomes. This system of personalization of treatment plans will set a new standard for robotic rehabilitation therapies.

Requirements:

We are seeking applicants who hold a Master's degree in Bioengineering, Informatics, or a related field, with a strong background in artificial intelligence and machine learning, particularly as applied to human physiological signals. Knowledge in neurorehabilitation would be a significant advantage. Candidates should possess an enthusiastic attitude towards experimental work, exceptional problem-solving skills, and a strong motivation to work in a multidisciplinary environment. The ability to adapt to new challenges and collaborate effectively with colleagues from diverse backgrounds will also be highly valued.

References:

1. Albanese, Giulia Aurora et al. 2021. "Efficacy of Wrist Robot-Aided Orthopedic Rehabilitation: A Randomized Controlled Trial." Journal of NeuroEngineering and Rehabilitation 2021 18:1 18(1): 1–15.
2. Iandolo, Riccardo et al. 2019. "Perspectives and Challenges in Robotic Neurorehabilitation." Applied Sciences (Switzerland) 9(15).
3. Mannella, Kailynn et al. 2021. "Preliminary Evaluation of an Adaptive Robotic Training Program of the Wrist for Persons with Multiple Sclerosis." Applied Sciences (Switzerland) 11(19): 9239.

Company name and link (for industrial projects):
ReWing s.r.l. (https://rewingtech.com)

Number of positions available:
1

Main Research Site
ReWing s.r.l. (https://rewingtech.com) Genova Via Giuseppe Macaggi 25/12, 16121

Contacts:

Email: jacopo.zenzeri@rewingtech.com

Funding Scheme: This doctorate grant is co-funded by PNRR program DM-630

Scholarship Amount:

- Fascia 2: 17,500 /year

5. Shared autonomy of Soft Robots for healthcare and wellness – Istituto Italiano di Tecnologia

Curriculum: Healthcare and wellness of persons

Hosting Institution
Istituto Italiano di Tecnologia

Department:
Soft Robotics for Human Cooperation and Rehabilitation https://softbots.iit.it/

Tutor(s):
Antonio Bicchi, Manuel G. Catalano, Giorgio Grioli

Description:
The Soft Robotics for Human Cooperation and Rehabilitation lab is a dynamic environment where the most advanced understandings of natural motor control and the development of the most innovative robotic technologies proceed in parallel. The lab counts on outstanding equipment and facilities, including most modern commercial robotic systems, motion and electromyography capture. We design, develop and fabricate our own experimental apparatuses with state-of-the-art CNC, laser cutting, and 3D printing technologies. The group has a keen interest in technology transfer and transformation of IP into economic value. We adopt the EU Open Source/Open Data strategy, and share most of our experimental data, code, and design on collaborative research platforms such as the Hand Corpus and the Natural Machine Motion Initiative.
The successful candidate will apply the paradigms of shared autonomy to the tools of soft robotics in order to develop solutions for Human-Robot Cooperation in the field of human healthcare and/or for Rehabilitation of people.

Requirements:

- An MSc degree in Robotic Engineering, Mechatronic Engineering or closely related fields.
- Good communication skills.
- Ability and willingness to integrate in a multidisciplinary international research group.
- Good knowledge of written and spoken English.
- Knowledge of Matlab, Simulink and ROS is welcome.

References:

1. Trompetto, C., Catalano, M. G., Farina, A., Grioli, G., Mori, L., Ciullo, A., ... & Bicchi, A. (2022). A soft supernumerary hand for rehabilitation in sub-acute stroke: a pilot study. Scientific Reports, 12(1), 21504.
2. Lentini, G., Settimi, A., Caporale, D., Garabini, M., Grioli, G., Pallottino, L., ... & Bicchi, A. (2019). Alter-ego: a mobile robot with a functionally anthropomorphic upper body designed for physical interaction. IEEE Robotics & Automation Magazine, 26(4), 94-107.
3. Fossati, M. R., Catalano, M. G., Carbone, M., Lentini, G., Caporale, D., Grioli, G., ... & Bicchi, A. (2020). LHF Connect: A DIY Telepresence Robot Against COVID-19. Strategic Design Research Journal, 13(3).

