ANALYSIS Bio-POTENTIAL TO ASCERTAIN MOVEMENTS FOR PROSTHETIC ARM WITH DIFFERENT WEIGHTS USING LabVIEW

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Abstract

The Prosthetic is a branch of biomedical engineering that deals with missing human body parts with artificial one. SEMG powered prosthetic required SEMG signals. The SEMG is a common method of measurement of muscle activity. The analysis of SEMG signals depends on a number of factors, such as amplitude as well as time and frequency domain properties.
In the present work, the study of SEMG signals at different location, below elbow and bicep branchii muscles for two operation of hand like grip the different weights and lift the different weights are carried out. SEMG signals are extracted by using a single channel SEMG amplifier. Biokit Datascope is used to acquire the SEMG signals from the hardware. After acquiring the data from two selected location, analysis are done for the estimation of parameters of the SEMG signal using LabVIEW 2012 (evaluation copy). An interpretation of grip/lift operations using time domain features like root mean square (rms) value, zero crossing rate, mean absolute value and integrated value of the EMG signal are carried out. For this study 30 university students are used as subjects with 12 female and 18 male that will be a very helpful for the research in understanding the behavior of SEMG for the development for the prosthetic hand.

Keywords : Electromyography, Prosthetic, LabVIEW, Root mean square, Zero crossing rate.

1 Introduction

Electromyography (EMG) is an experimental technique concerned with the development, recording and analysis of myoelectric signals of human muscles[1]. Human muscles consists of large number

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of fibers functionally arranged in to individual motor unit which are all activated by nerve impulse from the nervous system which are propagate through the length of the nerve fiber[1][2][3].

The surface electromyography (SEMG) used to analyze muscular condition during rest or functional activities. This method is used to capture and measure the electrical activity and changes of muscles electric potential from the surface of the skin and makes possible an investigation of muscle synergies[4]. The recording of SEMG signal highly influenced by several factors. These factors as type of muscle fiber, nerve fiber conduction, body temperature, anatomical (as a diameter of the muscle fiber), position(depth) of the muscle in respect to the electrode and thickness of the skin and technical, related to instrumentation during EMG analysis, involving aspects related to the recording and processing of EMG signal[5][6]. EMG can be recorded by two types of electrodes, which are an invasive electrode called as wire or needle electrodes and a noninvasive electrode called as surface electrode[7]. These electrodes are placed on the surface of the skin after cleaning the skin. Use of lotions and creams on skins for 24 hour is avoided prior to EMG recording. So Alcohol or sprit is used for cleaning the skin[8].

The most common reference for the normalization of the EMG signal is the percentage of the maximum isometric voluntary contraction (MIVC), more often used to analyze the static muscular contraction activity[9][10][11].

Once the SEMG signal has been captured, it is analyzed or processed by using the various features. There are several approaches to feature extraction specifically relevant to EMG data. These methods are in both time domain and frequency domain[12]. Features are time domain are mean absolute value, modified mean absolute value, root mean square, integrated of EMG, simple square integral, variance, willison amplitude, zero crossing, slope sign change and wave form length[13].

2 Materials and Methods

2.1 Subjects

It is a transversal analytic study performed between jan 2013 and may 2013 in USIC laboratory of Thapar university, Patiala. 30 volunteers with the mean age of 205 years, 12 females and 18 males participated in the research study. All the subjects are university students with the right hand dominant that performed regular activity with right hand.

SEMG was picked up with the help of disposable electrodes and analyzed and classification with Labview at two points (1) flexor carpum ulnaris (below elbow) for gripping and (2) biceps brachhi (between elbow and shoulder) for lift up different weights. 1 Kg. and 2 Kg. weights are used for this study.

