PhD in Bioengineering

Final Defense

POLITECNICO MILANO 1863

PhD Course in Bioengineering – Final Thesis Defense

PhD Candidate: ANDREA CIMOLATO
Advisor: Prof. Giancarlo Ferrigno
Co-advisor: Prof. Matteo Laffranchi
Prof. Leonardo De Matthos
Prof. Elena De Momi

18.06.2021
h. 15:30
@ Microsoft Teams

Thesis: BIDIRECTIONAL CONTROL IN LOWER LIMB PROSTHESIS

COMMITTEE MEMBERS

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SCHEDULE OF THE DAY

15:30 - 15:40	Committee Meeting
15:45 - 16:45	Thesis presentation - Discussion
16:45 - 17:00	Committee meeting
17:00	Award Ceremony

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Final Defense

PhD in Bioengineering

POLITECNICO MILANO 1863

PhD student: **ANDREA CIMOLATO – XXXII Cycle**

Thesis title: BIDIRECTIONAL CONTROL IN LOWER LIMB PROSTHESIS

Advisor: Prof. Giancarlo Ferrigno – Politecnico di Milano
Prof. Elena De Momi – Politecnico di Milano
Prof. Matteo Laffranchi – Fondazione IIT Genova
Prof. Leonardo de Matthos – Fondazione IIT Genova

Abstract:

THIS doctoral thesis presents the definition and implementation of a bidirectional neural control for a powered knee prosthetic devices.
A detailed review of the different implementation of EMG-driven controllers for lower limb prostheses is offered to the reader with the intent of acknowledging the necessity of paradigm shift respect to standard pattern recognition approaches. Additional literature investigation si presented on sensory restoration through implanted neural electrodes and further previous attempts in closing the sensory-motor control loop with prosthetic devices.
This thesis dissertation proposes the exploration of subject specific Neuromusculoskeletal (NMS) models for the direct control of the prosthetic joint through its forward dynamic simulation using only limited amount of sensors those can be embedded in the prosthesis. Machine Learning (ML) regression algorithms are used to solved highlighted limitations, such as high number of EMG electrodes and required Motion Capture system. Methodologies for a novel encoding algorithm for electrical nerve stimulation are additionally discussed. The activity of Ia afferent fibers can be estimated through muscle spindle transducer model employing the muscle kinematics resulting from simulation of the developed hybrid ML-NMS model. Ia fibers activity is finally used to modulate electrical stimulation parameters for the restoration of artificial proprioception in transfermoral amputees. Encoding strategy is tested on a realistic model replicating the neural electrical interface.
On the basis of the obtained results authors consider the developed frame-work a novel solution for the definition of bidirectional prosthetic control.
Moreover this work provides the basis for the formulation of a holistic approach for innovative human-machine interfaces. Modelization of the human NMS system is employed to optimize the information exchange with the human nervous system through optimal decoding and encoding of the neural activity.