Company name and link (for industrial projects):
Number of positions available: 1
Main Research Site Center for Robotics and Intelligent Systems (CRIS), IIT, Genova
Contacts: giorgio.grioli@iit.it
Funding Scheme: Istituto Italiano di Tecnologia
Scolarship Amount: • Fascia 4: 19,500 €/year

6. AI based control of prosthetic hands – Istituto Italiano di Tecnologia

Curriculum: Healthcare and wellness of persons

Hosting Institution
Istituto Italiano di Tecnologia

Department:
Humanoid Sensing and Perception https://hsp.iit.it
Rehab Technologies, https://rehab.iit.it

Tutor(s):
Lorenzo Natale, Nicolò Boccardo

Description:
There is a growing interest in applying AI methods to control prosthetic arms for grasping and manipulating objects (Vasile et al 2022, Starke et al 2022, Shi et al 2022). These techniques are applied in a shared-autonomy paradigm, where the AI system primarily controls the device based on visual inputs, while the user uses electromyography (EMG) to initiate or terminate the hand movements. This method is crucial for prosthetic devices that have multiple degrees of freedom (DoFs), which are challenging to manage with just EMG. Advancing these capabilities from basic grasping to more complex tasks (such as Activities of Daily Living, ADL) remains a significant challenge.
The project aims to develop shared control strategies for prosthetic arm devices using AI and sensory feedback to improve usability and minimize user effort. The focus will be on employing AI to interpret visual scenes and predict the user's intended actions to appropriately manage the device's DoFs. The approach will incorporate recent multi-modal architectures and various data sources, including visual data from cameras, tactile feedback from sensors in the hand, or head-mounted cameras. This project will be carried out in collaboration with the group Rehab Technologies Lab (https://rehab.iit.it/) using the Hannes hand prosthesis (https://rehab.iit.it/hannes).

Requirements:
Applicants are expected to have an MSc degree in computer science, engineering or related fields, background in Computer Vision, AI and Robotics, and experience with programming languages like C++ and Python and deep learning frameworks. In addition, the candidate is required to have a strong interest working with real robotic systems.

References:

1. F. Vasile, E. Maiettini, G. Pasquale, A. Florio, N. Boccardo and L. Natale, "Grasp Pre-shape Selection by Synthetic Training: Eye-in-hand Shared Control on the Hannes Prosthesis," in IROS, 2022.
2. J. Starke, P. Weiner, M. Crell and T. Asfour, "Semi-autonomous control of prosthetic hands based on multimodal sensing, human grasp demonstration and user intention," Robotics and Autonomous Systems, p. 104123, 2022.
3. Shi, W. Xu, W. Guo, and X. Sheng, “Target prediction and temporal localization of grasping action for vision-assisted prosthetic hand,” in 2022 IEEE International Conference on Robotics and Biomimetics (ROBIO). IEEE, 2022, pp. 285–290.

Company name and link (for industrial projects):

Number of positions available: 1
Main Research Site Istituto Italiano di Tecnologia, via San Quirico 19D, 16148, Genova
Contacts: **Email:** lorenzo.natale@iit.it
Funding Scheme: Istituto Italiano di Tecnologia
Scolarship Amount: • Fascia 4: 19,500 €/year

7. Innovative technologies for active prosthetic hands – Università della Campania

Curriculum: Healthcare and wellness of persons

Hosting Institution
Università degli Studi della Campania "Luigi Vanvitelli"

Department:
Dipartimento di Ingegneria

Tutor(s):
Prof. Salvatore Pirozzi
Prof. Marco Costanzo

Description:
An effective and acceptable prosthetic hand should replicate not only the external aspect of the human hand but also its functionalities. In the last years, several research groups worked on several attempts, but none considering a complete replication of the human hand. The authors in [1] analysed real needs for the amputee subjects to provide a focus to researchers to develop prosthesis more similar to the human hand. From this study, the following capabilities for a prosthetic hand emerged: performing Activities of Daily Living (ADLs); having sensory feedback; regulating force during grasp, lightening the visual attention and the cognitive burden for the user; avoiding slippage of the grasped object; manipulating an object; handling small objects.

