

Research Topics for  
**Doctorate in Bioengineering and Robotics,**  
curriculum in **Bioengineering**

**Research Topics**

1. Neuromuscular characterization of human motor behavior ..... 1
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**1. Neuromuscular characterization of human motor behavior**

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**Description**

Electromyographic (EMG) recordings enable the characterization of voluntary motor production. Indeed, modular architectures based on muscle synergies have been proposed [1], as well as techniques to infer motor unit recruitment underlying muscular contraction [2]. These methods have been used also for assessing the motor impairment in case of neurologic damage [3] and EMG-derived metrics have been proposed as control signals in robotic based neurorehabilitative treatment [4] and in upper limb prosthetics [5]. However, despite the great amount of proposed EMG-based techniques to describe motor impairment and/or guide neurorehabilitation, none of them is currently employed in the clinical settings.

The ultimate goal of this PhD work thus consists in integrating different EMG-based methods in order to provide a unified description of voluntary motor production, both in the healthy and pathological condition, which can be exploited to obtain new biomarkers or to design novel rehabilitation solutions [6].

The PhD activities will include: (i) experiments with healthy subjects, upper-limb amputees and neurologic patients during motor production with and without the support of a robotic device; (ii) software development and data analysis; and (iii) strong collaboration and interaction with our partners. To this end, the Candidate will benefit

from a lively network of collaborations with hospitals and research institutions, such as Fondazione Mondino in Pavia, Ospedale Valduce - Villa Beretta in Lecco, Centro Protesi INAIL in Budrio, and Fondazione Don Gnocchi in Milan.

This project requires broad expertise in electrophysiology (i.e. EMG acquisitions and analysis) and a demonstrated expertise in biomedical engineering and software development. The ideal candidate should hold a degree in biomedical engineering or related disciplines, be a highly motivated and creative individual who wants to work in a dynamic, multi-disciplinary research environment. Former lab experience and previous technical and scientific results will be highly considered.

### Requirements

Background in bioengineering; proficient programming skills: experience with Matlab/Simulink, C and/or Python for data analysis. Experience with acquisitions of electrophysiological signals from humans. Experience in clinical environment will be taken in high account.

### References

1. D'Avella, A., Bizzi, E. Shared and specific muscle synergies in natural motor behaviors. *PNAS*, 2005.
2. Farina, D. et al. The extraction of neural strategies from the surface EMG. *Journal of applied Physiology*, 2004.
3. Cheung V.C.K. et al. Muscle synergy patterns as physiological markers of motor cortical damage. *PNAS*, 2012.
4. Irastorza-Landa N. et al. Functional synergy recruitment index as a reliable biomarker of motor function and recovery in chronic stroke patients. *Journal of Neural Engineering*, 2021.
5. Farina D. et al. The extraction of neural information from the surface EMG for the control of upper-limb prostheses: emerging avenues and challenges. *IEEE Transactions in Neural Systems and Rehabilitation Engineering*, 2014.
6. Garro F. et al. Neuromechanical Biomarkers for Robotic Neurorehabilitation. *Frontiers in Neurorobotics*, 2021.

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