Signal Analysis and Processing

Review - III

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EMG SIGNAL ANALYSIS

Abstract

A person's limb is the most important part of the body to perform actions to interact with the normal world. A lot of people in this world are without limbs, the reasons being many. With the advancing technology many people have come with unique solutions to combat this problem. For instance, scientists use brain signals to simulate the movement of limbs. This will allow patients to produce movements directly through their thoughts. The research is still under development. Electromyography is one of the emerging technologies where the electrical activity of muscle tissue is recorded using electrodes, inserted into the muscle and loaded into robotic arms. In this project we focused on processing and implementing EMG signals.

Any signal can be easily analysed in frequency domain using fourier transforms. So we first extracted raw EMG data from online and used fourier transform and shifting to convert to frequency domain. We used a bandpass filter to remove noise in the EMG signal and converted back to time domain. We analysed the signal by getting its MAV(mean absolute values) and plotted it using MATLAB. To demonstrate the signal we used stepper motor integrated with arduino. We also trained a model using the dataset for classification of the EMG signal . This trained model can be used to classify a new input emg signal.

Introduction

Electromyography (EMG) is a modern technological solution to treat amputated patients who are in dire need of limbs in their day-to-day lives. EMG is the recording of electrical signals of muscle tissue which are extracted by inserting electrodes or sensors on the surface of the skin or directly into the muscle. Any movement in the muscle will be recorded and a dataset is created for analysing and implementing into robotic arms. The stronger the contraction of muscles, the higher the voltage amplitude is recorded into the systems.

Surface electrodes are the key in extracting raw data from the muscles of the body. One of the disadvantages of using EMG is the noise generated is difficult to remove. Many measures are being taken in order to minimize the noise especially electrical noise picked up from surrounding power sources. The noise due to electromagnetic radiation is also difficult to remove. Some noise like generated inside the system cannot be removed hence the experiments are done frequently to remove the error.

The raw data obtained from the electrodes or sensors is stored as a dataset through which the signal is analysed carefully and removing unnecessary noise through filters, calibrating properly to obtain the desired results. After obtaining the results the dataset is trained using logistic regression model so that any future input will give a response.

In medication, a prosthetic implant is a gadget that replaces a missing body part, which might be lost through accidents, birth defects. Prostheses are planned to reestablish the typical elements of the missing body part. This project also aims to prototype this prosthetic limb in a cost efficient and a better way using simple yet very powerful developing platform of MATLAB.

Objective

- Processing the signal acquired from the EMG sensor using Fourier Transform or, the design and application of digital filters with powerful tools that MATLAB provides and then sending the processed signal to a prosthetic arm's servo motors which should be able to replicate the human arm with the best accuracy possible.
- Here in the project we are using ready made dataset available from online data banks .
- Making a prosthetic/robotic arm to simulate a human using the filtered EMG signals whose basic action is closing and opening of the fists to hold objects.
- This will help a lot of people to gain mobility and help them enjoy their life like normal people.
- Moreover we are implementing ML(Machine Learning) with Python for the Data set training.
- The main aim of using ML is to train data according to the input voltage given i.e. when we give real time data the ML algorithm will detect the further movement of the limb as per its training and will perform the further movements.

