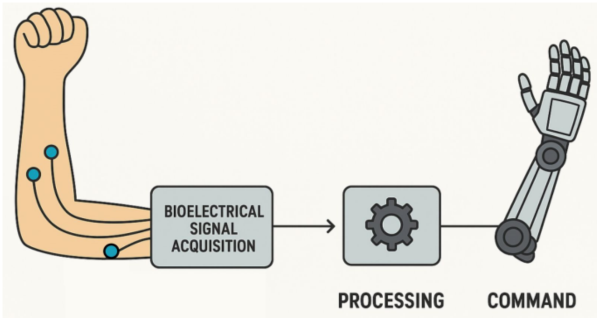
HMI for prosthetic limb control

As engineers, we bear the responsibility of developing solutions that enhance the quality of life for humanity while preserving the ecosystem in which we live. Bioelectrical engineers, in particular, strive to design advanced devices for diagnostic, therapeutic, and prosthetic purposes. Among these, limb prostheses hold a special significance, as they are intended to replicate the natural functions of lost limbs as closely as possible.



This project aims to develop a practical and reliable solution for a prosthetic limb and a human–machine interface (HMI) control system driven **solely** by bioelectrical signals—such as electromyography (EMG), electroneurography (ENG), and electroencephalography (EEG)—recorded from the human body. The system will be designed to non-invasively acquire the relevant bioelectrical signals and process them in order to generate commands that control the prosthetic limb in near real time. Within the scope of this project, the prosthetic limb may be physically represented by a robotic arm.

The project involves the design and implementation of a bioelectrical data acquisition system capable of capturing raw bioelectrical signals of interest from the operator's body. The system must comply with patient safety regulations, ensuring that any leakage current to the body does not exceed 10 µA. All components electrically connected to the body will be battery-powered and fully isolated from the mains power supply.
Once acquired, the raw bioelectrical signals are processed to generate appropriate control signals for the actuators (servo motors) of the prosthetic (robotic) arm. Specific features of the voluntarily generated bioelectrical signals are extracted and mapped to control designated servo motors, enabling targeted actions of the robotic arm. To achieve this, a range of time- and frequency-domain signal processing techniques, as well as artificial intelligence (AI)-based methods, can be explored and implemented.

After being trained to operate the designed HMI system, the operator is capable of fully controlling the robotic arm to perform fundamental manipulation tasks, including grasping, carrying, positioning, and releasing objects.

Extra features:

- Design and construction of the robotic arm are not mandatory within the scope of this study; however, groups interested may undertake it as an additional feature.
- Robotic arms with more than two fingers, each independently controllable, may be considered.
- Demonstrating the control of a robotic arm to transport a glass of water from a table top to the operator's mouth for drinking.
- Implementing wireless communication between the control system and the prosthetic arm.
- Enabling the system to execute all signal processing tasks autonomously, without the need for an external computer.