THE ANDREW & ERNA VITERBI FACULTY OF ELECTRICAL ENGINEERING

Control Robotics and Machine Learning Laboratory

TECHNION Israel Institute of Technology

Control of robotic arm using EMG sensor on upper leg

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Introduction

- Below-elbow amputees often rely on prosthetics controlled by EMG signals from damaged muscles, which can cause phantom pain.
- A robotic hand provided by Haifa 3D, combined with a newly developed control mechanism, offers improved, pain-free functionality.

Goals

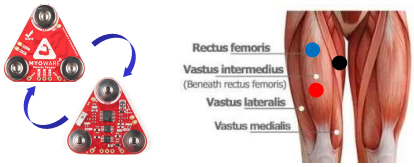
- Create a discreet user-friendly system
- Maximize the degrees of freedom for enhanced control
- Minimize Noise and capture the optimal signal

Robotic Hand

- Custom prosthetic hand using 3D printing.
- Ability to move 4 fingers
- Wrist joint rotation
- Bluetooth controlled
- Features 11 preset modes

EMG Signal

- Electromyography) signals are electrical signals produced by muscle contractions.
- They can be detected using Myoware sensors with 3 electrodes:
  - MID – middle of the muscle.
  - END – toward the neuromuscular junction
  - REF – neutral position or aligned with the line between MID and END.



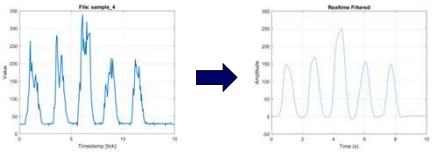
Myoware sensors \ Proper placement of the sensors on the Vastus intermedius muscle

- The strength of the signal is determined by the number of nerve and muscle fibers involved and the firing rate (frequency) of the motor units.

Signal Processing

Band Pass Filter

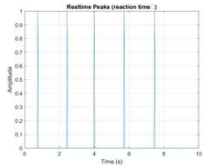
- LPF - Butterworth filter with a cutoff frequency of 0.8 Hz
- HPF - An automatic calibration algorithm detects low-activity periods (~128 samples) to estimate the DC offset



Example of filtered signal of 5 short muscle contractions

Peak Recognition

- detected when the signal crosses a defined threshold from signal rise to signal fall

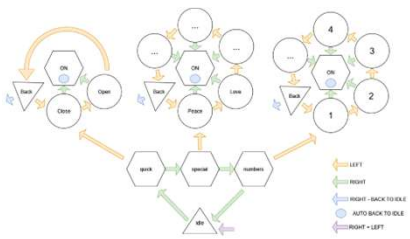


Example of recognized peaks of 5 short muscle contractions

State Machine

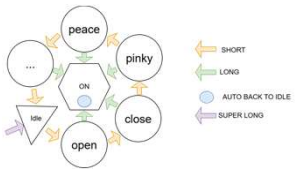
Full Version

- Controlled by a Both legs (left and right)
- Faster access to commonly used states
- Requires a longer learning period master



Simplified Version

- Controlled by a Single leg
- Easier to control for beginners
- Operating time increases significantly when increasing number of outputs

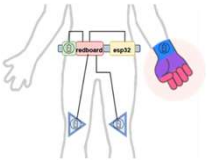


Noise Reduction

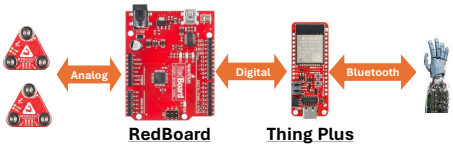
- One of the main challenges noise affecting the EMG sensors, including sampling noise and inductive interference.
- Measures taken:
  - Wire Braiding
  - Floating Circuit
  - Anti-static Bags
  - Faraday Cages
  - Shielded wire with internal metallic shielding
  - Optical isolator
  - Electrode placement – muscle covered by a thing subcutaneous fat layer

Hardware

- fully wearable system. Features a floating circuit.



Components



- Redboard\Arduino Uno - sampling the EMG signal and noise filtering and peak recognition
- Thing Plus\ESP32-wroom - State machine and Bluetooth communication

Results

- Reliable System when seated or standing still.
- Non-functional during walking
- Good Recognition of both long and short ,muscle contractions
- Operation become easier with practice

Conclusions

- Best used as part of a multi-sensor system
- Long contraction detection might enable fine control
- The sensors were found overly sensitive to noise
- A dual-core processor could replace the two current microcontrollers

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