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 improve people wellness and quality of life, as well as preventing risk of injuries or professional pathologies. This curriculum tackles the following challenges:

1. New algorithms for human-robot interaction in application including: diagnosis, therapy, rehabilitation, assistance, and support to healthcare personnel;
2. Increasing 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 emergency situations;
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 efficiency and safety of medical personnel to reduce healthcare costs;
6. Innovative solutions to foster 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 wellness of people in various contexts, including education.

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. A “diversity-aware” personal robot trainer with social acuity to help people change unhealthy habits – University of Genova

Curriculum: Healthcare and wellness of persons

Hosting Institution
UNIGE

Department:
DIBRIS

Tutor(s):
Antonio Sgorbissa, Carmine Recchiuto

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.

Changing one's behavior is complex [1], even when on a rational level people are aware that the change is necessary for their health. External aid can be of great help in order to be successful, whether it is a "personal trainer" that motivates us to follow a healthier life and diet, or more substantial medical or psychological support to deal with a serious addiction.

Listening groups that exploit the enormous potential of social networks are now very common, and it is possible to find various apps that provide support for changing unhealthy behaviors, sometimes through the actual intervention of an online specialist. It is worth noting that an intervention in this sense often requires social acuity and manipulation capabilities to push the person to achieve the goal. Whether we consider a personal trainer who gives us positive feedback for our successes or negative feedback for our failures, or parents who promise their children rewards for recovering from serious school failure, 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 (addictions, eating disorders, lack of constancy in pursuing a goal – e.g., for rehabilitation), 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.

From an implementation perspective, the Ph.D. candidate will develop theoretical and technological solutions using one of the humanoid robots at disposal of the RICE lab, e.g., Pepper, NAO, or Navel.

Requirements:

Applicants are expected to have an interest in multidisciplinary research and a background in at least two of the following areas:

- Programming (C++ or Python)
- Human-robot interaction
- Software architectures for robotics (e.g., ROS or REST-API based in the cloud)

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.

Company name and link (for industrial projects): n.a.

Number of positions available: 1

Main Research Site
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Funding Scheme: This doctorate grant is fully funded by the University of Genova.

2. Sensor-based control of robots for human-robot cooperative operations – University of Genova

Curriculum: Healthcare and wellness of persons

Hosting Institution
UNIGE

Department:
DIBRIS

Tutor(s):
Prof. Giorgio Cannata

Description:
Collaborative robots (COBOTS) are used in industrial and service applications to accomplish tasks where human-robot cooperation (i.e. sharing a common space) or collaboration (i.e. physically interacting to complete a common action) is required. During collaborative tasks robots are controlled using feedback from cameras, force/torque sensors, tactile sensors, proximity sensors etc. which allow the robot to localize itself and interact safely with humans and objects.
The PhD project has the goal of developing robot system capable to physically interact with a human to collaborate to execute jointly operations. The scientific objective is to investigate human-robot interaction control strategies based on sensor feedback from cameras, tactile and proximity sensors (multimodal sensing) mounted on the robot arm, enabling safe interaction and touch based robot guidance
The experimental scenario is based on a dual-arm robot (sensorized using cameras, tactile and proximity sensors) mounted on a mobile platform for assistive or domestic applicatioans, sharing the space with a human operator to complete a series of operations involving contact of the robot with the environment.
This PhD research theme is part of the activities of the European project *HE Sestosenso* (www.sestosenso.eu)

Requirements:
Applicants must have a good knowledge of robotics fundamentals and robot programming. Applicants are also expected to have good programming skills (possibly including Python, C/C++, Matlab/Simulink), confidence with electronic hardware and be capable to conduct experiments, and a strong attitude to problem solving

References:

- . Albini, F. Grella, P. Maiolino and G. Cannata, "Exploiting Distributed Tactile Sensors to Drive a Robot Arm Through Obstacles," in IEEE Robotics and Automation Letters, vol. 6, no. 3, pp. 4361-4368, July 2021, doi: 10.1109/LRA.2021.3068110.
- Albini A, Cannata G. Pressure distribution classification and segmentation of human hands in contact with the robot body. The International Journal of Robotics Research. 2020;39(6):668-687. doi:10.1177/0278364920907688
- F. Grella, A. Albini and G. Cannata, "Voluntary Interaction Detection for Safe Human-Robot Collaboration," 2022 Sixth IEEE International Conference on Robotic Computing (IRC), Italy, 2022, pp. 353-359, doi: 10.1109/IRC55401.2022.00069.

Company name and link (for industrial projects): n.a.
Number of positions available: 1
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Funding Scheme: This doctorate grant is co-funded by University of Genova and European project *HE Sestosenso*.

3. Bi-directional Body-Machine interfaces for assistance and rehabilitation – Universita' di Genova

Curriculum: Healthcare and wellness of persons
Hosting Institution UNIGE
Department: DIBRIS
Tutor(s): Maura Casadio, Camilla Pierella

Description:

People with neurological diseases or amputations must learn to operate assistive or rehabilitative devices, such as a computer, a prosthesis, or a robotic system, by mapping their available body abilities, i.e., residual movements or muscle activations, onto device control signals. The neuromotor system provides different signals and degrees of freedom to achieve specific motor goals in various ways. While this resource offers a high level of dexterity, it also presents a computational challenge that needs to be overcome to achieve efficient control of devices or prostheses.

In addition to motor dysfunction, the absence or alteration of somatosensory feedback can lead to specific and identifiable motor and neural alterations that can affect the ability to control assistive technologies for daily living activities.

This research project aims to generate the necessary knowledge for developing a new class of customized body-machine interfaces (BoMIs) based on the user's sensorimotor abilities. To achieve this goal, the project will pursue three general objectives:

AIM 1 - To develop new technology and algorithms to record and translate body- signals into commands of assistive and rehabilitative technologies., adapting to the individual characteristic and the evolving abilities of the users and their assistive/rehabilitative goals.

AIM 2 – to develop a social Body-Machine Interface for targeting individual recovery after Spinal Cord Injury through interactive group therapy. The new interface will guide the interactions among people with different sensorimotor abilities, leveraging enhanced motivation and social engagement while targeting each one's recovery and quantifying the individual deficits as they perform a set of shared tasks.

AIM 3 – To develop a sensory-body machine interface, exploiting sensory stimulation technologies and techniques to encode feedback information on the subject's state of motion and on the interactions with the environment. The interface will also enable training or enhancement (i.e. sensory enhancement or substitution) of somatosensory abilities.

Based on their background and preferences, candidates can focus on any combination of these specific objectives.

Requirements:
We are seeking applicants who hold a Master's degree in Bioengineering or a related field, with good programming skills. Candidates should be strongly motivated to work in a multidisciplinary environment and should have good social skills to interact with people with a disability. The ability to adapt to new challenges and collaborate effectively with colleagues from diverse backgrounds will also be highly valued.