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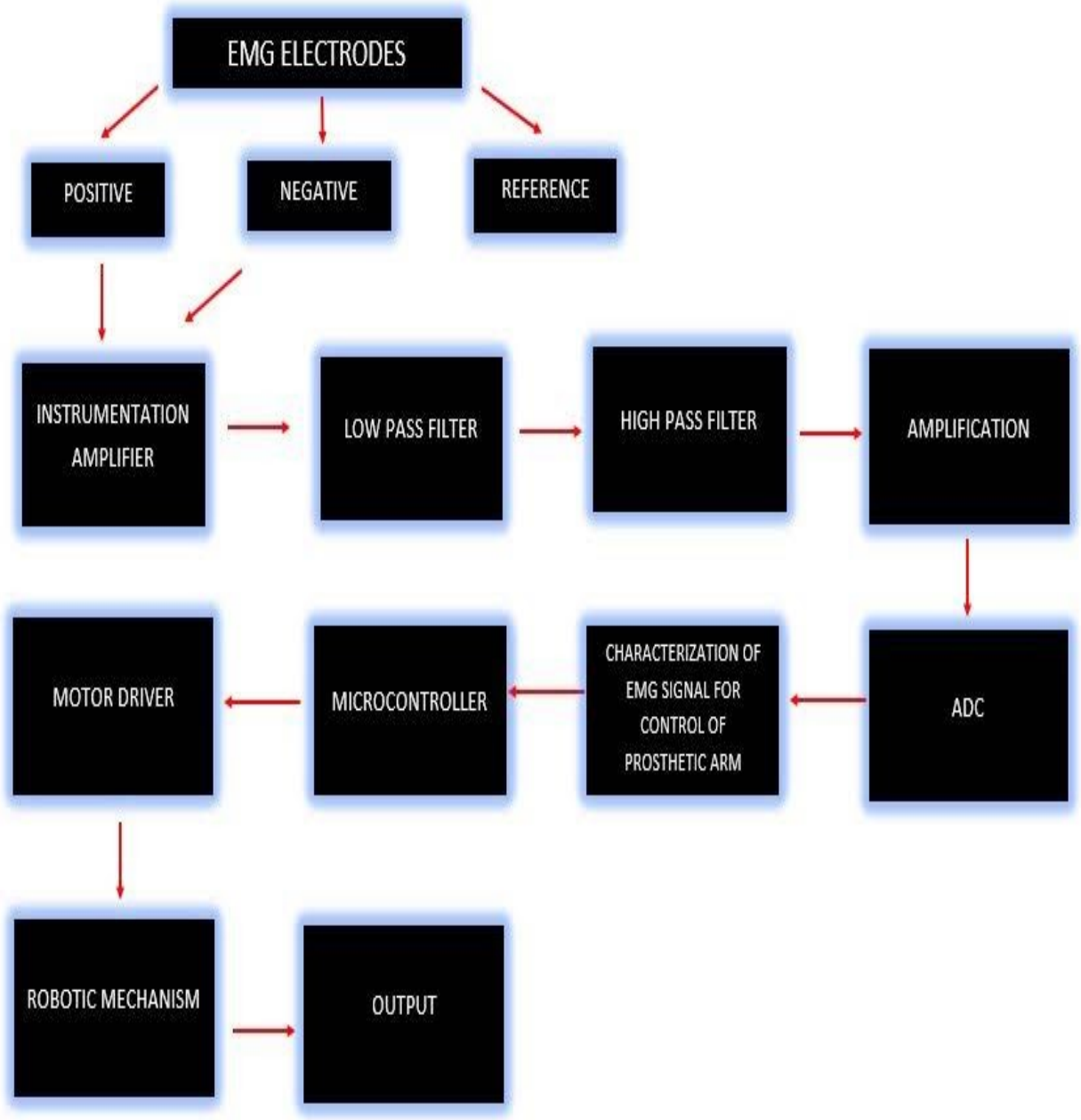
Block Diagram



Experiments carried out while making of the project

1. SELECTION OF DATASET

This was a very crucial and the very first step while thinking of the project. The first thing was to select the right dataset for this project. The dataset was obtained from the website http://zju-capg.org/myo/data/ . Normally the EMG sensor what we use for the fingers detection has 3 electrodes even with the simplest s ensor also. The raw dataset 001 was downloaded and the 001-001 dataset was used for preprocessing and analyzing the emg signals. The dataset consists of 104600x128 which corresponds to 104600 samples and an array of 128 electrodes for increased accuracy while capturing the emg signals. According to the website the signal was sampled at a sampling frequency of 1000 hz.

