POLITECNICO DI MILANO

PhD in BIOINGEGNERIA / BIOENGINEERING - 40th cycle

THEMATIC Research Field: ADVANCED HUMAN-MACHINE INTERFACE FOR MULTI DEGREES OF FREEDOM, HIGHLY DEXTEROUS CONTROL FOR UPPER LIMB PROSTHETICS

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	Conventional human-machine interface (HMI) control methods for upper limb prostheses often rely on EMG amplitude modulation or pattern recognition to decode EMG signals, enabling discrete movement control. While these approaches improve usability, they limit users to one movement at a time and lack robustness to changes like electrode shifting or muscle fatigue. Advanced data-driven algorithms such as linear regression, neural networks, and deep learning have been explored, but they fail to establish the relationship between neural control signals and muscle-joint motions or adapt to unseen movements. Recently, musculoskeletal models (MMs) have emerged as a promising alternative for EMG-based HMIs. This study builds on prior work to propose an enhanced MM leveraging HD-EMG (10.1109/LRA.2024.3451388) for predicting at lease 3-DoF motions, addressing these challenges.
Methods and techniques that will be developed and used to carry out the research	The research will involve designing innovative control architectures to achieve simultaneous and proportional control of multiple degrees of freedom (DoFs) building on the foundations of musculoskeletal models (MMs) and high-density EMG (HD-EMG) processing. The candidate will conduct in-depth analysis and simulation of cutting-edge algorithms such as neural

	networks, non-negative matrix factorization, and deep learning, while addressing challenges like robustness to electrode shifting, muscle fatigue, and unseen motions. Regular testing on physical prototypes will provide iterative feedback, ensuring the designs are optimized for real-world applications. The research will culminate in contributions to the next generation of prosthetic control systems, advancing both scientific knowledge and practical utility in the field.
Educational objectives	The Ph.D. candidate will focus on developing and implementing advanced experimental solutions in the field of biomedical engineering, specifically tailored to improve human-machine interface (HMI) systems for upper-limb prostheses.
Job opportunities	The Rehab technologies Lab (IIT) is looking for a Ph.D. candidate with an M.Sc. in robotic/biomedical engineering or related fields. The candidate will contribute to developing new control algorithms for a new upper limb prosthesis, which is going to be designed and manufactured in Rehab Technologies, in collaboration with Aalborg University and Friedrich-Alexander-Universität Erlangen-Nürnberg, within the INAIL-IIT project DexterHand.
Composition of the research group	2 Full Professors 0 Associated Professors 18 Assistant Professors 24 PhD Students
Name of the research directors	Nicolò Boccardo; Matteo Laffranchi; Elena De Momi

Contacts
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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

Educational activity: The student will be encouraged to attend to courses at POLIMI or abroad 2 / 3 in International Schools.
Teaching assistantship: There are various forms of financial aid for activities of support to the teaching practice.
The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.
Computer and desk availability: the student will be allowed to access facilities of the DEIB.