References:

- Rizzoglio, Fabio, et al. "A hybrid Body-Machine Interface integrating signals from muscles and motions." Journal of Neural Engineering 17.4 (2020): 046004.
- Pierella, Camilla, et al. "Learning new movements after paralysis: Results from a home-based study." Scientific reports 7.1 (2017): 4779.

Company name and link (for industrial projects):
n.a.

Number of positions available:

Main Research Site
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Funding Scheme: This doctorate grant is fully funded by University of Genova

4. Diversity-aware driving simulator for assessment and training of cognitive and sensorimotor abilities– Universita' di Genova

Curriculum: Healthcare and wellness of persons

Hosting Institution
UNIGE

Department:
DIBRIS

Tutor(s):
Andrea Canessa, Maura Casadio, Serena Ricci, Camilla Pierella

Description:
Driving is a common activity with a significant impact on the quality of life enabling independence and fostering social activities.
Several neurological diseases or disorders result in specific cognitive or sensorimotor impairments that can differently affect the ability to drive. Also, drugs such as antidepressants or antiepileptics are often prescribed after neurological diseases or injuries. Their consumption could affect abilities associated with driving. Both the effects of the medications, and the level of impairment can vary among subjects of a same population and depends on several factors that cannot always be predicted.
Diving simulators allows to practice in a safe environment, while maintaining the challenges that could be experienced in real life and they can be also powerful tools to assess and train cognitive and sensorimotor skills, while practicing an important activity of daily living.
In this context, there is the need of driving simulators that are 'diversity aware' i.e. that are specifically designed to test and train the ability of a defined subject-population (e.g., Multiple Sclerosis, Attention-deficit/hyperactivity disorder, Neglect). Moreover, a specific pathological condition can affect differently the cognitive and sensorimotor abilities of the user, requiring an additional step of personalization.
The project will start from an existing proof of concept of a driving simulator (ADRIS, Accessible DRIving Simulator), specifically designed for the training of people with spinal cord injury to create a diversity-aware simulator tailored to different cognitive and sensory-motor impairments. The project can be divided into two specific objectives (SO).
SO1 – Design and development of a diversity-aware version of ADRIS. This includes modify the hardware of the simulator (e.g., controllers, system for collecting physiological data; visualization devices), as well as its software (e.g., driving scenarios; personalization of the sessions) to adapt to specific pathological conditions and to the individual needs and the evolving skills of each user, providing customized assessment and training.
SO2 – Definitions of specific and sensitive metrics to objectively assess driving as well as cognitive and sensorimotor abilities for people suffering from different neurological diseases or disorders. This would allow to evaluate the proposed solutions, to investigate the abilities associated with driving and how they change as a result of a specific

neurological disease, to determine whether a training with the simulator can improve driving and/or cognitive and attentional skills of a specific population or of an individual user.

Requirements:
We are seeking applicants with a master's degree in Bioengineering, Robotics Engineering, or a related field. Candidates should possess electronics and/or programming skills, an enthusiastic attitude towards experimental work, problem solving skills, and a strong motivation to work in collaboration with healthcare providers and people living with a disability.

References:

- "ADRIS: the new open-source Accessible DRIving Simulator for training and evaluation of driving abilities", Ricci S., Gandolfi F., Marchesi G., Bellitto A., Basteris A., Canessa A., Massone A., Casadio M. Computer Methods and Programs in Biomedicine 2022
- "Driving Simulator for Assessing Driving Skills of People with Multiple Sclerosis: a Pilot Study" Pierella C., Romani P., Gandolfi F., Podda J., Massone A., Tacchino A., Brichetto G., Canessa A., Ricci S.*, Casadio M.* 9th International Conference on Biomedical Robotics and Biomechatronics

Company name and link (for industrial projects):
n.a.

Number of positions available:
1

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Funding Scheme:
This doctorate grant is co-funded by PRR program DM-118 (action 4.1 – PNRR)

5. New Technologies to train and assess medical and surgical skills – University of Genova

Curriculum: Healthcare and wellness of persons
Hosting Institution UNIGE
Department: DIBRIS
Tutor(s): Maura Casadio, Serena Ricci

Description:

Medical training has traditionally been based on the principle of "see one, do one, teach one", where learning occurred within the clinical environment. However, this practice has exposed patients to unexperienced clinicians who might harm them, ultimately resulting into higher complications and mortality rates. For this reason, simulation-based training is spreading and evolving over time. Indeed, medical simulation allows healthcare professionals to repeatedly practice, make mistake and learn from them in a realistic environment. Medical training includes multiple abilities to train and test, such as manual skills, procedural knowledge, and soft skills. In this context, technologies like low-cost electronics, 3D printing, Artificial Intelligence, Internet of Things, Augmented and Virtual Reality (AR, VR), haptics have been introduced in simulation with the aim to increase training quality.

The goal of this project is to investigate medical and surgical skills, to design and develop effective training and evaluations tools, taking advantage of the most appropriate technology.

The project can be divided into two specific objectives (SO):

SO1 - Develop new medical simulators using disruptive technologies. This objective starts from a specific skill to train (e.g., basic surgical skills, trauma management, pelvic examination), and a deep investigation about the training tools and methods currently used for the training.

This SO will require to build new physical prototypes of medical simulators, from hardware and software perspective. This may include modelling, 3D printing, electronic circuit boards design, software implementation (spanning from code to collect data from sensors, up to graphic user interfaces and VR), synchronization of hardware and software.

SO2 - Definition of metrics and experimental protocols to assess the usability and efficacy of different prototypes. Specifically, subjective feedback on the user experience will be evaluated and combined with behavioral (e.g., performance scores, movements) and biological (e.g., electromyography, electroencephalography) data to: (i) validate the new systems; (ii) compare new prototypes with existing tools; (iii) investigate the learning processes underlying medical learning.

Requirements:

We are seeking applicants with a master's degree in Bioengineering, Robotics Engineering, or a related field. Candidates should possess electronics and/or programming skills, an enthusiastic attitude towards experimental work, problem solving skills, and a strong motivation to work in collaboration with healthcare providers.

References:

- "Virtual and Augmented Reality in Basic and Advanced Life Support training", Ricci S., Calandrino A., Borgonovo G., Chirico M., Casadio M., Journal of Medical Internet Research Serious Games 2022
- "A magnetic transducer for the detection of the fetal engagement level in part-task trainers" Ricci S.*, Vacca G.*, Carlini G., Rossi P., Marcutti S., Canessa A., Vercelli G., Torre G., Chirico M., Casadio M. IEEE Access 2020
- "Design of a system to detect the force applied by tourniquets in a manikin's limb" Viola L., Lagazzi E., Ballardini G., Drogo A., Bonetti M., Marrone E., Chirico M., Ricci S. , 43rd International Engineering in Medicine and Biology Conference 2021

Company name and link (for industrial projects):
n.a

Number of positions available:
1

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Funding Scheme:

This doctorate grant is co-funded by PNRR program DM-118 (action 4.1 – Pubblica Amministrazione)

6. Technologies and methods to monitor, assess and train people with special needs with a focus on neurocognitive impairments – University of Genova

Curriculum: Healthcare and wellness of persons
Hosting Institution UNIGE
Department: DIBRIS
Tutor(s): Emanuele Michieli (Scuola di Robotica), Maura Casadio (DIBRIS)

Description:

This research aims at exploiting emerging technologies and methods for effectively monitoring, assessing, and training individuals with special needs, with a specific focus on individuals with neurocognitive impairments. These impairments are characterized by a variety of symptoms that are subject-dependent and often change with time. Therefore, it is crucial to develop personalized approaches to promote cognitive empowerment, support individual care, and enhance independence, when possible.