The rms value of this data in row wise is taken to generate a time sampling sequence of 104600 samples. The data was amplified by a factor of 1000 and the raw emg signal was plotted.

2. FOURIER TRANSFORM

The term Fourier transform refers to both the frequency domain representation and the mathematical operation that associates the frequency domain representation to a function of time. The term Fourier transform refers to both the frequency domain representation and the mathematical operation that associates the frequency domain representation to a function of time.

Fourier transform is an important part of processing any signal since it tells us about the different frequencies and their different proportions. We have used this property if fourier transform here in order to distinguish between the noise frequency and the useful data . When we take the fourier transform of the signal and represent it on a graph we can find the noise frequency. In order to filter out this output we are making a band pass filter which allows the noise free frequency to pass through it.

3. BAND PASS FILTER(Generation and its Implementation)

Band Pass Filters are used to isolate or filter out certain frequencies that lie within a particular band or range of frequencies. The conditioning of the signal we knew about the implementation of Band Pass Filter in particular. So we stuck to the same plan and generated a band pass filter in MATLAB.

In order to eliminate the noise produced while acquiring the signal, we are using a band pass filter. The cutoff frequency of the band pass filter is decided from the raw data that is obtained from the electrode after plotting the fourier transform of the raw data. After Passing it through a Band Pass filter we are taking the inverse fourier transform of the band passed signal inorder to get the usable signal. While researching about the frequency range of EMG signals, we found out that the most significant range of frequency of emg signals is 50-450 Hz. S0, a Band pass filter of 50-450 Hz was generated to filter the EMG signal from the noise.

4. INVERSE FOURIER TRANSFORM:

Inverse Fourier Transform of the signal is taken to get back the EMG signal from the Frequency domain to time domain. This signal in time domain is considered to be free of noise and to be most effective to replicate a robotic prosthetic limb.

The Mean Absolute value of this time domain signal is taken to analyze the brain impulses sent to recognize motion of the limb. A threshold value can be selected to decide whether there is movement or not.

5. SERVOMOTOR AND ITS ROTATION

This is one of the most important parts of this project. For the limb movement we are using Arduino UNO board to move the servo motor.To control and to code the Arduino the Arduino Matlab library was used . The angle through which our limb moves

was taken as reference . As because the limb can move through a full angle rotation from 0 to around 135 degrees.

So for the servo motor the full rotation corresponds to the 180 degrees which in the code corresponds to 1. According to the dataset used, the threshold voltage to detect the movement changes. So by unitary method we got the the value corresponding to 135 degrees. So, 135 is the maximum rotation of the Servo Motor.

6. Classification of EMG signal using ML

To classify the emg signal, we have trained a logistic regression model to classify the signal into high or low output. The dataset of the emg signals and the gesture data which corresponds to movement as 1 and rest as 0 which was recorded during the data acquisition was used to train the ML model to further classify the EMG data obtained from a different person.

Individual Contribution

1. Ketan Akul :
   - Finding the Dataset library
   - ML algorithm and Dataset training
   - Working with the Arduino Library
   - A Lot of Hard Work
   - Experimenting with the matlab code to get the desired output.
2. Chaitanya Krishna :
   - Finding the Dataset library
   - ML algorithm and Dataset training
   - Performing servo motor operations
   - Experimenting with the matlab code to get the desired output.
   - A Lot of Hard Work
3. Aakar Mutha :