An active prosthetic hand is a mechatronic device provided with: sensors and actuators; a system that decodes human biological signals in gestures; a control law that translates all the inputs (from the hand and the user) in the desired movement.
We aim at developing a multi-modal sensing system (e.g., tactile, inertial, optical, temperature) similar to human capabilities for autonomous control of prosthesis and for intuitive interfacing with the patient. The autonomous control system should include multiple manipulation modalities (from fixed grasp to controlled slipping) easily adaptable to a variety of objects (from rigid to soft), by exploiting both model-based and/or data-driven methodologies. The interface should be customizable to the specific needs of the patient and highly intuitive, e.g., by means of AI-based methods. More in details, the development of control laws capable to replace human hand functions and makes a prosthesis acceptable and simple to use by the amputee is the main challenge. Thanks to the information from positions, forces, tactile, IMU it is possible to realize control strategies to regulate forces during grasping and to avoid slippages. The integration in the prosthesis of a control system able to drive hand actuators, managing the forces acquired by an embedded tactile system could guarantee the grasp and the stability of different objects with less visual attention concerning most of the commercially available prosthesis hands where the force regulation during grasping is managed only by a visual control from the user.

Challenge. Improving the prosthesis grasping capabilities during the execution of Activities of Daily Living, by developing:

- innovative multi-modal sensing system, also beyond human capabilities
- innovative patient interface based on tactile sensing technology

- model-based and/or data-driven control laws, which the exploit developed sensing systems

During the PhD, the student will exploit the SeedRobotics 5-fingered anthropomorphic hand, available in our lab, in order to experimentally test his/her studies.

Requirements:
We are looking for a highly motivated, creative, and ambitious student, able to work in a team as well as independently. The candidate should fulfill, at least partially, the following requirements:

- Successfully completed scientific university degree in Computer Science, Robotics, Automatic Controls, Mechatronics Engineering, or other closely-related discipline
- Experience in sensor development, mechatronic design, control techniques
- Experience in development of control algorithms and embedded platforms
- Experience with Matlab, ROS, ROS2, Python, C++, Fusion360
- Experience in composing academic and technical writing pieces (papers, deliverables, etc.)

References:

1. Cordella, F., et al., Literature review on needs of upper limb prosthesis users. Front. Neurosci., 10:209, 2016.
2. Liu, H., et.al., The PRISMA Hand II: A Sensorized Robust Hand for Adaptive Grasp and In-Hand Manipulation. Springer Proceedings in Advanced Robotics, 20 SPAR, pp. 971-986. 2022.
3. Cirillo, A., et al., Tactile sensors for parallel grippers: Design and characterization. Sensors, 21 (5), art. no. 1915, pp. 1-20, 2021.
4. Costanzo M., et al.. Two-Fingered In-Hand Object Handling Based on Force/Tactile Feedback. IEEE T-RO, 36.1, 157-173, 2020.
5. Costanzo M., et al., Tactile Feedback Enabling In-Hand Pivoting and Internal Force Control for Dual-Arm Cooperative Object Carrying. IEEE RAL, 7(4), pp. 11466-11473, 2022.

