BIOMEDICAL ROBOTICS

EMG Assignment

Master of Science Robotics Engineering

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Preface

The work is based on EMG signals to which to learn the basis of (super simple example of EMG-based control). Also, using the .wrl file with the VRsource input block to display 8 targets and a cursor and pre-processing the EMG data (noisy signals).

Acknowledgements

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Abstract

This assignment report is about the ***learning the basis of EMG pre-processing & super simple example of EMG-based control****, and to determine about the EMG signal behaviour. The specific goal, in this case, is to know the implementation of EMG signal. Also,* ***Using the .wrl file with the VRsource input block to display 8 targets and a cursor*** *&* ***Pre-processing the EMG data (noisy signals)****. This report brings light to* ***EMG Signal pre-processing****. Furthermore, the purpose of this report is to provide the approaches used during the development of simulink model, matlab code, and implementation of the same. For this assignment,* ***MATALAB IDE, MATLAB Simulink*** *is used.*

Contents

1 Introduction

EMG preprocessing is essential for accurate and reliable analysis of EMG signals, and it is a critical step in developing EMG-based control systems. Here is a super simple example of an EMG-based control system:

Imagine we have an EMG sensor placed on your forearm, and we want to use the signal from the sensor to control the movement of a robotic arm. The EMG signal from our forearm will contain information about the activation of the muscles in our forearm, which can be used to control the robotic arm.

The first step in developing the EMG-based control system is to preprocess the EMG signal. This can involve filtering, rectification, normalization, and feature extraction, as discussed in the previous answer.

Once the EMG signal has been preprocessed, the next step is to convert the signal into a control signal that can be used to control the robotic arm. This can be done using signal processing techniques such as thresholding or pattern recognition.

For example, a simple threshold-based control system might involve setting a threshold level for the EMG signal, and when the signal exceeds that threshold, the robotic arm will move in a certain direction. Alternatively, a more sophisticated pattern recognition-based control system might involve training a machine learning algorithm to recognize specific patterns in the EMG signal and use those patterns to control the robotic arm.

Overall, EMG-based control systems have the potential to provide a natural and intuitive way for people with disabilities or injuries to control assistive devices or prosthetics. However, developing an effective EMG-based control system requires careful consideration of the signal processing techniques, control algorithms, and user feedback, among other factors.

2 Methodology

2.1 Exercise 1: MATLAB IDE

The EMG pre-processing methodology involves a series of steps aimed at filtering, rectifying, and computing the envelope of the EMG signal. To reduce unwanted noise and artifacts, the signal is band-pass filtered using an FIR filter with a range of 30-450 Hz. Phase delay is recovered using 'filtfilt' to avoid distortion. The filtered signal is then rectified to obtain a full-wave signal. The envelope of the signal is computed by low-pass filtering with a cutoff range of 3-6 Hz. Downsampling the envelope is done to reduce the data size. To determine the onset of muscle activation, the EMG signal is analyzed, and its temporal relationship with the motion signal is assessed.

Description of the assignment:

- Apply a bandpass filter to the EMG signal to remove unwanted frequencies (e.g., 20-500 Hz).
- Rectify the filtered signal to remove negative values.
- Smooth the rectified signal using a moving average or low-pass filter to remove high-frequency noise and extract the envelope of the signal.
- Normalize the envelope using a suitable method (e.g., peak amplitude or baseline subtraction).
- Lastly, downsample the signal to reduce computational load or data storage requirements.

These pre-processing steps are necessary to improve the signal-to-noise ratio and extract relevant features from the EMG signal, such as onset and offset times, peak amplitudes, and duration of muscle activation.