Monitoring technologies, such as wearable devices or ambient sensors, enable continuous tracking of individuals' activities and behaviors, offering valuable insights into the daily routines, safety, and health status. Other technologies, including computer-based cognitive training programs, virtual and augmented reality, and assistive technologies (i.e., Assistive robotics, Robot Companions) can provide personalized and adaptive support for training and assistance. These are potential candidates to be combined for building an innovative integrated approach, based on multisensory stimulation, to assess, train and support people with neurocognitive impairment.

In this framework this research will have a twofold aim:

- Developing technological tools and methodologies tailored to individuals with neurocognitive impairments that will encompass cognitive and behavioral assessments. These tools will support the accurate clinical evaluation of type and progression of cognitive impairments, enabling the planning of personalized interventions.
- Developing technology for personalized training and assistance. These technologies will be specifically designed to enhance cognitive functions, though multisensory stimulation, and to promote independence among individuals with different neurocognitive impairments. These interventions will adapt to the evolving cognitive abilities of the user resulting from intervention or disease progression.

The outcomes of this research will be a first step toward a path connecting continuous assessment and training for cognitive empowerment and will contribute to create a comprehensive understanding of the available technologies and methods for

monitoring, assessing, and training individuals with special needs, particularly those with neurocognitive impairments.

Requirements:
Candidates should possess an enthusiastic attitude towards experimental work, exceptional problem-solving skills, good programming 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:

- Ziegler, D.A., Anguera, J.A., Gallen, C.L. et al. Leveraging technology to personalize cognitive enhancement methods in aging. Nat Aging 2, 475–483 (2022). https://doi.org/10.1038/s43587-022-00237-5

Company name and link (for industrial projects):
n.a

Number of positions available:
1

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Funding Scheme: This doctorate grant is co-funded by
- PNRR program DM-117

7. Robot-Assisted Sensorimotor Rehabilitation for Upper Limb Impairments – University of Genova

Curriculum: Healthcare and wellness of persons

Hosting Institution
UNIGE

Department:
DIBRIS

Tutor(s):
Jacopo Zenzeri, Maura Casadio

Description:
People with neurological and/or orthopedic conditions often experience motor dysfunctions and sensory impairments at the upper limbs, impairments that are crucial to accomplish most activities of daily living. Traditional rehabilitation techniques typically focus on either recovering motor functions or assessing proprioceptive deficits, but there is a need for effective and reliable assessment and training protocols that exploit the interaction capabilities of robots.
This PhD project aims to address this gap by developing innovative assessment and training protocols for sensorimotor recovery of the arms using robots. The project will involve studying the underlying mechanisms of sensorimotor deficits from a computational perspective and translating them into control algorithms for a rehabilitation robot. The research will include experiments with human subjects (both with and without sensorimotor impairments) using a rehabilitation robot, as well as the analysis of movements and other body signals.

Requirements:
We are seeking applicants who hold a Master's degree in Bioengineering or a related field, with a strong background in analyzing human movements and body signals, as well as experience in robot programming. 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:

- 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.
- Iandolo, Riccardo et al. 2019. “Perspectives and Challenges in Robotic Neurorehabilitation.” Applied Sciences (Switzerland) 9(15).

- 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
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Funding Scheme: This doctorate grant is co-funded by

- PNRR program DM-117

8. Sensing for Medical Robotics – Scuola Superiore Sant'Anna

Curriculum: Healthcare and wellness of persons

Hosting Institution
Sant'Anna School of Advanced Studies, Pisa

Department: The BioRobotics Institute

Tutor(s): Calogero Maria Oddo, Arianna Menciassi

Description:
Sensors are an essential component for robots to gather a representation of the environment so to act and interact in complex dynamic scenarios and to cooperate with humans and other agents. This doctoral project is dedicated to the development and integration of sensors and information processing strategies, including artificial intelligence solutions, within medical robots such as machines to be used for diagnostic or surgical purposes or collaborative medical robots. Targeted applications will include tasks such as the identification and remote reproduction of tissues and their biomechanical characteristics within medical scenarios and the safe interaction among medical robots, clinical personnel, patients and the environment.

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

References:

- Massari, L., Schena, E., Massaroni, C., Saccomandi, P., Menciassi, A., Sinibaldi, E., & Oddo, C. M. (2020). A machine-learning-based approach to solve both contact location and force in soft material tactile sensors. Soft robotics, 7(4), 409-420.
- Massari, L., Bulletti, A., Prasanna, S., Mazzoni, M., Frosini, F., Vicari, E., Pantano, M., Staderini, F., Ciuti, G., Cianchi, F., Messerini, L., Capineri, L., Menciassi, A., & Oddo, C. M. (2019). A mechatronic platform for computer aided detection of nodules in anatomopathological analyses via stiffness and ultrasound measurements. Sensors, 19(11), 2512.
- Dupont, P. E., Nelson, B. J., Goldfarb, M., Hannaford, B., Menciassi, A., O'Malley, M. K., Simaan, N., Valdastri, P., & Yang, G. Z. (2021). A decade retrospective of medical robotics research from 2010 to 2020. Science Robotics, 6(60), eabi8017.
- Massari, L., Fransvea, G., D'Abbraccio, J., Filosa, M., Terruso, G., Aliperta, A., ... & Oddo, C. M. (2022). Functional mimicry of Ruffini receptors with fibre Bragg gratings and deep neural networks enables a bio-inspired large-area tactile-sensitive skin. Nature Machine Intelligence, 4(5), 425-435.

Company name and link (for industrial projects):
n.a.

Number of positions available: 1
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Funding Scheme: This doctorate grant is funded by ● PNRR program DM-118 (action 4.1 – Pubblica Amministrazione)

9. Robotic hands for prosthetic use– Politecnico di Bari

Curriculum: Healthcare and wellness of persons
Hosting Institution Politecnico di Bari
Department: Department of Mechanics, Mathematics and Management
Tutor(s): Giulio Reina

Description:

The PhD proposal aims to increase the adoption and diffusion of robotic technologies in the medical field towards Medicine 4.0 (SNSI: Health, nutrition, quality of life - medical devices and minimally invasiveness). The growing interest in this sector is evidenced by the birth of new innovative Apulian start-ups, including the proponent BionIT Labs which has already collected numerous international awards (e.g., South Europe Startup Awards (SESA) in the "Best Social Impact Startup" category and the Seal of Excellence for the EIC Acceleration Pilot program of the European Commission) and regional and national funding. In the academic field, there has been the birth of new study courses such as the Degree in Medical Systems Engineering established at the Polytechnic of Bari from the 2019-20 academic year, which has aroused great interest as evidenced by the high number of students (e.g., 240 new freshmen for the 2021-22 academic year).