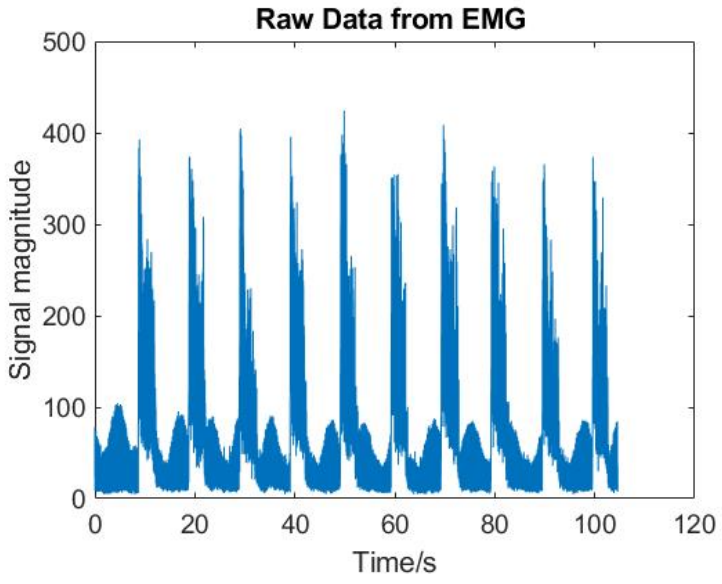
Finding the Dataset library
Making the Final review Report
Getting Various inputs for the project along with the required Research papers
A Lot of Hard Work
Experimenting with the matlab code to get the desired output.

4. Shwetank M :

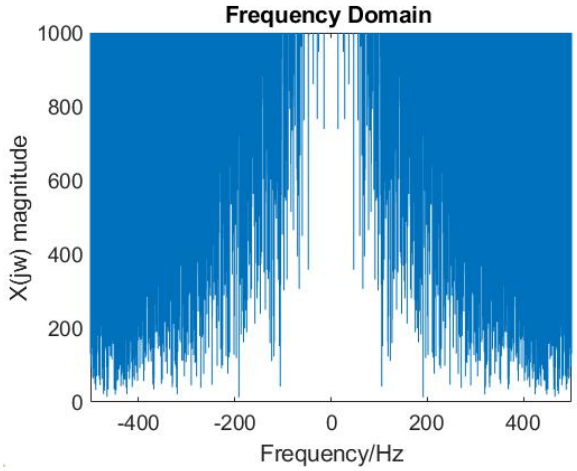
Finding the Dataset library
Making the Final Report
Code Scavenging for the different operations
A Lot of Hard Work
Experimenting with the matlab code to get the desired output

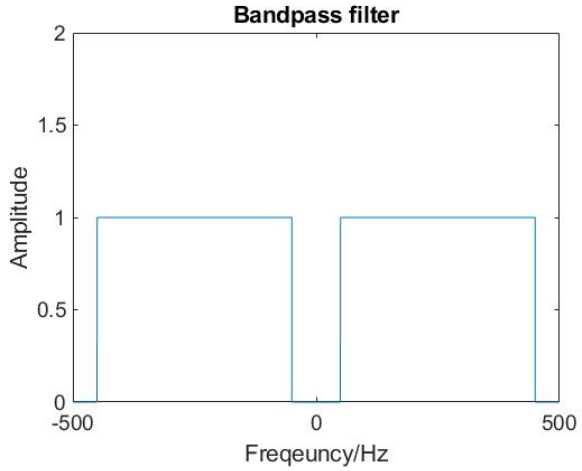
Results:

The raw EMG data was processed using fourier analysis and band pass filter was used to remove the noise from the EMG signal to produce a processed EMG signal without noise which can be further analyzed to control prosthetic limbs of a disabled person.

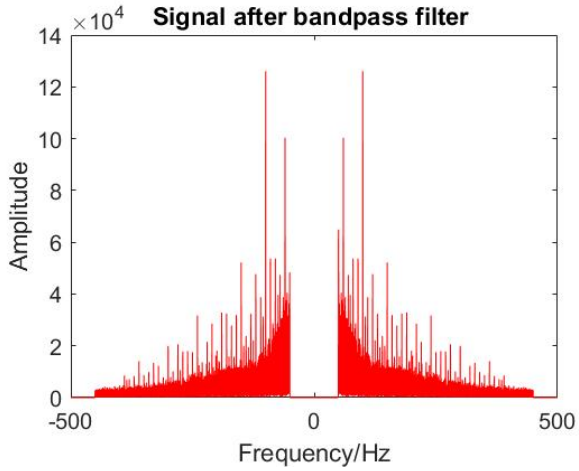


Raw EMG data(above image). Raw data in frequency domain(below).