Company name and link (for industrial projects):

Number of positions available:
1

Main Research Site
Dipartimento di Ingegneria, Via Roma 29, 81031 – Aversa (CE), Italy

Contacts:

Email: salvatore.pirozzi@unicampania.it, Tel.: +39 081 5010433

Funding Scheme: This doctorate grant is funded by Fondi di Ateneo

Scolarship Amount:

- Fascia 1: 16,500 €/year (TBC)

8. Design of customized low-cost hand prosthesis and orthosis – Università Campus Bio-Medico di Roma

Curriculum: Healthcare and wellness of persons	
Hosting Institution Università Campus Bio-Medico di Roma	
Department: Facoltà dipartimentale di ingegneria	
Tutor(s): **Fabrizio Taffoni; Loredana Zollo**	

Description:

In 2017, the World Health Organization reported that around 0.5% of the world population requires prosthetic and orthotic services due to the loss of a limb or a hand functional deficit [1].

Amputations are frequently caused by trauma but also by congenital limb deficiency, vascular pathologies or cancer [2]. About 38.7% of the cases reported in [1] regards the upper limb: 19.6% unilateral, 19.1% bilateral. The impact on the quality of life of the person with an upper limb amputation strongly depends on the amputation level. In the case of a total hand amputation, as in trans-radial or trans-humeral amputations, a huge amount of Activities of Daily Living (ADLs) are impossible [3]. Several neurological and orthopedic pathologies as well as injuries [4] may also cause severe functional hand deficits.

Robotic hand prostheses and orthoses can restore some of these functionalities mitigating the impact of hand amputation or functional deficits on patient's life. Unfortunately, the majority of hand exoskeletons are used for rehabilitative purposes, and only few of them are available for ADL assistance as research prototypes [5]. Moreover, the abandonment rate of robotic hand prostheses is still very high [6]-[9]. In a survey on 92 upper limb amputees, Datta and colleagues [6] point out how the main reasons of prosthesis abandonment are in the level of functionality (i.e., the number of ADLs they allow to restore), the level of cosmesis, and in the weight, frequently judged excessive by patients.

Several approaches have been pursued to support the design of custom devices, mainly focused on prostheses. They can be grouped in: discrete sizing and continuous scaling methods. In the first method, a set of different sizes are predefined according to the population distribution [10]. The prosthetic model is selected as the one closest to the anthropometric characteristics of the user. The second method can be implemented by using a uniform scaling of the 3D model [12]-[14] or by introducing a parametric modeling of the CAD which allows to scale the size of the prosthesis according to specific rules (*i.e.*, non uniform scaling) [15]-[16]. In both cases the shape of the prosthesis is predefined and not directly derived from the patient morphology. 3D scanning technologies may represent a possible source of information to be integrated in the customization process.

Within this research line the PhD candidate will explore the use of patient kinematic modeling, 3D scanning, and additive manufacturing techniques [17]-[20] to setup and validate a development workflow enabling production of low-cost customized hand prostheses and orthoses for both adult and pediatric patients (since 3 years of age). In particular, this research is grounded around the design and development of mechanical/mechatronic components for

custom hand prostheses and orthoses for functional substitution/assistance. The research will tackle with one of more of these activities:

- Biomechanical modelling of human hand
- Mechanical design for human robotics
- Digital manufacturing and system integration
- Development of proof-of-concept mechanical/mechatronic prototypes and of advanced devices.

Requirements:

Basic qualifications:

- MS in the area of Robotics and Mechatronics Engineering, Biomedical Engineering, Computer Engineering or Computer Science;
- Proficiency in different high-level programming languages (C/C++; MATLAB and/or Python);
- Knowledge of mechanical and electronic CAD tools;
- Fluency in English.

Appreciated plus:

- Past experiences in the use of Inventor professional and/or Fusion 360; Altium Designers;
- Past experience in the use of Code Composer Studio and/or MPLAB for microcontrollers and processors embedded code development;
- Electronic and software debugging skills;
- Past experience in similar relevant activities.

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Company name and link (for industrial projects):

Number of positions available:
1

Main Research Site
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Funding Scheme: This doctorate grant is fully covered by the PR23-PAS-P3 - 3Daid++ project "Protesi di mano ed ausili robotici esoscheletrici a basso costo per bambini e adulti", funded the Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro (INAIL) – CUP: C83C23001060001.