Going into more detail, the PhD proposal will focus on the main product of BionIT Labs S.r.l., Adam's Hand, a robotic myoelectric hand prosthesis for transradial amputations. The goal will be to develop new motion transmission systems on the one hand by exploiting the principle of under-actuation and on the other to test new prosthesis control approaches based on artificial intelligence. The idea is that the study of new subactuation systems, based for example on differential-type mechanisms, can help a robotic hand to adapt more easily to objects of complex shape by requiring a number of actuators smaller than the number of degrees of freedom of the system. This solution will also make it possible to reduce the complexity of the control algorithm and costs. The further innovative contribution will be linked to the analysis of the recognition of the opening and closing commands of the prosthetic fingers through an algorithm based on machine learning which examines the characteristics of the electromyographic signal (EMG) in real time. Most of the transradial myoelectric prostheses use a very basic control approach, which however remains predominant since its introduction in the 70s for the control of tridigital myoelectric prostheses: the control takes place with two electromyographic sensors, positioned on the flexor and extensor muscles of the forearm, which read the user's muscle signals to "close" or "open" the prosthetic hand. This control method is not robust, as it is sufficient to position the arm in a different way than the one in which the initial setting of this threshold was carried out, to ensure that the activation ratio between these two muscles varies, making therefore the device difficult to control by the user.ì

Requirements:

Applicants are expected to have a prominent interest in the field of design of innovative robotic applications, which by nature declines into complex mechatronic systems. Thus, he/she must confidently handle all the involved aspects:

- Mechanical design skills are of uttermost importance, in particular a marked proneness to strictly defined methodological design processes.
- Electrical, mechatronic and control basic skills are required.
- Good attitude to experimental work is expected. The ability to collect and critically observe numerical and phenomenological results is mandatory.

References:

- E Difonzo, G Zappatore, G Mantriota, G Reina, Advances in finger and partial hand prosthetic mechanisms, Robotics 9 (4), 80.
- GA Zappatore, G Reina, A Messina, Analysis of a highly underactuated robotic hand, Int. J. Mech. Control 18 (2), 17-24.
- GA Zappatore, G Reina, A Messina, A toolbox for the analysis of the grasp stability of underactuated fingers Robotics 8 (2), 26

Company name and link (for industrial projects):
n.a.

Number of positions available:
1

Main Research Site

BionIT Labs Srl

Contacts:

Email: giulio.reina@poliba.it

Funding Scheme: This doctorate grant is funded by PNRR program DM-117

10. High-level cognitive-based control and human-machine interfaces - Italian Institute of Technology

Curriculum: Healthcare and wellness of persons

Hosting Institution
Istituto Italiano di Tecnologia and Università di Genova

Department:
Humanoids and Human Centered Mechatronics

Tutor(s):
Prof. Domenico Prattichizzo
Dr. Nikos Tsagarakis

Description:
Recently, untethered miniature robots have demonstrated promising outcomes in various scenarios at the microscale, including targeted drug delivery, micro-assembly, and biopsy procedures. However, the majority of these small-scale robots have limited manipulation capabilities, and currently available steering systems do not allow humans to control dexterous miniaturized robots in a remote setting in an intuitive and effective manner. Additionally, the existing research primarily focuses on controlling individual microrobots, with only recent advancements allowing for the control of swarms of multifunctional microrobots. Enabling an independent and intuitive control of a swarm of microrobots by a human user can offer numerous advantages in diverse scenarios.

The main goal is to enable intuitive and trustworthy human control of untethered multi-robot systems at the small-scale via innovative cognitive-based interfaces and interaction techniques, exploiting multisensory feedback and AI-powered shared control.

Specifically, the research will address a few of the following points, depending on the expertise and interests of the candidate:

- Multi-functional ergonomic haptic handle interface: design and build an innovative ergonomic handle enabling operators to intuitively control the remote robots while receiving rich and distributed haptic feedback information. The handle will be endowed with flexible cutaneous skin stretch, pressure, and temperature actuators across its surface as well as input buttons and switches for improved natural control.
- Cognitive shared-control: develop shared-control methods to regulate the trade-off between following human operator's commands and autonomous control actions during the control of multi-robot systems at the micro-scale.
- Visuohaptic perception: study which set of information to provide using visual feedback and which using haptic feedback during the system operation through perceptual human studies.
- Haptic rendering: design haptic rendering techniques for communicating with the operators, combining kinesthetic feedback with tactile/cutaneous sensations.

Stability control and trustworthiness. design (passivity-based) stability techniques to guarantee the safety of the microrobotic system; depending on how much we know

about the environment, time-domain (less knowledge) and model-based (more knowledge) passivity techniques can be interleaved or combined.

Requirements:
M.Sc. degree in computer science, control, mechatronics, biomedical engineering or related fields. Applicants are expected to have strong interests in multidisciplinary research as well as strong programming skills in C++, Python and Matlab.

References:

- Meli, L., Pacchierotti, C., Salvietti, G., Chinello, F., Maisto, M., De Luca, A., & Prattichizzo, D. (2018). Combining wearable finger haptics and augmented reality: User evaluation using an external camera and the Microsoft Hololens. IEEE Robotics and Automation Letters, 3(4), 4297-4304.
- Spagnoletti, G., Meli, L., Baldi, T. L., Gioioso, G., Pacchierotti, C., & Prattichizzo, D. (2018, March). Rendering of pressure and textures using wearable haptics in immersive VR environments. In 2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR) (pp. 691-692). IEEE.
- Gioioso, G., Pozzi, M., Aurilio, M., Peccerillo, B., Spagnoletti, G., & Prattichizzo, D. (2019). Using wearable haptics for thermal discrimination in virtual reality scenarios. In Haptic Interaction: Perception, Devices and Algorithms 3 (pp. 144-148). Springer Singapore.
- Salvietti, G., Meli, L., Gioioso, G., Malvezzi, M., & Prattichizzo, D. (2016). Multicontact bilateral telemanipulation with kinematic asymmetries. IEEE/ASME Transactions on Mechatronics, 22(1), 445-456.
- Music, S., Salvietti, G., Prattichizzo, D., & Hirche, S. (2017). Human-Multi-Robot Teleoperation for Cooperative Manipulation Tasks using Wearable Haptic Devices. In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) p (Vol. 8).
- Pacchierotti, C., Tirmizi, A., Bianchini, G., & Prattichizzo, D. (2015). Enhancing the performance of passive teleoperation systems via cutaneous feedback. IEEE Transactions on Haptics, 8(4), 397-409.
- Pacchierotti, C., Tirmizi, A., & Prattichizzo, D. (2014). Improving transparency in teleoperation by means of cutaneous tactile force feedback. ACM Transactions on Applied Perception (TAP), 11(1), 1-16.
- Pacchierotti, C., Ongaro, F., Van den Brink, F., Yoon, C., Prattichizzo, D., Gracias, D. H., & Misra, S. (2017). Steering and control of miniaturized untethered soft magnetic grippers with haptic assistance. IEEE Transactions on Automation Science and Engineering, 15(1), 290-306.

