EMG Assignment

Exercise 1 - Matlab

Goal: Understand the fundamentals of EMG signal pre-processing.

Exercise Description:

1. Upload “ES1_emg.mat”
2. Filter the raw EMG signal (band pass filter, 30-450 Hz). It's recommended to use an FIR filter. To compensate for the phase delay, utilize the “filtfilt” function.
3. Rectify the signal
4. Compute the envelope (low pass filter, 3-6 Hz)
5. Down-sample the signal

Questions to Address:

Question A: Why is the down-sampling performed after the envelope computation?

Question B: Based on the motion signal, when does the muscle activation commence in relation to the movement?

Submission Guidelines:

Submit the Matlab code (with comments) to your group channel on Teams. The code should automatically generate the following figures (preferably as a single figure with three panels):

1. Raw EMG signal overlaid with the filtered signal, plotted in a different color.
2. Rectified EMG signal overlaid with the envelope, plotted in a different color.
3. Movement signal overlaid with the envelope signal (plus answers to questions A and B).

Optional - You may use live scripts for this assignment. If you decide to do so, please upload both the code and a PDF printout.

Exercise 2 - Simulink

Goal: Learning the basics of EMG-based control. You will learn to manipulate a cursor on the screen using EMG signals.

Exercise Description:

1. Start by utilizing the provided .wrl file with the VRsource input block to display 8 target points on the screen in addition to a cursor.
2. Control the cursor's movement on the screen by processing the readings from the four muscles in the "ES2_emg.mat" file (these muscle data have been normalized based on maximal voluntary contraction, scaling the values relative to the average obtained from 5 maximum contractions). The goal is to reach the targets positioned in the four cardinal directions. To achieve this, map the EMG signals from the muscles to cursor movement based on predefined thresholds. For instance, when a muscle contracts beyond a specified threshold, the EMG signal is translated into cursor movement in a corresponding cardinal direction (tip: use one muscle to move the cursor up, another to move it down). A target is reached when the muscle contraction surpasses a chosen threshold.
   Note: Before initiating any cursor movement, it is essential to preprocess the EMG data real-time (noisy signals).

3. How can you reach the other 4 direction displayed on the screen? Determine and implement a method to reach the remaining four targets in the diagonal directions.
4. Can you think about a different way to map the muscles and be able to reach all 8 targets with the activation of these muscles? Explore an alternative mapping approach between muscles and cursor movement that enables reaching all 8 targets. Identify any potential drawbacks associated with this alternative mapping method.
5. Can you think of a different way to map the EMG activity to control of the cursor? There is no need for implementation, just answer the question, motivating your answer.

Submission Guidelines:

Please submit the Simulink files and the answers to the previous questions to your group channel on Teams. We will run them and want to see the cursor moving and reaching the targets, simulating real-time acquisition of muscle activity and related real-time cursor control for cases 1, 2, and 3. Please submit separate Simulink projects for each case.

Optional - You can ask the TA to use the EMG system and try in real time with your muscles. This is for your enjoyment. It would not influence your marks.