Improvement of Myoelectric Underactuated Hand Prosthesis

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Introduction

The project's objective is classification of EMG signals to control a prosthetic hand. By accurately decoding these signals, we aim to enable the prosthetic to replicate complex hand gestures, thereby offering users with limb loss a more natural and intuitive experience.

Signal Acquisition

To obtain an EMG signal, the raw signal needs to be filtered and amplified. This process include an instrumentation amplifier, a high-pass filter, and a low-pass filter.

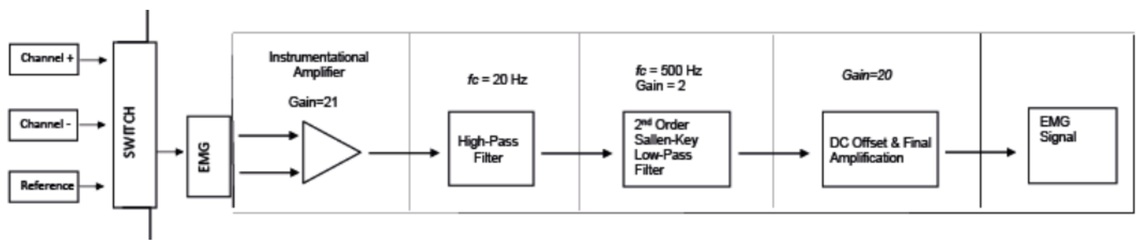

Figure 1 – EMG signal processing block diagram [1].

Feature Extraction

Mean Absolute Value (MAV) : $MAV = \frac{1}{N}\sum_{i=1}^{N}|x_i|$

Zero Crossings (ZC):

$$ZC = \sum_{i=1}^{-1} \begin{cases} 1, & if(x_i \times x_{i+1} < 0) \cap (|x_i - x_{i+1}|) > threshold) \\ 0, & otherwise \end{cases}$$

Slope Sign Changes (SSC):

$$SSC = \sum_{n=2}^{N-1} f[[(x_n - x_{n-1}) \times (x_n - x_{n+1})]]$$

$$f(x) = \begin{cases} 1, & x > threshold \\ 0, & otherwise \end{cases}$$

Waveform Length (WL): $WL = \sum_{i=1}^{N-1}|x_{i+1} - x_i|$

Root Mean Square (RMS): $RMS = \sqrt{\frac{1}{N}\sum_{i=1}^{N} x_i^2}$ [2]

Support Vector Machine (SVM) Classification

The diagram shows the steps of a gesture recognition system using an SVM model:

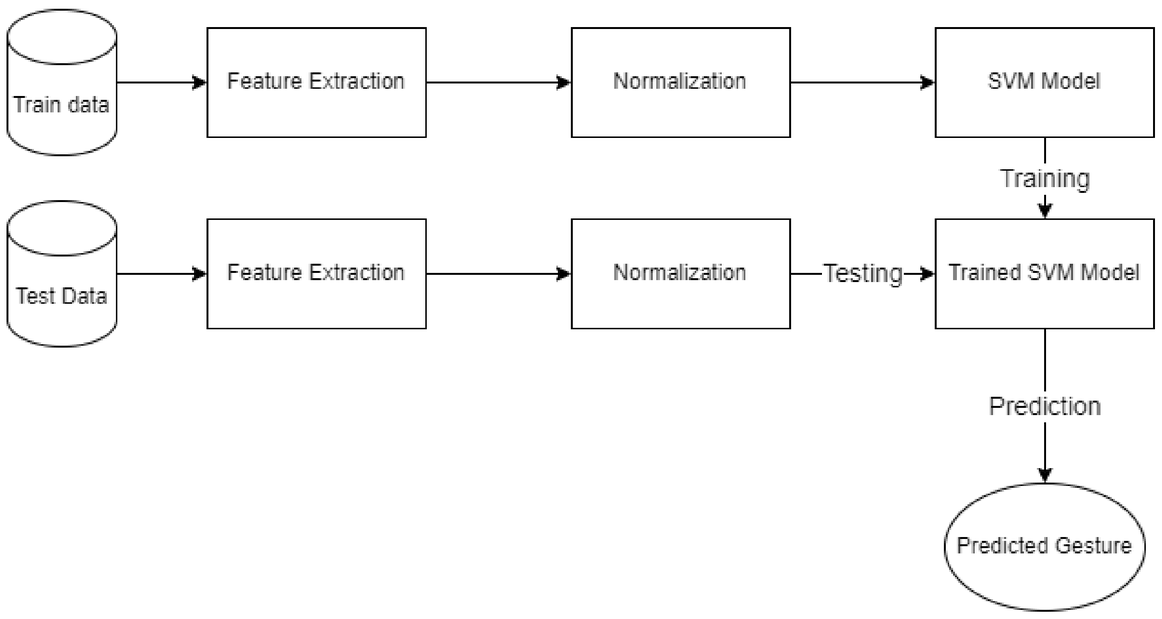

Figure 2 – SVM model block diagram.