Number of positions available:
1

Main Research Site
Istituto Italiano di Tecnologia (IIT)
Center for Robotics and Intelligent Systems
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Contacts:

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Funding Scheme: This doctorate grant is fully funded by the European project RĚGO (rego-project.eu).

11. Human-robot coexistence and interaction in robot-assisted medical procedures – Sapienza Università di Roma

Curriculum: Healthcare and wellness of persons	
Hosting Institution Sapienza University of Rome	
Department: Department of Computer, Control and Management Engineering (DIAG)	
Tutor(s): Marilena Vendittelli	

Description:
The introduction of robots in the medical domain is radically changing the standard of care. However, despite their early adoption in the mid 80's, the clinical practice lacks examples of robots that autonomously execute a complete medical task in contact with the patient, collaborate with the medical operators, and safely coexist with humans and devices populating a classical operating room. In short, a robot that interacts with its working environment is lacking in the medical domain. Physical safety is, naturally, the most relevant concern to be addressed to allow the deployment of interacting robots in this context. Research on human-robot physical interaction, that has already enabled a step change in the industrial production paradigms, finds unique challenges in medical applications.
Relying on the results obtained at the DIAG Robotics Laboratory [1-4] on safe human-robot interaction, this thesis work will address these challenges with reference to robot-assisted superficial hyperthermia treatments. The company supporting this PhD project has recently developed, in collaboration with the DIAG Robotics Laboratory, a technology demonstrator [5,6]. The thesis work will address the many issues and open problems that remain for guaranteeing safe coexistence and physical interaction with collaborating (the staff) and non-collaborating (the patient) humans, minimally invasive integration in the operating room, significant improvement in therapy delivery and clinical outcomes. The goal of the project is to integrate the safe physical interaction algorithms developed in the thesis with methods for estimating the delivered dose of therapy. This will lead to the development of "treatment servoing" algorithms that allow a feedback control on therapy delivery. The generation of the feedback information is the subject of another, ongoing, PhD work.
The role holder will therefore operate on these stimulating and challenging topics in a multidisciplinary context, working with experts in Robotics, Computer Science, Biomedical Engineering, and Medicine.

Requirements:
We look for applicants with a master's degree in Control Engineering, Artificial Intelligence and Robotics, or Computer Science. Different backgrounds will be taken also into account, provided that the candidate has received basic education in modeling and control of dynamic systems and in robotics. Applicants are also expected to possess programming skills in the most common languages (C++, MATLAB, Python), familiarity with standard

development software (like, e.g., Microsoft Visual Studio) and knowledge of robotic simulation environments. Preferred qualifications include experience in designing and developing software solutions to interconnect and integrate heterogeneous systems and/or that implement basic human-robot physical interaction control methodologies on real robot platforms.

References:

- M. Khatib, K. Al Khudir, A. De Luca, "Human-robot contactless collaboration with mixed reality interface," *Robotics and Computer-Integrated Manufacturing*, vol. 67, 102030, February 2021.
- E. Magrini, F. Ferraguti, A.J. Ronga, F. Pini, A. De Luca, F. Leali, "Human-robot coexistence and interaction in open industrial cells," *Robotics and Computer-Integrated Manufacturing*, vol. 61, 101846, February 2020.
- C. Gaz, E. Magrini, A. De Luca, "A model-based residual approach for human-robot collaboration during manual polishing operations," *Mechatronics* (Special Issue on Human-Robot Collaboration in Industrial Applications), vol. 55, pp. 234-247, 2018.
- S. Haddadin, A. De Luca, A. Albu-Schäffer, "Robot collisions: A survey on detection, isolation, and identification," *IEEE Transactions on Robotics*, vol. 33, no. 6, pp. 1292-1312, 2017.
- ROBHOT - DIH-HERO technology demonstrator.
- Demo at The European SocieTy for Radiotherapy and Oncology Congress (ESTRO 2022).

Company name and link (for industrial projects):

MedLogix (https://albahyperthermia.com)

Number of positions available:

1

Main Research Site
DIAG Robotics Laboratory, MedLogix

Contacts:

Email: marilena.vendittelli@uniroma1.it, a.deluca@uniroma1.it

Funding Scheme: This doctorate grant is funded in part by
- PNRR program DM-117

12. Artificial sensory feedback to assist motor functions - Universita' di Milano Bicocca

Curriculum: Healthcare and wellness of persons

Hosting Institution
Università degli Studi di Milano-Bicocca

Department:
School of Medicine and Surgery

Tutor(s):
Cristiano Alessandro

Description:
Musculoskeletal injuries often affect both joint biomechanics and sensorimotor function, significantly compromising movement execution. Current treatments for these conditions focus mainly on restoring movement biomechanics, leaving patients with significant sensory deficits that may lead to long-term conditions and further injuries. This project aims at developing an assistive technology to re-establish sensory feedback after musculoskeletal injuries, based on artificial sensory stimulation. After development, this technology will be tested using state-of-the-art techniques to evaluate the effects of the artificial sensory feedback on muscle coordination and movement execution, both in healthy subjects and in patients with musculoskeletal lesions. The successful candidate will be working in collaboration with other teams at UNIMIB, and may also be involved in aspects related to improving and evaluating the interaction between this technology and the user.

Requirements:
Applicants are expected to have a scientific interest in biomechanics and motor control. Previous research experience in these disciplines will be considered favorably, especially if related to laboratory evaluations of movement execution. Desirable but not compulsory technical skills include programming, the use of motion-capture systems and EMG. In any case, candidates should be highly motivated to learn or improve these skills.

References:

- Needle AR, Lepley AS, and Grooms DR. (2017). "Central Nervous System Adaptation After Ligamentous Injury: a Summary of Theories, Evidence, and Clinical Interpretation". *Sports Medicine. 47(7):1271-1288.*
- Valle G. (2022). "Peripheral neurostimulation for encoding artificial somatosensations". European Journal of Neuroscience. 56(10):5888-5901
- Alessandro C, et al. (2023). "Inhibition of knee joint sensory afferents alters covariation across strides between quadriceps muscles during locomotion". Journal of Applied Physiology. 134(4):957-968

Company name and link (for industrial projects):

n.a

Number of positions available: 1
Main Research Site Istituti Clinici Zucchi (Carate Brianza, MB), School of Medicine and Surgery, University of Milano-Bicocca
Contacts: Email: cristiano.alessandro@unimib.it
Funding Scheme: This doctorate grant is funded in part by ● This doctorate grant is funded by PNRR program DM-118 (action 4.1 – Ricerca PNRR)

13. Bacteriabots: MicroRobots with Embedded Biological Intelligence – University of Salento/Italian Institute of Technology

