Lab 3: Biopotential

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1. Introduction

Electromyography (EMG) is a technique used that measures electrical activity of muscles and nerves. Moreover, healthcare professionals rely on this diagnostic test to assess the health and function of the muscle contractions and neuromuscular function.

This experiment aims to utilize an EMG sensor to capture muscle signals, analyze the data in MATLAB, and control LEDs based on muscle activity levels. The analysis involves real-time data plotting and threshold-based LED activation to indicate different levels of muscle engagement. MATLAB was employed for data collection and visualization, interfacing with an Arduino Leonardo board. MATLAB was crucial for real-time data acquisition, plotting EMG signals, and enabling decision-based LED control.

Key concepts:

Neuromuscular system: Combination of the nervous system and muscle that allows for movement, posture, and breathing.

Electrodes: A device that carries electrical signals from muscles, organs, and other parts of the body to recording devices

Electrical activity: The measurement of electrical properties if cells and tissues

2. Methods and Materials

Materials:

- Arduino Leonardo
- Myoware EMG sensor
- Breadboard and jumper wires
- Three LEDs (connected to digital pins D9, D10, D11)
- Resistors
- MATLAB with Arduino Support Package
- Electrodes

Procedure:

1. **Hardware Setup:** The Myoware EMG sensor was connected to the Arduino via the analog input pin (A0), while three LEDs were connected to digital output pins D9, D10, and D11. Resistors were used to limit the current flow.
2. **Code Implementation:** An Arduino-MATLAB script was written to:
    - Read real-time muscle signal data from the sensor.
    - Compare sensor readings against predefined threshold values.
    - Activate corresponding LEDs based on muscle activity levels.

- Continuously plot the EMG signal values in real time over 30 seconds.

3. **Data Collection:** The experiment ran for 30 seconds, recording muscle activity during three different states (resting, weak contraction, strong contraction). Furthermore, the depending on the state, the corresponding LED would serve as the activation point.

3. Results

The experiment produced real-time EMG signal graphs that displayed muscle activity fluctuations over a 30-second period. Below are the recorded results:

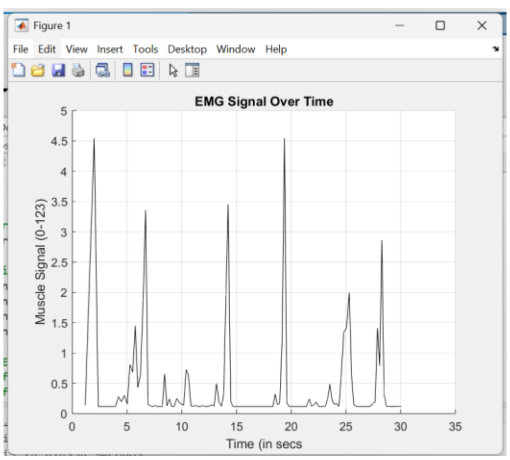

Figure 1. EMG Signal Over Time: Initial Data Collection

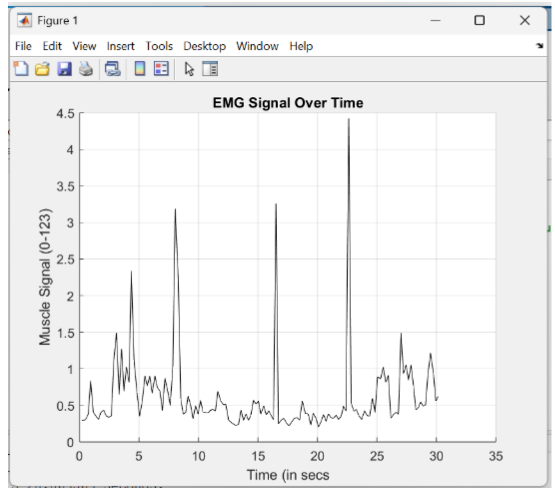

Figure 2. EMG Signal Over Time: Refined Data Collection with Clearer Signal Patterns

1. EMG Signal Over Time
   a. The figures show variations in muscle signal strength, with distinct peaks representing strong contractions and lower values indicating rest states.
   b. A comparison between both figures highlights how sensor placement and environmental factors influence signal clarity. The refined data in Fig. 2 demonstrates improved peak detection and noise reduction.
   c. As expected, these findings align with typical applications where EMG sensors are employed; however, in real world applications that rely on precise EMG signals like gesture recognition, signal amplification, filtering techniques, etc. are utilized to refine signal interpretation.

4. Discussion

The results demonstrate that the EMG system successfully captured and processed muscle activity. The plotted data showed clear trends in muscle contractions, with LED responses matching the corresponding threshold criteria. The experiment validated the feasibility of using an EMG sensor for real-time muscle monitoring and external device control.

However, many challenges were encountered during the experiment:

1. **Code Execution Issues:** Initially, the MATLAB script did not function as expected due to incorrect pin configurations and syntax errors. Debugging was necessary to ensure proper communication with the Arduino.
2. **LED Malfunction:** The LED pins were unresponsive at first because the jumper cables connecting to them were mistakenly grounded. Once this wiring issue was corrected, the LEDs functioned correctly.
3. **Signal Accuracy:** The EMG sensor produced inconsistent readings at times due to faulty components and improper electrode placement. Adjusting the sensor placement on various positions on the forearm improved signal reliability.

Despite these obstacles, the experiment was successfully completed, and the system effectively demonstrated how EMG signals could be processed in real time. Future improvements could involve filtering out noise from the signal and enhancing the stability of LED response through software-based signal smoothing techniques.

5. References

[1] C. L. Ng et al., "A Flexible Capacitive Electromyography Biomedical Sensor for Wearable Healthcare Applications," in IEEE Transactions on Instrumentation and Measurement, vol. 72, pp. 1-13, 2023, Art no. 4007213, doi: 10.1109/TIM.2023.3281563.

[2] “MyoWare 2.0 Muscle Sensor,” Sparkfun Electronics, https://www.sparkfun.com/myoware-2-0-muscle-sensor.html (accessed Feb. 21, 2025).

https://youtube.com/shorts/Sqy11DbwZLs?si=D0KuJXi7F3JgLYm8