Scolarship Amount:
Fascia 1: 16,500 €/year

9. Social robot assistant for intelligent health care – Università degli Studi di Palermo

Curriculum: Healthcare and wellness of persons	
Hosting Institution University of Palermo (Università degli Studi di Palermo)	
Department: Department of Engineering	
Tutor(s): Seidita Valeria Fagiolini Adriano Chella Antonio	

Description:

Context. Improving citizen's health, care and lifestyle is one of the main goals of our society. The last years of the 21st century have seen an increase in average age and chronic diseases. Today's society in Europe is made of more over-60s than under-5, and according to WHO estimates, the World population is growing at an accelerating rate. Most people will reach and exceed the age of 60 by 2050. A serious consequence is less time and resources available to cope with the effects of population growth from the perspective of health services. Indeed, the main health problems are age-related and chronic diseases (from declining cognitive and motor skills to diabetes, cancer, and Alzheimer's). Economic pressure on national health systems is increasing. They are overburdened due to lack of staff, budget constraints imposed by public health, emergency, or exceptional events.

Another problem is the lack of doctors and nurses, the staff dropouts due to burnout and work-related stress or, even more challenging, the presence of changing contexts i.e., cases where patients with the same disease but placed in different family or social contexts have different characteristics and needs. Probably no single medical protocol can be applied in these cases, but doctors must be able to decide on a case-by-case basis.

Within this context, three main factors can be identified that explain the crisis in the health care sector: the gradual decrease in the number of physicians, the aging population, and the increased demand for care for chronic diseases. Providing adequate treatment and care to the population may become almost impossible, generating tragic consequences and domino effects on the economy and society. Investing in prevention is a strategy that could bring excellent results in the long term, but in the short and medium terms one solution is to invest in how to provide services to patients in a way that improves affordability and efficiency of care. An efficient health care system depends on accessibility,

quality, availability of professionals and services. In today's scenarios, doctors can no longer rely solely on themselves to provide patients with quality diagnosis and care and in an acceptable time frame. It is necessary for the health care system to be supported and complemented by intelligent and (semi-) autonomous systems to support both the doctors and the patients. As EU documents show the urgent need for intelligent systems for healthcare should not be underestimated. Investigating the importance of AI and Robotics in health care is the current challenge for scientists and doctors.

Activities. The new digital technologies covered in this research will play a major role in the transformation of health and care systems. Robotics and Artificial intelligence can potentially transform health and care facilities in all their functions, from the clinical aspects (screening and prevention, diagnosis, treatment, surgical support) to the organizational and the logistical ones. The results of this research project will contribute in the future to transforming traditional healthcare systems into a data-driven, experience-driven, patient-centered model that is more collaborative, distributed, and personalized and that can be cross-cutting across the various domains of healthcare.

The proposed Ph.D. project aims at investigating and analyzing how an intelligent system can help a doctor, or nurse, make decisions, even in dynamic contexts and support a patient during his or her care journey. The doctoral research activity will be carried out mainly in the Robotics Laboratory of the Department of Engineering. The idea is to create an intelligent system that can continuously interact with users (doctors, nurses, patients) and an often-changing environment. An intelligent system that can self-adapt to changing situations and decide the best action to take even in the complete or partial absence of input data from doctors or patients. All these aspects include the design of systems that can plan and adapt at runtime and at the same time provide the right level of reliability, acceptability, and transparency (closely related to the concepts of Trustworthiness and Human in the loop that underlie the well-known Explainable AI).

Two main activities will be pursued over the three-year PhD program:

- Intelligent and Adaptive Support for Healthcare Professionals. This activity aims to create intelligent support to respond in a timely and efficient manner to the changing and sudden needs of patients and the environment. Support is also configured in the management of human-computer interaction. During this activity, techniques for creating autonomous, adaptive, and self-conscious systems will be explored from both a design and implementation perspective. The solution adopted to achieve this goal will lead to reduced costs and, most importantly, increased efficiency in cases of overloaded healthcare facilities.
- Advanced patient monitoring. The objective of this activity is the analysis and implementation of techniques suitable for patient monitoring and support. To do this, robots and IoT devices can be used to constantly monitor the patient in care facilities, or at the same time a set of patients.