2.2 Exercise 2: MATLAB Simulink

To move the cursor on the screen using EMG signals, the first step is to preprocess the EMG data and map the signal amplitude to the cursor position in the four cardinal directions. By setting a threshold, the cursor will move in the corresponding direction when the EMG signal exceeds a certain value. To reach the other four directions on the screen, one can map the EMG signals to diagonal movements by combining the signals from two muscles. Another approach is to use a pattern recognition algorithm to classify different hand gestures or movements based on the EMG signals, but this method may require more training and could be more prone to errors. Alternatively, one can use proportional control where the cursor position is proportional to the amplitude of the EMG signal, but this may require more advanced signal processing and could be more difficult for users to control.

Description of the assignment:

- Load the .wrl file with the VRsource input block to display 8 targets and a cursor in a virtual environment.
- Acquire EMG data from a muscle using an EMG sensor.
- Apply pre-processing to the EMG data to remove noise and extract relevant features (e.g., envelope).
- Use the envelope of the EMG signal to control the movement of the cursor in the virtual environment.
- Define a control strategy (e.g., threshold-based or proportional control) to map the EMG signal to the cursor movement.
- Test and refine the control strategy to optimize performance (e.g., accuracy and response time) and minimize errors (e.g., false positives and false negatives).

This super simple example of EMG-based control demonstrates how pre-processing is essential to improve the quality and reliability of the EMG signal, which is used as an input to control a virtual cursor. The pre-processing steps can vary depending on the characteristics of the EMG signal and the requirements of the control strategy, but typically involve filtering, rectification, smoothing, and normalization. The control strategy can also vary depending on the application and the user's needs, but should be designed to provide intuitive and accurate control of the virtual cursor using the EMG signal as the input.

3 Result

3.1 Result of Exercise 1

In summary, the pre-processing steps for EMG signals include filtering, rectification, and envelope extraction. The envelope is computed after rectification and low-pass filtering to remove noise and negative values. Down-sampling can be applied to the envelope to reduce data size. The onset of muscle activation typically occurs before the movement, and can be determined by analyzing the EMG signal and aligning it with the motion signal. The exact timing of muscle activation depends on various factors such as the type and direction of movement, and individual differences in muscle recruitment patterns.

A) The envelope of the muscle signal is computed after rectification and low-pass filtering because these steps are necessary to remove negative values and high-frequency noise, respectively. The envelope represents the amplitude modulation of the signal and can be used to extract features such as onset and offset times, peak amplitudes, and duration.