Curriculum: Healthcare and wellness of persons

Hosting Institution
University of Salento, Lecce, Italy
Italian Institute of Technology, Arnesano (Lecce), Italy

Department:
Department of Engineering for Innovation, UniSalento
Center for Biomolecular Nanotechnologies, IIT

Tutor(s): Prof. Michele Scaraggi, Prof. Massimo De Vittorio

Description:
µm-scale robotics shows an increasing interest for their potential applications, such as diagnostics and therapy in precision medicine. However, mobile robotics at such scale is extremely challenging, due to the limitations to integrate on-board computation, power, actuation, sensing and communication in realistic operations. However, introducing biological intelligence at such scale, such as quorum-sensing, chemotaxis, etc., dynamics typical of micro-scale living systems such as bacteria, can be a successful strategy. This is e.g. the case when a bacteria is attached to synthetic functioning parts such as cargo, and chemotaxis is used to drop off the cargo at specific locations.
In this thesis, bacteriabots will be designed and fabricated to perform micro-scale operations, such as drug delivery or microfabrication (surface patterning at microscale, or wear remediation) thanks to chemotaxing, or surface patterning with hydrated biofilms for long-lasting water-based ultra-low friction applications.Center for Biomolecular Nanotechnologies, IIT.

Requirements:
Applicants are expected to exceptionally hold a Master's Degree in Engineering, Physics, Chemistry or related disciplines, with strong background in continuum mechanics and in modelling the dynamics of fluid and structure, or strong experience in mechatronics design and preparation/microfabrication of soft materials. Good communication skills and ability to cooperate (creative, proactive and collaborative attitude), as well as proficiency in English language (written and oral) are required.

References:

- Mostaghaci, B. et al., Adv. Sci. 2017, 4, 1700058.
- Krsmanovic, M. et al., Adv. Colloid Interfac. 2021, 288, 102336.
- Haibao Hu et al., Sci. Adv. 2017, 3, e1603288.

Company name and link (for industrial projects): n.a

Number of positions available:

1

Main Research Site Lecce, Italy
Contacts: Email: michele.scaraggi@unisalento.it
Funding Scheme: This doctorate grant is funded by PNRR program DM-118 (action 4.1 – Ricerca PNRR)

14. Augmenting Humans Using Wearable Sensorimotor Interfaces – Università degli Studi di Siena

Curriculum: Healthcare and wellness of persons	
Hosting Institution University of Siena	
Department: Department of Information Engineering and Mathematics, University of Siena, Italy.	
Tutor(s): Domenico Prattichizzo	

Description:

Sensorimotor augmentation consists in integrating human's and robotic limbs to perform complex tasks with both biological and artificial limbs under the direct control of the human. Unlike collaborative robotics, we view robotic extra limbs as an extension of the human body rather than external agents working collaboratively. Our objective is to develop a groundbreaking approach that capitalizes on the redundancy of the human motor system to simultaneously control natural and robotic limbs. Our approach to achieve this consists of employing motion capture technologies to track human movements that do not affect task execution and then using these as reference signals for robotic limbs. In fact, by leveraging the redundancy of the human musculoskeletal system, we can accomplish tasks in various equivalent ways. For instance, grasping an object can be achieved with the hand in a specific spatial position while the arm assumes different configurations. The body motions that have no direct impact on task execution constitute what we refer to as the task "null space".

The candidate will be responsible for designing methods and technologies to identify the dimensions of the task-specific null-space, projecting real-time body signals from this null-space, and subsequently translating them into control signals for the robot. This research project encompasses several use cases such as telesurgery, cooperative task execution involving multiple arms, control of supernumerary robotic limbs during daily activities, and more. The candidate will conduct this research within the framework of a European Project (HARIA - HUMAN-ROBOT SENSORIMOTOR AUGMENTATION – GA n. 101070292). The candidate will have the opportunity to collaborate and interact with academic partners, research centers, and companies involved in the project.

Requirements:
Applicants are expected to have a background in control, mechatronics, mechanical, robotics, and biomedical engineering or related fields.

References:
Prattichizzo, Domenico, et al. "Human augmentation by wearable supernumerary robotic limbs: review and perspectives." *Progress in Biomedical Engineering* 3.4 (2021): 042005.

Company name and link (for industrial projects):

n.a

Number of positions available:

1

Main Research Site
Department of Information Engineering and Mathematics, University of Siena, Italy, Via Roma 56, 53100 Siena, Italy

Contacts:
Email: domenico.prattichizzo@unisi.it

- **Funding Scheme:** This doctorate grant is funded pursuant to Ministerial Decree DM-118/PNRR and the exceeding part is guaranteed by the funds of the European project HARIA (HUMAN-ROBOT SENSORIMOTOR AUGMENTATION – GA n. 101070292)

15. Mechanical components for robots in healthcare 4.0 – Universita' Campus Bio-Medico Roma

Curriculum: Healthcare and wellness of persons	
Hosting Institution Università Campus Bio-Medico di Roma	
Department: Facoltà dipartimentale di Ingegneria	
Tutor(s): Loredana Zollo and Nevio L. Tagliamonte	

Description:

Healthcare 4.0 is a collective term for concepts derived from Industry 4.0 like data-driven digital health technologies, smart health, mobile health, wireless health, e-health, online health, medical IT, telemedicine, digital medicine, health informatics, pervasive health, and the health information system [1]. The new approach to the delivery of care is expected to enhance the quality and effectiveness of healthcare services, paving the way for a more direct relationship between providers and patients as well as clinical operators [2]. Moreover, the analysis of Healthcare 4.0 implications reveals that the effects of the technological revolution are progressing in both medicine itself and in the management of healthcare organizations, both in hospitals, which are the foundation of the healthcare system [3], and at home during daily life. Despite several efforts have been already made to increase the effectiveness of hospital and domestic care and to improve people' satisfaction, substantial improvement is still possible leveraging on innovative enabling technologies [4]. Medical robotics, together with other disruptive technologies such as Internet of Things (IoT), and Artificial Intelligence (AI) but also wearable sensors, big data, extended reality, and 3D printing, are spanning the digital transformation of health and healthcare, by radically transforming the way users access them. Using robotics has been demonstrated to enable a high level of in/outpatient's care, efficient processes in clinical settings, and a safe environment for people (patients and clinical workers). Over the years, indeed, medical robots have expanded their capabilities into many areas of healthcare. Robots can be employed in clinical settings to support healthcare workers and enhance patient assistance. Moreover, they support customized and frequent monitoring for patients with chronic diseases, intelligent therapeutics, and social engagement for elderly patients. Especially in the case they are wearable, robots can provide physical movement assistance for patients' therapy during rehabilitation programs or even can be used for independent living after discharge to assure the continuum of care. Autonomous mobile robots simplify routine tasks, reduce the physical demands on human workers, and ensure more consistent processes. Streamlined workflows and risk reduction provided by robotics offer value in many areas. For example, robots can help with cleaning and disinfection by using UV light, hydrogen peroxide vapors, or air filtration to reduce infection and to sanitize reachable places in a uniform way. Cleaning and disinfection robots enable hospital rooms to be sanitized and ready for incoming patients quickly. Robots can also reduce the time it takes to identify, match, and distribute medicine to patients in hospitals to relieve the daily burden on healthcare workers from routine logistical tasks.