For example, at the entrance of triage, to capture in real time all useful data to be sent to the intelligent system. By useful data, we mean data that can be used to formulate a diagnosis or treatment hypothesis. Another key element of patient monitoring is the support of all activities during the stay in the healthcare facility. The outcome will be the improvement of the patient's quality of life, in fact, the system will adapt to the patient's needs, for example, it will make suggestions on how to take medication or complete a therapy. At any time, the monitoring system will alert the doctor or nurses of any abnormality in the patient's status or behavior.

Expected results. The proposed PhD program promotes the design and development of tools for ameliorating, modernizing the current public health with a specific goal to overcome the effects of the current crisis and its social consequences and to prepare for a green, digital, and resilient recovery of the economy. The doctoral track aims at fostering the creation of new knowledge and new technologies for the improvement of patient diagnosis, treatment and quality of life can find its natural verticalization in combating the health, social and economic challenges.

The results and impact of the PhD project will be directly measured through KPI indicators such as scientific excellence and industrial impact. Regarding scientific excellence, the publications produced in the three years of the doctoral program will be considered, in relation to the internal regulations of the doctoral host university and the regulations of the doctoral program itself. Bibliometric indicators will be mainly used, and reference will be made to the SCOPUS and/or WOS databases.

On the other hand, as far as industrial impact is concerned, the spin-off in terms of the production of software prototypes, within the company that will host the doctoral student, for the realization of the intelligent system to support doctors and patients will be considered.

Requirements:
Applicants are expected to have a general background in robotics, artificial intelligence, expert systems, control theory.

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Number of positions available:
1

Main Research Site
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Funding Scheme: This doctorate grant is fully funded by "Fondi di Ateneo" of UNIPA.

Scholarship Amount: 16,500 €/year

10. Intelligent assistive walking support and fall-prevention – Free University of Bozen-Bolzano

Curriculum: Healthcare and wellness of persons

Hosting Institution
University of Bolzano

Department:
Faculty of Engineering

Tutor(s):
Angelika Peer

Description:
Falls are a prevalent problem in our society. Incidence and consequences of falls are e.g. associated with age related changes and cognitive impairment, but falls are also of high relevance for patients with amputation above the knee joint and patients with orthotic devices that also have a high risk of falls. The problem of falls though may also become relevant for healthy subjects, which may be confronted with the risk of falls when aiming for example for body augmentation by means of exoskeletons.
In this PhD project we aim at contributing to the large field of fall prediction and prevention by developing generic and intelligent robotic modules with the capabilities of falls risk prediction and fall prevention that can be adopted to a series of different robotic devices like rollators and exoskeletons. For the development of such systems particular focus will be given to the analysis of near-fall situations since they allow gaining inspiration for the design of fall prevention systems as they resemble examples of internally-triggered and successful stabilizations. They allow systematically studying predictors of such situations without bringing subjects at risk.

Particularly, the project aims at:

- Analysis of existing and eventually recording of a multi-sensory database of near-fall and fall situations in healthy subjects and the processing of the recorded multi-sensory data in order to not only detect falls, but predict the falls risk by means of a to-be-developed generic fall risk prediction module, with particular emphasis on fusing information of body pose estimation, gait pattern analysis, musculoskeletal analysis, action recognition, context, and physiological state.
- Using the calculated falls risk along with available behavioral and contextual information as inputs to a context-aware decision-making framework, which takes high-level decisions on the operation mode, to be adopted fall prevention policy and thus, parametrization of robotic controllers to provide proactive and user-adapted fall prevention assistance in different situations including transfer situations and walking at different mobility impairment and fatigue levels.
- User evaluation of the developed fall prevention systems and modules to assess their capability of predicting falls risk and preventing falls in different user groups and testing on selected robotic devices.

