Project title: Design and Evaluation of a Context-Aware Multimodal Intent Detection System for Lower-Limb Assistive Exoskeletons
Proposal ID: 646975

Exoskeletons—robotic systems worn on the body—are emerging as promising solutions to help people walk, recover from injury, or perform physically demanding tasks. While once limited to science fiction or industrial use, exoskeletons are now becoming relevant in healthcare, rehabilitation, and everyday mobility support. However, most available systems still rely on narrow, rigid control strategies that fail to fully address the variability of human movement and intention.

Currently, exoskeletons often use sensors that detect motion or muscle signals (e.g., EMG) to infer what the user wants to do. These systems can be fragile in real-world settings, requiring frequent calibration and assuming consistent movement patterns. They also tend to minimize the user's agency: rather than enabling clear, active control, users often feel like they are simply reacting to the machine's behavior. This makes daily use frustrating and limits the broader adoption of these technologies.

This project addresses these limitations by designing an intelligent control system that integrates gesture, voice, touchscreen, and tactile commands with real-time motion data. The goal is to interpret what the user wants to do, not just based on a signal, but based on when and in what context it is issued. For example, the system will distinguish between a command given while standing and the same command given while walking—adjusting the exoskeleton's behavior accordingly.

The project will be carried out through laboratory experiments using a testbed exoskeleton, which allows for fast development and evaluation without full-body instrumentation. The system will be tested by adult participants with diverse backgrounds and levels of tech experience. They will complete a range of movement tasks using various control methods, while researchers measure both technical performance (accuracy, delay, signal failure recovery) and user perceptions (comfort, trust, sense of control).

This work builds on previous research conducted by the principal investigator in collaboration with Chalmers University of Technology (Sweden) and Khalifa University (UAE). Earlier efforts led to the development of four distinct control interfaces and a gesture-based motion dataset. The current project advances this foundation by focusing on adaptive, explainable intent recognition and a detailed evaluation of user experience.

The research will be divided into four phases: (1) literature and dataset review; (2) benchmarking and synthetic data augmentation; (3) development of the intent detection architecture; and (4) user studies. The approach combines quantitative methods (classification metrics, reaction time, usability surveys) with qualitative techniques (interviews, behavioral observation, and eye-tracking during interaction).

Expected results include a working prototype of the control system, a set of design guidelines, and two scientific publications. More broadly, the project will provide new knowledge on how to build intelligent, context-aware, and user-friendly interaction systems for assistive technologies. The findings will apply not only to exoskeletons but also to other wearable solutions such as prosthetics, orthotic supports, or mobility aids for older adults. The project's core contribution lies in bridging advanced robotics with the practical realities of everyday human experience—enabling more accessible, transparent, and trustworthy human–machine collaboration.