System Design

Based on the classification results from the artificial intelligence model, the STM32 microcontroller activates the servo motors and makes the desired hand movement.

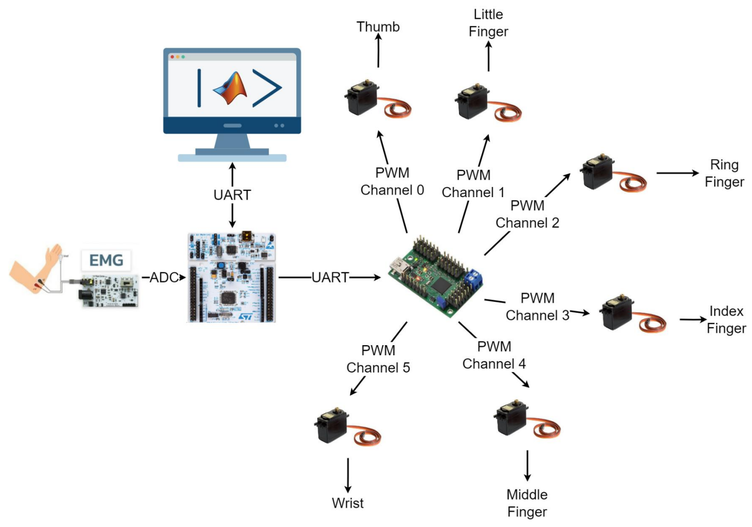

Figure 3 – Overall system.

Results and Discussion

20% of the overall data was used to examine the model's accuracy. The model was fed after being trained, and the results were plotted onto a confusion matrix. The model's accuracy was calculated to be 92.5%.

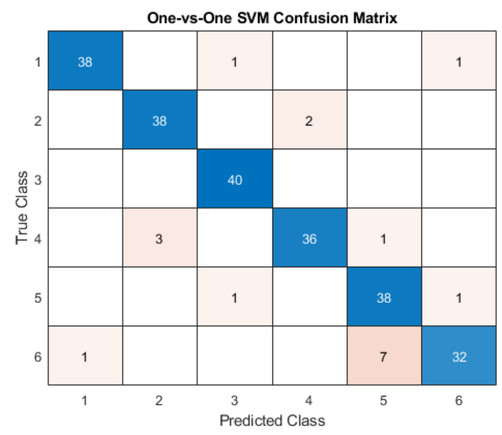

Figure 4 –SVM confusion matrix.

The prosthesis hand performs 5 different gestures.

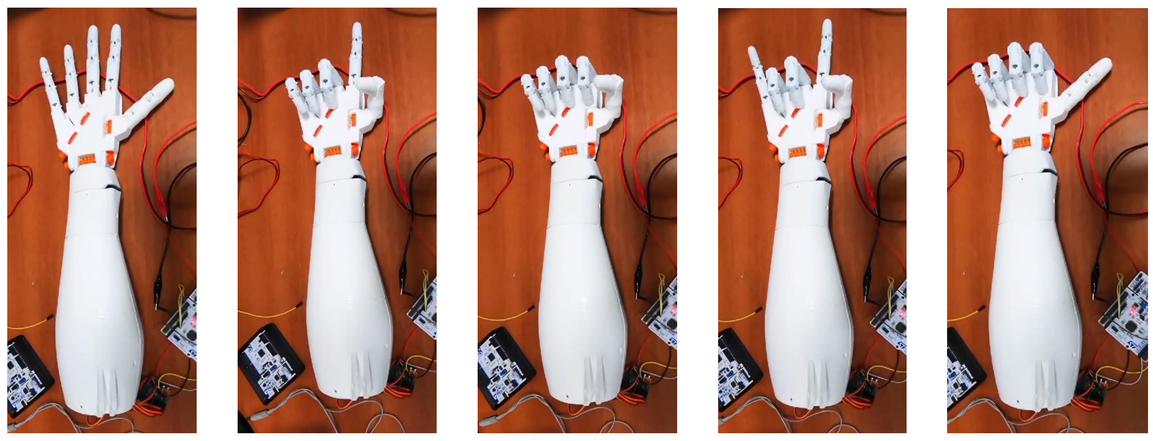

Figure 5 – Performed gestures.

References

- [1] Mam Sense – MaM High Tech. https://www.mamhightech.com/portfolio/mam-sense-eog-emg-ecg-sensor/ (Accessed: January 1, 2024).
- [2] Phinyomark, A. et al. (2011) 'Evaluation of EMG feature extraction for movement control of upper limb prostheses based on class separation index,' in IFMBE proceedings, pp. 750–754. https://doi.org/10.1007/978-3-642-21729-6_183.

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