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.

The candidate may address these issues from a theoretical, implementation, or experimental perspective.

Requirements:

Applicants are expected to have an interest in multidisciplinary research.

The ideal candidate is either (1) a computer scientist / robotic scientist with a strong motivation for psychological and social studies or (2) a psychologist / social scientist /cognitive scientist with a strong motivation for computer science and multimedia, robotics and AI

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
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 fully funded by the University of Genova.

2. 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:
1

Main Research Site
DIBRIS Department, Bioengineering Lab, Via Opera Pia 13, Genova, Italy.

Contacts:

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

5. Intelligent end-effector embodiment and autonomous grasping control principles – Italian Institute of Technology

Curriculum: Healthcare and wellness of persons
Hosting Institution Istituto Italiano di Tecnologia
Department: Humanoid and Human Centred Mechatronics Research line (https://hhcm.iit.it/)
Tutor(s): Nikos Tsagarakis nikos.tsagarakis@iit.it
Description: The realization of effective manipulation skills has strong dependencies on the robot end-effector mechatronics including the articulated kinematics, the actuation and the sensing principles of the end-effector module. This research topic targets to develop kinematically minimalistic end-effector modules that are equipped with intrinsic adaptation as well as multi-modal sensing capabilities to facilitate the manipulation robustness as well as the realization of low level autonomous grasping and manipulation skills. The mechatronic design and the engineering of the end-effector modules will explore the instrumentation of the grippers with integration of visual and haptic sensing that will provide the cues for implementing autonomous grasping and manipulation functionalities. Control methodologies and a set of autonomous manipulation skills will be explored and implemented to enable the execution and adaptation of grasping actions. Proprioceptive feedback will be employed for the regulation of the grasping forces and for their adaptation through reflex controllers. The end-effector device will be developed with different articulation topologies to serve the grasping and manipulation requirements of the assistive robotic arm developed within HARIA project (http://haria-project.eu/). The end-effector requirements will also include intrinsic features to favour safe human-robot interaction and inherent adaptation to arbitrary shape objects.
Requirements: We are seeking for highly motivated candidates with a background in Mechanical and Control engineering, Physical Sciences or Robotics. Candidates should have competencies in CAD mechanical design and/or robot dynamics and control. (Mechanical design 60%, Control %40). The applicants should be fluent in English and team players.
References: ● Barrett E., Ren Z., Tsagarakis N.G., Grasping with Embedded Synergies through a Reconfigurable Electric Actuation Topology, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2021, pp6131-6138. ● Ren Z, Kashiri N., Zhou C., Tsagarakis N.G., Heri ii: A robust and flexible robotic hand based on modular finger design and under actuation principles, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018, pp 1449-1455.
Number of positions available: 1
Main Research Site Istituto Italiano di Tecnologia, Center for Robotics and Intelligent Systems, Genova
Contacts: Email: Nikos.tsagarakis@iit.it

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