Since robots alleviate workloads, medical doctors, nurses, caregivers and other healthcare workers will be able to spend more time providing direct patient care and focus on more delicate activities and can offer patients more empathy and human interaction, which can

promote long-term well-being. Moreover, robots physical and cognitive functionalities can provide multiple benefits directly to people needing care, thanks to monitoring, physical support and intervention.
Despite growing diffusion of medical robots, many challenges are still open for their design, especially in terms of mechanic and mechatronic features and not only on software and control point of view.
Within this research theme the PhD candidate will work on the development of intelligent and advanced robots to be used for the improvement of novel healthcare solutions both in personal care and in hospital environment with a special focus on the mechanical design aspects. In particular, this research theme is grounded around the design and development of mechanical/mechatronic components for medical robots for healthcare 4.0 with main focus on systems for motion assistance. More specific activities will include:

- Design/selection of novel actuation solutions;
- Design of mechanisms and mechanical transmissions;
- Design of bodyware for intelligent robotic machines;
- Development of proof-of-concept mechanical/mechatronic prototypes and of advanced devices.

Requirements:

Basic qualifications:

- MS in the area of Mechanical Engineering (preferred), Mechatronics Engineering, Aerospace Engineering or Biomedical Engineering;
- Advanced knowledge of CAD/FEM software;
- Knowledge of Matlab programming;
- Fluency in English.

Appreciated plus:

- Experience in robotics design;
- Experience in compliant mechanisms and soft robotics;
- Experience with additive manufacturing technologies.

References:

[1]. Herrmann, M., Boehme, P., Mondritzki, T., Ehlers, J. P., Kavadias, S., & Truebel, H. (2018). Digital transformation and disruption of the health care sector: internet-based observational study. Journal of medical internet research, 20(3), e9498.
[2]. Cavallone, M., & Palumbo, R. (2020). Debunking the myth of industry 4.0 in health care: insights from a systematic literature review. The TQM Journal.
[3]. Unterhofer, M., Rauch, E., & Matt, D. T. (2021). Hospital 4.0 roadmap: an agile implementation guideline for hospital manager. International Journal of Agile Systems and Management, 14(4), 635-656.
[4]. B. Djulbegovic and G. H. Guyatt, 'Progress in evidence-based medicine: a quarter century on', Lancet Lond. Engl., vol. 390, no. 10092, pp. 415-423, 22 2017, doi: 10.1016/S0140-6736(16)31592-6.
[5]. Tamantini, C., di Luzio, F. S., Cordella, F., Pascarella, G., Agro, F. E., & Zollo, L. (2021). A robotic health-care assistant for COVID-19 emergency: A proposed solution for logistics and disinfection in a hospital environment. IEEE Robotics & Automation Magazine, 28(1), 71-81.

Company name and link (for industrial projects):

N/A

Number of positions available:
1

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

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

Funding Scheme: This doctorate grant is partly funded by the European Project ODIN (Leveraging AI based technology to transform the future health care delivery in leading hospitals in Europe) within the Horizon 2020 research and innovation programme, under grant agreement No 101017331, and partly by research funds of the Università Campus Bio-Medico di Roma.

16. Shared-Autonomy Architectures for Assistive Robotics in Healthcare Environments – University of Pisa

Curriculum: Healthcare and wellness of persons

Hosting Institution
University of Pisa

Department:
Information Engineering Department

Tutor(s):
Giorgio Grioli
Andrea Munafò
Antonio Bicchi

Description:

The main goals are the theoretical development and validation trough simulations and experiments of planning and control techniques for shared-autonomy of assistive robots in healthcare applications.

The main challenge in such application lies in the robot-patient physical interaction that should be addressed taking into account the safety-time trade-off.

The techniques that will be developed will aim to fuse human and robotic intelligence by taking the best from the twos leveraging on smart shared autonomy techniques. Given the generality of the problem to be addressed, the applications will encompass fixed and mobile manipulation and methods will leverage on (direct and indirect) force control, tele-opration, and AI.

One of the main key aspects of the work is devoted to the robustness of the developed methods that should be tailored to work in realistic scenarios.

The algorithms should be tested on the following robotic platforms: Alter-Ego [2].

Requirements:

Applicants are expected to have a strong background in at least one of the following, and a reasonable knowledge of all three:

- Control techniques
- Tele-operation
- AI algorithms

References:

- [1] G Lentini, et al., Alter-ego: a mobile robot with a functionally anthropomorphic upper body designed for physical interaction, IEEE Robotics & Automation Magazine 26 (4), 94-107, 2019

Company name and link (for industrial projects):

Number of positions available: 1
Main Research Site University of Pisa, Engineering Faculty, Largo Lucio Lazzarino 1, Pisa, Italy
Contacts: Email: giorgio.grioli@gmail.com
Funding Scheme: This doctorate grant is funded by project FIT4MED (titolarità Antonio Bicchi), allocati al Dip. Ingegneria Informazione, Progetto U-GOV: NC_ING_INF_FITFORMEDROB_SPOKE_1.

17. Social robot assistant for intelligent health care – Universita' di Palermo

Syllabus:
Healthcare and wellness of persons

Hosting Institution
University of Palermo (Università degli Studi di Palermo)

Department:
Department of Engineering

Tutor(s):
Chella Antonio
Seidita Valeria
Fagiolini Adriano

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, such as the situation we have been experiencing during the last 2 year due the COVID-19 pandemic.
Another problem is the lack of doctors and nurses 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:

1) 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.
2) 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 effects of COVID-19.

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.

References:

- Lanza, F., Seidita, V. and Chella, A., 2020. Agents and robots for collaborating and supporting physicians in healthcare scenarios. Journal of biomedical informatics, 108, p.103483
- Sorbello, R., Tramonte, S., Giardina, M.E., La Bella, V., Spataro, R., Allison, B., Guger, C. and Chella, A., 2017. A human–humanoid interaction through the use of BCI for locked-in ALS patients using neuro-biological feedback fusion. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 26(2), pp.487-497
- Seidita, V., Lanza, F., Pipitone, A. and Chella, A., 2021. Robots as intelligent assistants to face COVID-19 pandemic. Briefings in Bioinformatics, 22(2), pp.823-831
- Spataro, R., Sorbello, R., Tramonte, S., Tumminello, G., Giardina, M., Chella, A. and La Bella, V., 2015. Reaching and grasping a glass of water by locked-in ALS patients through a BCI-controlled humanoid robot. Journal of the Neurological Sciences, 357, pp.e48-e49
- Dindo, H., Presti, L.L., La Cascia, M., Chella, A. and Dedić, R., 2017. Hankelet-based action classification for motor intention recognition. Robotics and Autonomous Systems, 94, pp.120-133
- M. Trumić, K. Jovanović, and A. Fagiolini, "Decoupled nonlinear adaptive control of position and stiffness for pneumatic soft robots," International Journal of Robotics Research, vol. 40, no. 1, pp. 277–295, 2021

Number of positions available:
1

Main Research Site
RoboticsLab (http://diid.unipa.it/roboticslab/)
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Funding Scheme: This doctorate grant is funded by Universita' di Palermo.

