POLITECNICO DI MILANO

PhD in BIOINGEGNERIA / BIOENGINEERING - 39th cycle

THEMATIC Research Field: LOWER LIMB ULTRA-LIGHT ORTHOSIS INTEGRATED WITH FUNCTIONAL ELECTRICAL STIMULATION TO SUPPORT LOCOMOTION

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Worldwide, more than one billion people live with some type of disability, which in most cases are motor disabilities. The main sources of motor disabilities related to walking result from lesions or pathologies of the Central Nervous System. Among these, traumatic injuries are the most frequent cause consisting mainly of spinal cord injuries and head trauma. People with motor disability may benefit from the use of assistive technologies in order to regain functional ability, such as locomotion. In order to support people with some residual motor capabilities, the actual research is oriented towards the development of more wearable and lighter solutions, such as soft exoskeletons. These devices can be combined in a more natural and discreet manner with the human body with respect to rigid robotic devices. Another technology which has been used for several years to support motor recovery in people with motor disabilities is Functional Electrical Stimulation (FES). FES consists in the application of low-energy electrical stimuli to induce the contractions of paralyzed or paretic muscles. Several studies have shown the therapeutical benefits of FES, such as the increase of muscle strength, the decrease of spasticity and spasms, and the enhancement of neural plasticity at the central level. Recently, hybrid systems including a combined action of FES and motorized robots have been proposed to take full advantage of both concepts. As compared to FES alone, hybrid systems offer supplementary torque support, ensuring precise

	movements while preventing early muscle fatigue, which strongly characterized FES-induced muscle contractions. Simultaneously, the integration of FES within wearable robotics can reduce power requirements, while preserving FES benefits. Within this framework, this PhD project aims at the design of an ultra-light wearable exoskeleton integrated with FES to support overground locomotion in people with a partial motor disability. This project will be carried out within the FeatherEXO project, funded by INAIL Centro Protesi (PR23-RR-P1), in collaboration with the Italian Institute of Technology (Rehab Technologies Lab) and the University of Heidelberg (Prof. L. Masia). The specific role of Politecnico di Milano, and therefore of the PhD student, will be the integration of FES within the robotic platform developed by the other partners.
Methods and techniques that will be developed and used to carry out the research	The main objective of this PhD project is the integration of an FES system within an ultra-light and wearable exoskeleton to support overground locomotion. We foresee an integration both at hardware and software level. A light and portable neuro-muscular electrical stimulator with a minimum of 8 stimulation channels will be integrated and a direct communication between the stimulator and the central control unit of the exo will be established. Textile electrodes will be integrated in the exo structure in order to minimize the donning and doffing time and to allow the use of the integrated system from personnel with no experience in electrodes placement (e.g. target users or informal caregiver). A cooperative control system which shares the torque requirement between FES and motor assistance will be implemented. This is a particular novel aspect of this research project, since no example with soft-exo integrated with FES exist so far. Torque requirement will be modulated during training execution in order to adapt to the actual performance, to the residual capability of the subject, and to muscle fatigue. Iterative tests with subjects with no disabilities and potential target users will be carried out in order to verify the correct functioning of the developed system and to optimize user’s experience and performance. This research activity will be carried out mostly at the WeCobot laboratory located at Lecco

	Campus of Politecnico di Milano.
Educational objectives	We provide doctoral candidates with high-level scientific training, fostering and refining research and problem-solving abilities by focusing on both theoretical and experimental skills. A PhD in Bioengineering will be able to layout, draft and carry on original research, by leading a research group or working in a team.
Job opportunities	National and international academic and non-academic institutions and organizations, engaged in innovation, research and technical development; high-tech SMEs, government departments.
Composition of the research group	2 Full Professors 1 Associated Professors 3 Assistant Professors 8 PhD Students
Name of the research directors	Proff Emilia Ambrosini - Alessandra Pedrocchi

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Two laboratories will be involved in this project: the Neuroengineering section of the NEARLAB, within the Department of Electronics, Information and Bioengineering of Politecnico di Milano https://nearlab.polimi.it/ and the interdepartmental laboratory WECOBOT Wearable and collaborative robotics laboratory located at Polo Territoriale di Lecco of Politecnico di Milano

https://www.polo-lecco.polimi.it/ricerca/laboratori-interdipartimentali/we-cobot-lab-wearable-and-collaborative-robotics-laboratory The PhD student will collaborate with the other partners of the project, e.g. Italian Institute of Technology (Genova) and University of Heidelberg.

A shared desk and computer will be given to the PhD student for the time needed to carry out research. Short periods of teaching assistantship are encouraged during the program.