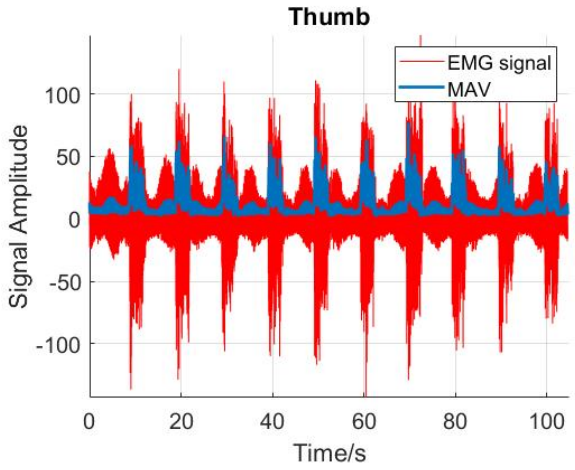




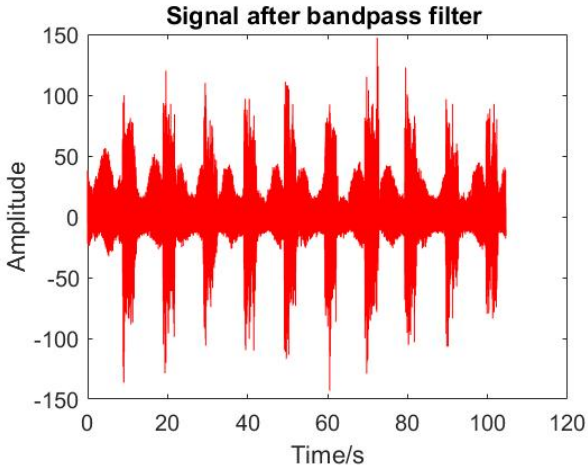
Band Pass filter



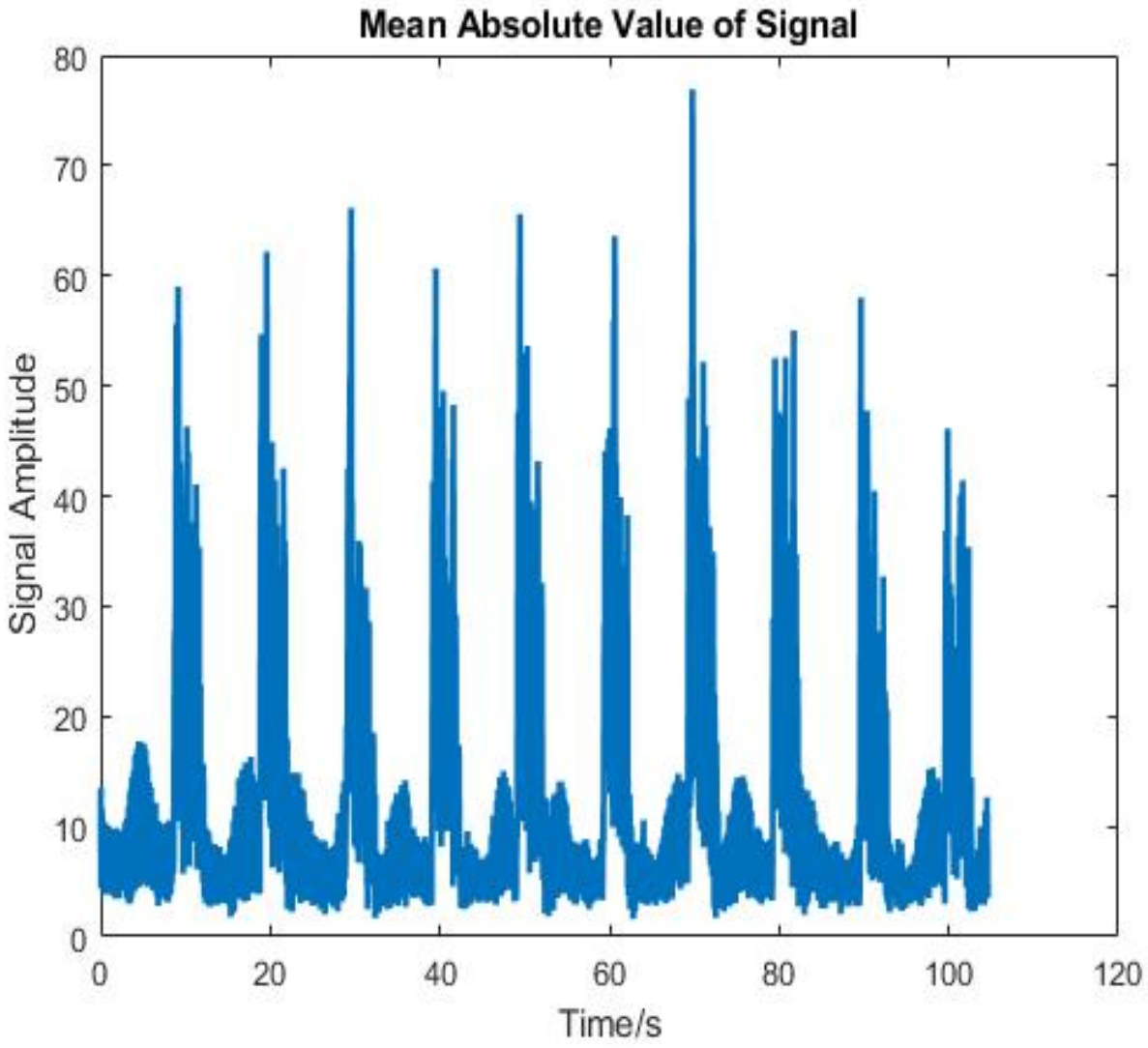
Signal After passing through a Bandpass Filter(Frequency Domain)



EMG and MAV signal Superimposed



EMG signal in time Domain after Passing through Bandpass Filter



Mean Absolute Value

Using MAV values we demonstrated the output, which in this case is movement of thumb using servo motor.