Requirements:
Applicants are expected to have strong interests in multidisciplinary research and should ideally come with previous experience in processing multimodal signals as well as strong programming skills in C++, Python and Matlab.

References:

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Company name and link (for industrial projects):
-

Number of positions available:
1

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Funding Scheme: This doctorate grant is fully funded by the Free University of Bozen-Bolzano.

Scholarship Amount:
- Fascia 1: 16,500 €/year

11. Edge AI computing for intelligent machines – Scuola Superiore Sant'Anna in collaboration with ST Microelectronics

Curriculum: Healthcare and wellness of persons	 *In collaboration with* 
Hosting Institution: Scuola Superiore Sant'Anna, in collaboration with ST Microelectronics	
Department: The BioRobotics Institute, Department of Excellence in Robotics & AI, and Interdisciplinary Research Center Health Science	
Tutor(s): Calogero Maria Oddo (Scuola Superiore Sant'Anna) Giuseppe Desoli (ST Microelectronics)	

Description: This doctoral project focuses on developing and integrating advanced information processing strategies, including AI and neuromorphic solutions, within robots. Emphasizing edge implementations, it aims to enhance real-time interaction in complex, dynamic environments, enabling robots to cooperate with humans and other agents. Applications include service robotics and telepresence operations, ensuring safe and effective bidirectional interactions among machines, people, and their surroundings. A key aspect of the project involves leveraging in-memory computing and neuromorphic computing to achieve ultra low power and efficiency. These technologies aim to significantly boost the computational capabilities of robots, fostering more autonomous and intelligent behavior in service and telepresence roles.

Requirements: Applicants are expected to have a background in electronic, control, mechatronic, biomedical, mechanical, or computer engineering or related fields. However, this is not limiting, and other STEM MSc degrees could be considered.

References:

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Company name and link:
ST Microelectronics (https://www.st.com/)

Number of positions available: 1

Main Research Site: The BioRobotics Institute, viale R. Piaggio 34, 56025 Pontedera (PI), Italy and facilities of ST Microelectronics (particularly in Milan area, but other locations may be proposed depending on the scientific and technical activities of the PhD)

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Funding Scheme: This doctorate grant is funded by • PNRR program DM-630 and ST Microelectronics
Scholarship Amount: • Fascia 4: 19,500 €/year

12. Context Awareness for Interaction with Social Robots – Università degli Studi di Napoli Federico II

Curriculum: Healthcare and wellness of persons

Hosting Institution
Università degli Studi di Napoli Federico II

Department:
Department of Electrical Engineering and Information Technologies

Tutor(s):
Prof.ssa Silvia Rossi, Dott.ssa Valentina Russo

Description:
This project aims to investigate how a robotic system can engage a user in context-aware interactions by leveraging dialogue and multimodality. To do so, we aim to investigate how a robotic system can understand and appropriately interpret human multimodal cues or predict the intentions, situational and social context, and future actions of other actors. The project intends to investigate how the use of LLM and multimodal LLM can leverage natural mechanisms for both understanding users' intentions, beliefs and situational context as well as to produce effective content-dependent and personalized dialogues as follows:
1) Investigate the use of multimodal LLM and Transformer models with cross-modal attention layers for simultaneously identifying and interpreting human social verbal and non-verbal cues and understanding people's intentions.
2) Design of Retrieval Augmented Generation systems, including knowledge representation and LLM fine-tuning.
3) Combine Situational and Domain knowledge representation supporting context-aware social robots.

- 4) Fine-tuning of multimodal LLM to support image-grounded dialogue systems in virtual environments.

Hosting Institution
Università degli Studi di Napoli Federico II

References:

Company name and link (for industrial projects):
Logogramma (www.logogramma.com)

Number of positions available:
1

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Funding Scheme: This doctorate grant is funded by PNRR program DM-630
Scholarship Amount: • Fascia 1: 16,500 €/year