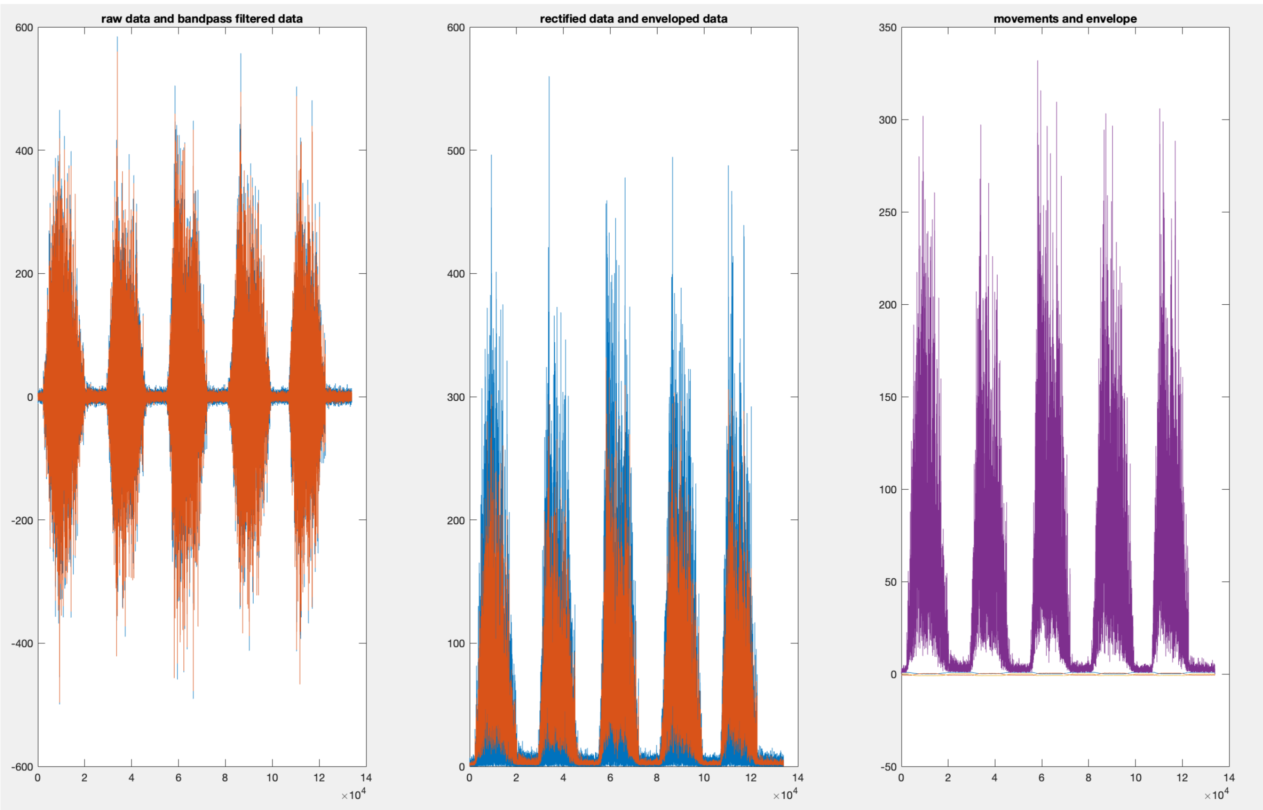

Figure 1: Exercise 1 Result

B) The muscle activation starts before the movement, typically a few hundred milliseconds to a second before. This is called the pre-activation phase and it prepares the muscles for the upcoming movement. The onset of muscle activation can be determined by analyzing the EMG signal and looking for the first significant deviation from the baseline activity. The motion signal can be used to align the EMG signal with the movement and determine the temporal relationship between them.

3.2 Result of Exercise 2

To control the cursor on the screen using EMG signals, one can preprocess the raw data using filtering and rectification techniques and then map the EMG signals to cursor movements in the four cardinal directions using threshold-based control. To reach the other four directions, one can map the EMG signals to diagonal movements by combining signals from two muscles. Another approach is to use pattern recognition algorithms or proportional control, which provide more intuitive and continuous control but may require more advanced signal processing techniques and may be more difficult for some users to learn and control accurately.

1) Simulink model when cursor moving in ± X & ± Y direction.

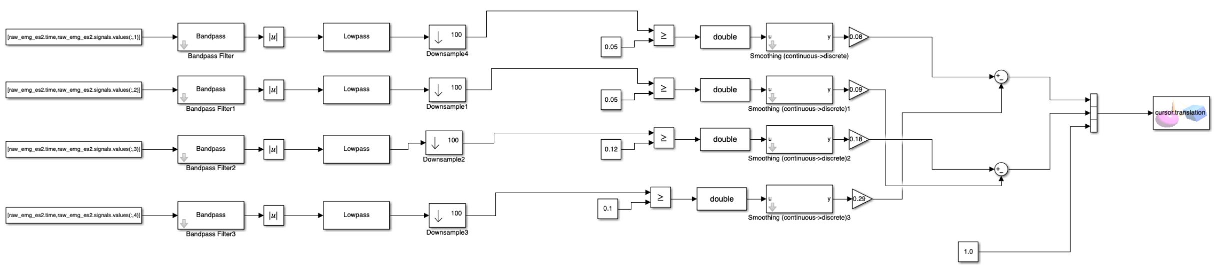

Figure 2: Cursor in ± X & ± Y

2) Simulink model when cursor moving in diagonal direction.

