Category: Development of Technology

Workshop Title: Control Meets Visual Feedback: New Paradigms for A Better Rehabilitation Experience in wearable robotics

Organizer(s): Bodo Giulia, Giannattasio Raffaele, Ceroni Indya, Di Domenico Dario, Quadrelli Debora, Lucaroni Andrea and Laffranchi Matteo
The workshop demo and organization are also carried out in collaboration with co-organizers: Mariani Giulia, Di Bello Pietro, Berrettoni Andrea and Fenoglio Elena.

Speaker(s): Marchal-Crespo, Laura, Delft University of Technology
Huang, He (Helen), North Carolina State University,
Koh, Zen, IISART, MotusAcademy and Fourier Intelligence,
Garcia Hernandez Nadia Vanessa, Cinvestav,
Bodo, Giulia, Italian Institute of Technology

Workshop Time: 10:30 - 12:00

Attendee Engagement: During the workshop, experts in rehabilitation technology, including both prosthetics and exoskeletons, will share insights on potential solutions and strategies to enhance user experience also, in some cases providing demo of their cutting-edge technologies (for example we will host a demo form IISART, MotusAcademy). We will showcase examples of integrating visual feedback with control strategies for rehabilitative devices, alongside discussions on current limitations and future developments.
On-site demonstrations featuring augmented and virtual reality visors, as well as visual feedback systems developed at the Rehab Technologies Lab at the Italian Institute of Technology (Genoa, Italy), will engage participants, allowing them to experience the potential of these technologies first-hand.
Serious games developed for the Hololens augmented reality headset will be showcased. These games are designed for use in upper limb robotic-assisted shoulder rehabilitation with the Float exoskeleton. They engage patients by combining interaction with both virtual environments and physical objects, enhancing the therapy experience. Participants will have the opportunity to try out the Hololens headset and the featured games.
Participants will also experience advances in lower limb stimulation, with a focus on sensation restoration in virtual environments, expanding the possibilities for immersive prosthetic experiences.
We will show the implementation of a virtual reality environment in Unity, designed to help upper-limb prosthetic users learn to control and actuate the Hannes hand. This environment not only facilitates training but also enables the evaluation of control performance using the Target Achievement Control (TAC) test. The training phase is essential for users to become familiar with the prosthesis' responsiveness and actuation within an engaging, immersive environment, which can enhance their learning experience. To quantitatively assess prosthesis controllability, the TAC test evaluates the user's performance in reaching target configurations. By integrating score reports, the test becomes more interactive, encouraging users through a game-like experience while offering valuable feedback on their progress and performance.
Attendees will also participate in interactive Q&A sessions, providing opportunities to engage with invited speakers, exchange experiences and ideas, and foster future collaborations among researchers in this field.
Abstract: Rehabilitation often involves repetitive task training for both prosthetic and exoskeleton applications. In prosthetics, learning to control the device can be time-consuming. Similarly,

exoskeleton rehabilitation often requires repeated movements to ensure effective training. These procedures may feel tedious and monotonous, potentially leading to patient disengagement. Thus, exploring technologies that sustain motivation is crucial. In prosthetics, virtual pre-training allows users to practice and build proficiency in controlling the device before transitioning to the actual prosthesis, boosting both skills and confidence. Exoskeleton-mediated therapy can be enriched by gamification resulting more engaging and effective in empowering the patient' skills. Tools like videos, immersive experiences, and augmented reality can enhance the usability of prosthetic and exoskeleton devices, improving the overall rehabilitation experience.

In exoskeletons, advanced control strategies can integrate visual feedback. For example, if the patient approaches a digital wall, a resistive controller can simulate a virtual barrier, creating an immersive experience. The dynamics of interacting objects can also be recreated, allowing patients to perceive external weights or motions during interactions with virtual objects.

In prosthetics, virtual environments are widely used to assess control strategies, offering quantifiable insights into usability and controllability. This framework also enables reinforcement learning, updating control algorithms based on user performance to refine real-time adaptability. For lower limb prosthetics, gamified environments can simulate activities like walking on different terrains or avoiding obstacles, offering real-time feedback on balance and gait to improve motor control and strength. Similarly, for upper limb prosthetics, patients can practice grasping and manipulating virtual objects, helping to improve coordination and dexterity.