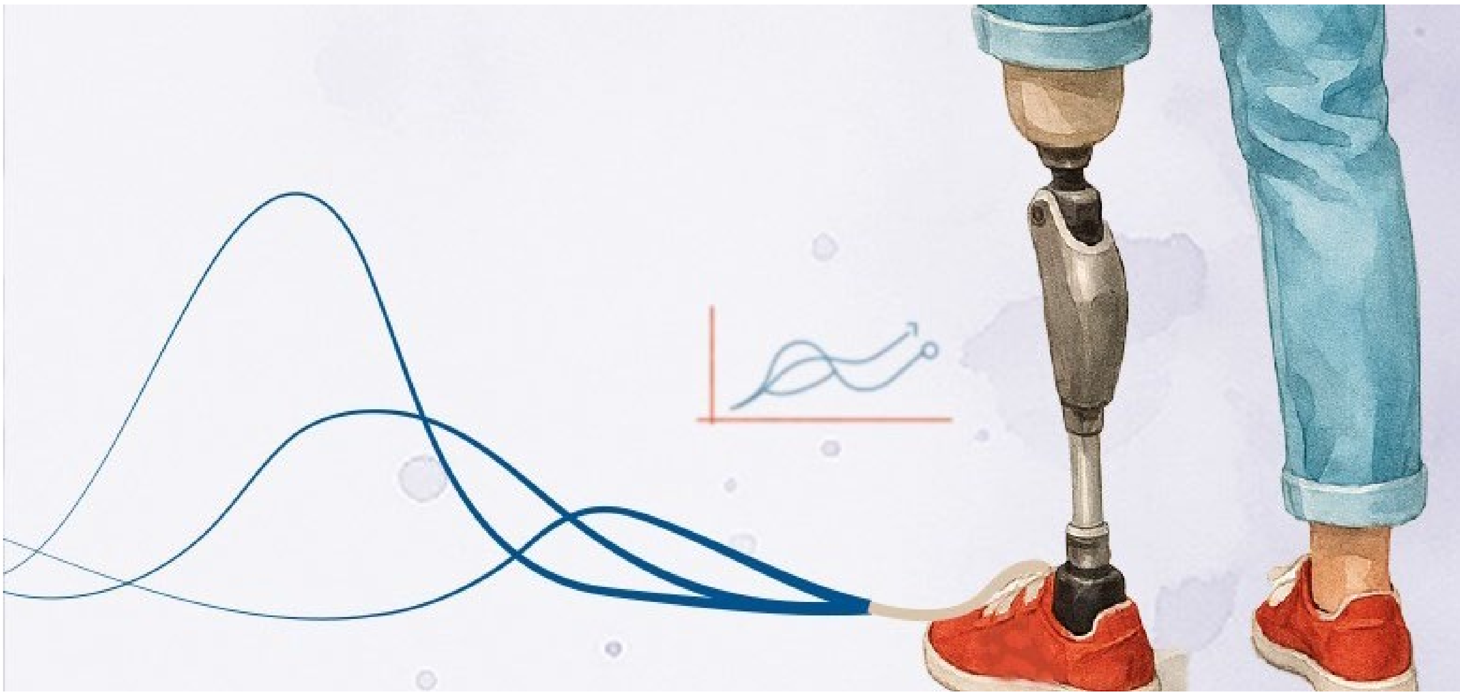

NEW OBJECTIVE FUNCTIONS FOR HUMAN-IN-THE-LOOP OPTIMIZATION
Toward personalized wearable robots and rehabilitation

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PUBLIC PHD DEFENCE FOR THE DEGREE OF
DOCTOR OF INTERDISCIPLINARY STUDIES: MOVEMENT AND SPORT SCIENCES, AND ENGINEERING SCIENCES

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ABSTRACT OF THE RESEARCH

Assistive robotic devices, such as prosthetics or exoskeletons, are designed to interact with humans. However, many devices lack sufficient knowledge about the user, which can reduce their effectiveness and decrease user acceptance. A main challenge is to increase the acceptability of these devices. One way to achieve this is by providing individualized assistance based on the user's requirements and/or user performance.

Human-in-the-loop optimization (HILO) is a method that iteratively updates device assistance while measuring and optimizing user performance. It is a powerful strategy used to personalize assistive robotic devices and improve human-robot interaction. For example, individualizing exoskeleton assistance with HILO has helped healthy individuals to significantly reduce their energy expenditure in walking.

Nowadays, HILO has been used to optimize many other physiological, biomechanical, or subjective metrics, which served as objective functions that characterize user performance. However, there is still an ongoing effort to determine the best ways to implement HILO. One of the challenges is to select a proper objective function (i.e., performance metric) that captures the complexity of human movement and can be further used in real-world environments. In this context, proposing objective functions that can explain the neuromuscular mechanisms underlying movement coordination and its relation with the natural energetic behavior of the human body would be of added value.

This dissertation explores muscle activity-based objective functions. These functions emphasize the role of muscle activity in explaining energy expenditure, and highlight how the coordination between muscles, also known as muscle synergies, plays an important role in improving motor control. We present the potential of these objective functions to improve movement efficiency and quality, and their potential to be applied in a wearable assistive robotic device or rehabilitation robotic setting.

Additionally, a self-exploratory user preference optimization for individuals with a transfemoral amputation is introduced. It allows users to explore different assistance settings and select the one that feels more comfortable. The goal is to optimize for user preference and understand whether physiological signals can uncover the underlying factors that guide individuals' preference.

In conclusion, both muscle activity-based and preference-based objective functions can contribute to HILO frameworks by supporting the personalization of robotic assistance in ways that improve acceptance, comfort, movement efficiency, and motor functionality.

CURRICULUM VITAE

Maria A. Diaz Pinilla is a doctoral student within the Human Physiology and Sports Physiotherapy research group (MFYS), who also works together with the Brussels Human Robotics Research Center (Brubotics). She obtained her bachelor's degree in Biomedical Engineering in 2016 from Universidad de los Andes, Colombia, and her master's degree in Biomedical Engineering, in the track of neural and motor systems, in 2018 from the University of Twente, The Netherlands.

She has always been very interested in the field of biomechanics, and has gained experience through various roles and research projects. In 2019, she worked as a Biomedical Research Engineer at the military school in Bogotá, Colombia. In 2020, she did an internship at the Musculoskeletal Research Group at KU Leuven, where she worked on biomechanical data analysis. Then, in 2021, she started her interdisciplinary PhD. Her research focuses on human-in-the-loop optimization strategies to improve human-robot interaction with a particular emphasis on enhancing user performance.