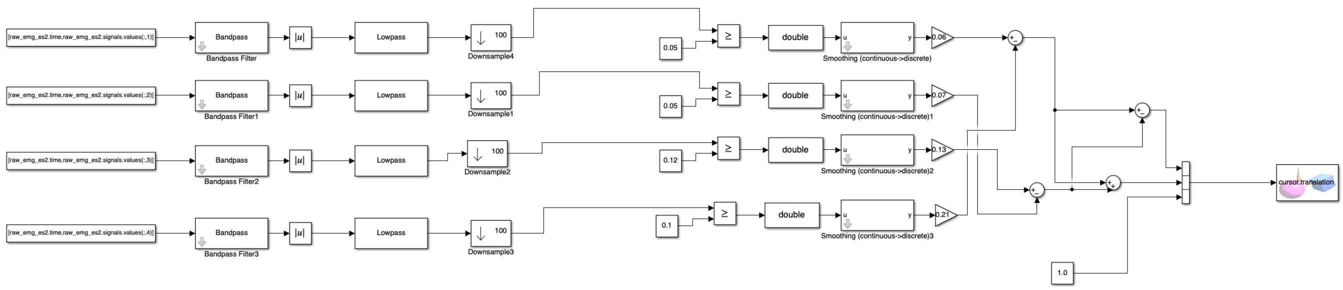

Figure 3: Cursor in diagonal direction

3) Simulink model when cursor moving in all 8 direction.

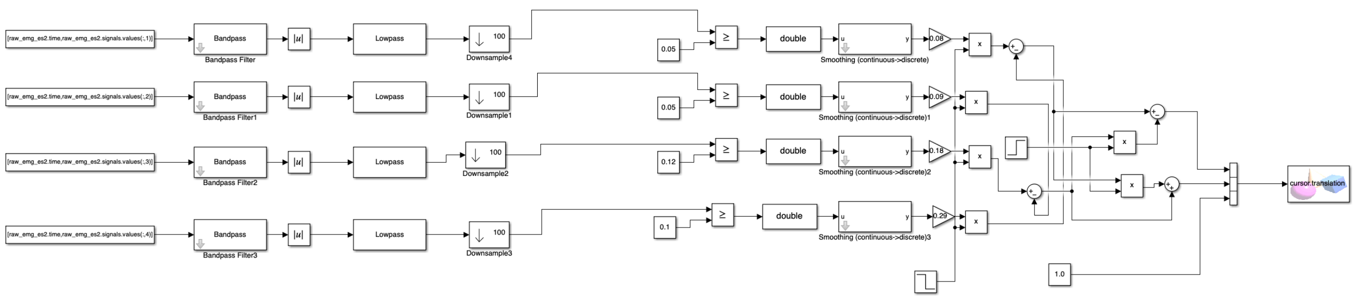

Figure 4: Cursor in all 8 direction

4) Another way to map the EMG activity onto the control of the cursor could be to use a proportional control approach. Instead of using threshold values to map EMG signals onto cursor movements, the amplitude of the EMG signal could be directly proportional to the movement of the cursor. This would require a more sensitive and precise control system, as small changes in the EMG signal would correspond to small changes in the cursor movement. The drawback of this approach is that it may be more difficult for the user to control the cursor accurately and consistently.

4 Conclusion

In conclusion, this assignment aimed to introduce the basics of EMG pre-processing and EMG-based control through a super simple example of controlling a cursor on a screen using EMG signals. The assignment involved pre-processing noisy EMG signals, mapping EMG signals to cursor movements in the four cardinal directions using threshold-based control, and exploring alternative ways to control the cursor such as diagonal movements and pattern recognition algorithms. Additionally, we discussed the use of proportional control as an alternative approach that provides more intuitive and continuous control but may require more advanced signal processing techniques and may be more difficult for some users to learn and control accurately. Overall, this assignment provides a foundational understanding of the key concepts and techniques involved in EMG pre-processing and EMG-based control that can be applied to more complex and sophisticated applications in the field of electromyography.