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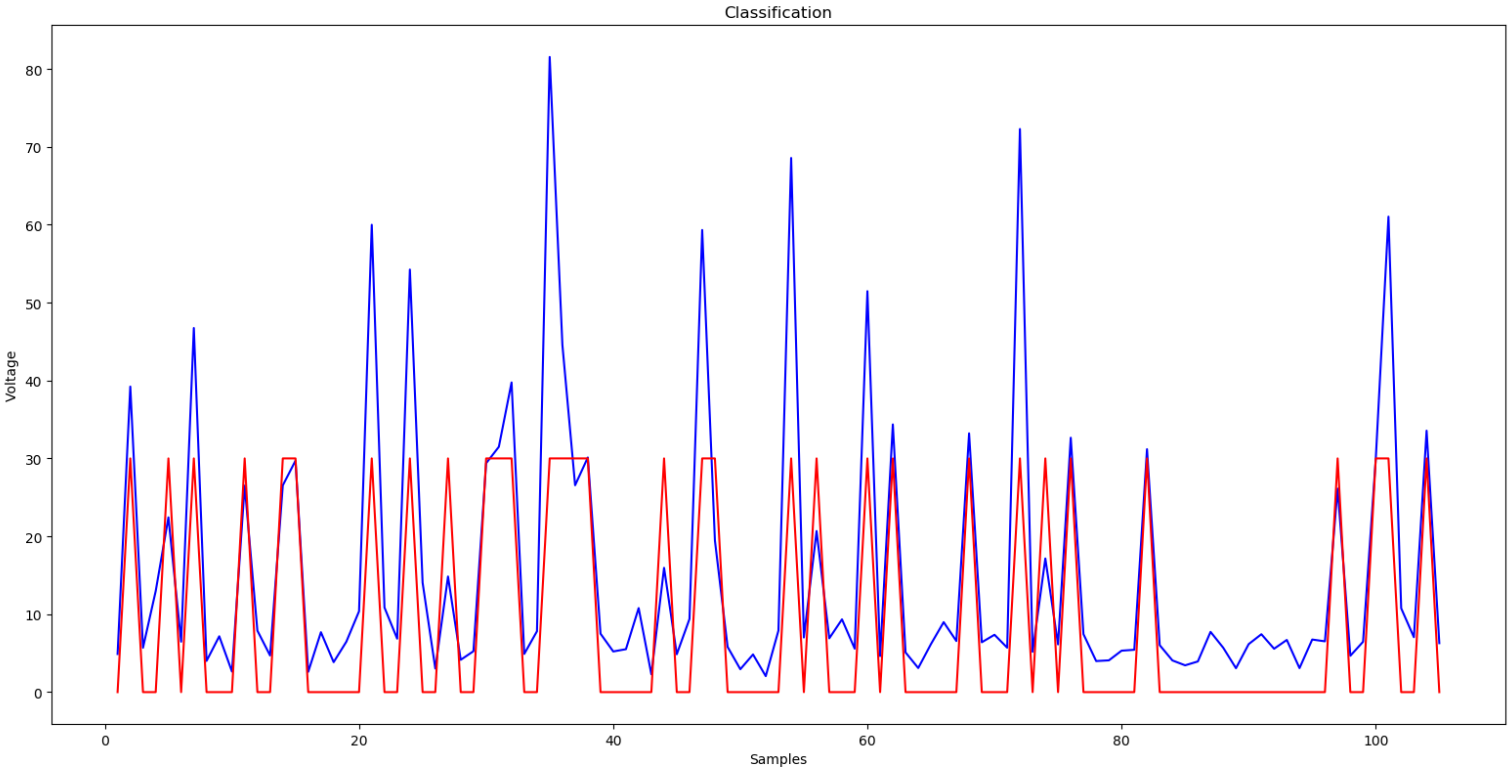

Classification Graph of thumb

The logistic regression model was able to classify the high and low output with an accuracy of **93.74%**.

Project Summary

The purpose of this project is as follows:

1. To analyse the signals that we can be obtained from the EMG sensor.
2. After the analysis of the signals from the plots of its fourier transform getting the range of the noise frequencies in the input sensor signals.
3. Removing the noise signals from the input signals using bandpass filters.
4. Getting the output on the form of the movement in the stepper motor using arduino uno board as the microcontroller
5. Using the ML algorithm trying to train the Data Set to predict the movement of the limb from the real time Data given.

References

- http://zju-capg.org/myo/data/ -link for dataset
- https://en.wikipedia.org/wiki/Fourier_transform
- https://whatis.techtarget.com/definition/bandpass-filter
- https://en.wikipedia.org/wiki/Fourier_inversion_theorem
- https://physionet.org/content/emgdb/1.0.0/ - dataset of tibialis muscle(leg)
- https://www.youtube.com/watch?v=W5ZOg1x49Rc
- https://pdfs.semanticscholar.org/c591/fca8f3ad1e7c09a27b5fb2fd6742da7b65cf.pdf - research paper on noise of emg
- https://www.researchgate.net/post/What_is_the_range_of_Human_EMG_signal_frequencies_Min_and_Max2 - range of emg signal
- https://www.delsys.com/downloads/TUTORIAL/semg-detection-and-recording.pdf
- https://stackoverflow.com/questions/32166879/do-i-need-to-call-matlab-fftshift-before-a-call-to-fft-or-ifft - use of fftshift