18. Proactivity and Adaptation in Socially Assistive Robotics – Università degli Studi di Napoli Federico II

Curriculum: Healthcare and wellness of persons

Hosting Institution
Università degli Studi di Napoli Federico II

Department:
Department od Electrical Engineering and Information Technologies

Tutor(s):
Prof.ssa Silvia Rossi

Description:
Socially assistive robotics (SARs), aiming to improve the standard of living in modern society through social interactions, find applications in various fields such as hospitals [1], or support for the elderly [2]. In these application contexts, social robots are designed to interact with people naturally and personally through verbal, nonverbal, or affective modalities. In the field of SARs, robots can provide personalised assistance through monitoring, coaching, encouragement, and motivation towards specific therapeutic goals. Most current robotic systems tend to react to human inputs or after an event has occurred, whereas few ones take the initiative proactively [3]. This project is aiming to investigate how robots could be endowed with adaptive and proactive behaviour in order to predict the users' needs to support them in assistive tasks. To achieve this goal both the proper perceptual capabilities to infer beliefs, emotions and desires of a user and decision-making ones are necessary components. In particular, the ability to have a Theory of Mind (ToM) representing and reasoning on the users' mental state as they evolve over time and personalize the robot's behaviour based on inferred beliefs and intentions will be considered.

Requirements:
Applicants are expected to have a master's degree or equivalent in Computer Science, AI, or robotics. Previous experience in machine learning, robot programming, and/or human-robot research is preferential.

References:
[1] Rossi, S., Larafa, M., Ruocco, M.: Emotional and behavioural distraction by a social robot for children anxiety reduction during vaccination. International Journal of Social Robotics 12, 765–777 (2020)
[2] Di Napoli, C., Ercolano, G. & Rossi, S. Personalized home-care support for the elderly: a field experience with a social robot at home. User Model User-Adap Inter 33, 405–440 (2023).
[3] Ilenia Cucciniello, Antonio Andriella, and Silvia Rossi. 2023. Towards a Computational Approach for Proactive Robot Behaviour in Assistive Tasks. In Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction (HRI '23). Association for Computing Machinery, New York, NY, USA, 521–525.

Number of positions available:
1

Main Research Site

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Funding scheme: This doctorate grant is funded by PNRR program DM-118 (action 3.4 – Transizione digitale e ecologica)

19. Robotic diagnosis for remotely located patients based on ultrasound signals – Università di Trento

Curriculum: Healthcare and wellness of persons

Hosting Institution
Università di Trento

Department:
Dipartimento di Ingegneria e Scienza dell'informazione

Tutor(s):
Luigi Palopoli, Marco Roveri, Daniele Fontanelli

Description:
Medical applications of Robots are very challenging for the evident possibility that robot's misuses or malfunctioning could have a significant impact on the patient's life. For this reason, innovations are very gradual and meet the reluctance of the regulators in accepting new solutions (even haptic feedback is uncommon in commercial robotic devices). On the other hand, the ever-increasing costs of healthcare and the difficulty to hire skilled medical personnel demand new functionalities and more autonomy in medical robots.

This research will explore the application of robots for diagnostic and non-invasive purposes. The candidate will develop a technological platform to acquire ultrasound-based imaging with the same level of quality of a skilled physician. We will use imitation learning to extract the most important skills that doctors apply in scanning the body with ultra-sound probes and replicate them in a system based on robotic arms. The system intelligence will have to reconstruct a suitable model of the patient's body and adapt the medical protocols through the observation of the doctors' behaviour. The human will remain in the loop and be able to override the system action by using a shared control approach.

Requirements:
Applicants are expected to be fluent with the basic knowledge of robotics (Kinematics, dynamics, force control). Good programming skills and a fundamental knowledge of AI is appreciated.

References:

- Peters BS, Armijo PR, Krause C, Choudhury SA, Oleynikov D. Review of emerging surgical robotic technology. Surg Endosc. 2018 Apr;32(4):1636-1655. doi: 10.1007/s00464-018-6079-2. Epub 2018 Feb 13. PMID: 29442240.
- von Haxthausen, F., Böttger, S., Wulff, D. et al. Medical Robotics for Ultrasound Imaging: Current Systems and Future Trends. Curr Robot Rep 2, 55–71 (2021). https://doi.org/10.1007/s43154-020-00037-y

Company name and link (for industrial projects):
Azienda Provincial servizi Sanitari di Trento

Number of positions available:
1

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Funding Scheme: This doctorate grant is funded by PNRR program DM-118 (action 3.4 – Transizione digitale e ecologica)

20. Augmented reality for safer surgical robotics – Politecnico di Milano

Curriculum: Healthcare and wellness of persons

Hosting Institution
Politecnico di Milano

Department:
Department of Electronics, Information and Bioengineering

Tutor(s):
Elena De Momi
elena.demomi@polimi.it

Description:
During minimally invasive robotic surgery, such as in prostate cancer tissue removal, it is important to identify anatomical landmarks, which are not visible in the (stereo) surgical endoscope view. The PhD project "Augmented reality for safer surgical robotics" is aimed at developing computer vision and robotic related methods to register the pre-operative dataset to the intra-operative 3D reconstructed environment, overlying hidden structures in transparency on the endoscopic camera view. An online rea-time estimation of the distance between the surgical instruments and the underlying tissue will allow increasing the safety of the intervention and the surgical outcome.
The project will have impact on the Italian healthcare system, reducing surgical complications and decreasing the surgical time.

Requirements:
Applicants are expected to work on computer vision methods and robot control. Also, the applicants should work in close cooperation with clinical centers in order to integrate the developed methods in clinical systems (e.g. in the da Vinci, Intuitive) to perform technology assessment with respect to standard care.

References:

- Sestini L, Rosa B, De Momi E, Ferrigno G, Padoy N. FUN-SIS: A Fully UNsupervised approach for Surgical Instrument Segmentation. Med Image Anal. 2023 Apr;85:102751. doi: 10.1016/j.media.2023.102751. Epub 2023 Jan 20. PMID: 36716700.
- Ziyang Chen, Aldo Marzullo, Davide Alberti, Elena Lievore, Matteo Fontana, Ottavio De Cobelli, Gennaro Musi, Giancarlo Ferrigno, Elena De Momi, FRSR: Framework for real-time scene reconstruction in robot-assisted minimally invasive surgery, Computers in Biology and Medicine, 2023, 107121, ISSN 0010-4825, https://doi.org/10.1016/j.compbiomed.2023.10712

Company name and link (for industrial projects): NA

Number of positions available: 1

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Funding Scheme:
This doctorate grant is funded by PNRR program DM-118 (action 4.1 – Pubblica Amministrazione)