Figure 1: Flexor carpum ulnaris for grip the weights

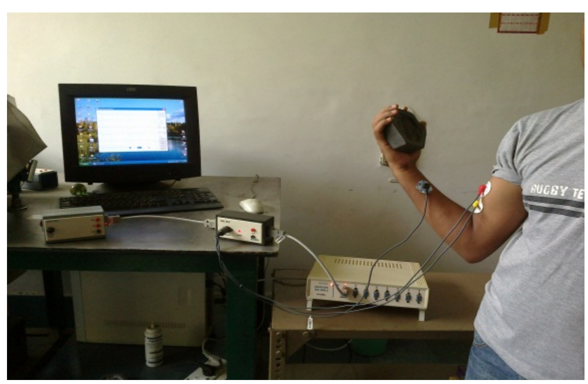

Figure 2: Flexor carpum ulnaris for lift the weights

2.2 Experimental Protocol

The SEMG signals were recorded under usual conditions for MUAP analysis. A standard disposable electrode was used. The EMG signals were recorded from bicep brachhi of bicep and flexor carpum ulnaris of below elbow. Acquisition of EMG for analysis can be performed by using bio-potential acquisition systems. For this BIOKIT data acquisition system used in this research.

The BIOKIT system is used for amplify and capturing biomedical signal. The captured signals analyzed BIOKIT data-scope software. The data acquisition unit acquires the amplified data and converts in to a digital format, which would be input to the PC through a serial port/USB.

2.3 Power Supply Unit

Power supply unit gives the 12V power to the EMG amplifier unit. For this purpose a 12V battery is used.

2.4 Amplifier Unit

Amplifier unit appropriately amplifies the SEMG signals grabbed from the surface of the skin with the help of disposable electrodes. EMG amplifier having specification:

- Input Impedance > 10 M
- CMRR > 80 dB
- Gain= 10,000 max
- Frequency Response= 40 Hz to 200 Hz

2.5 Data Acquisition Unit

Data acquisition unit acquires the amplified data and converts into a digital format, which is interfaced to the personal computer through a serial port (RS232). It is able to provide different sampling rate at different channel. Some other features of a data acquisition unit given below:

- RISC microcontroller based
- 4096 samples/Sec for single channel capture
- 1024 samples/Sec/channel for multi channels capture
- 8 channels
- Baud rate of 115200 bits/Sec.
- Optical isolation

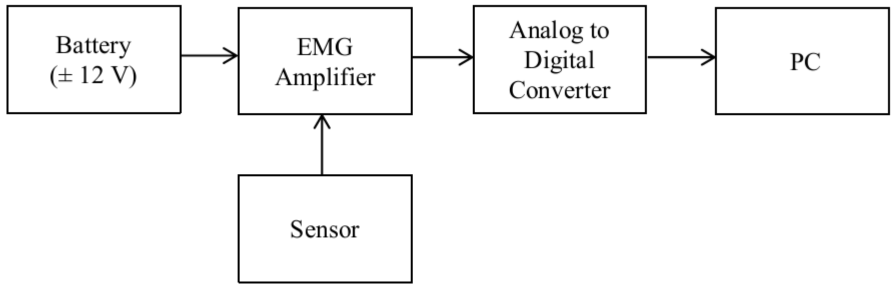

Figure 3: Block diagram of EMG acquisition system

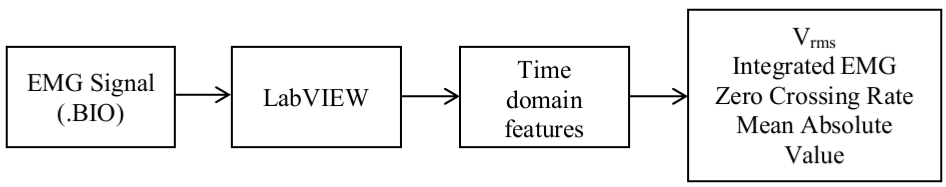

Figure 4: Block diagram of EMG acquisition system

3 Proposed Method

SEMG signal is obtained from the surface of the body by using disposable electrodes. For the acquisition of SEMG signal BIOKIT Datascope system is used. BIOKIT system having various parts like a rechargeable battery, EMG amplifier, analog to digital converter, sensor, connecting cords and personal computers. The block diagram of acquisition of EMG signal is shown in Figure 3. Further analysis and feature extraction of SEMG signals is done by using LabVIEW. LabVIEW, short for Laboratory Virtual Instrument Engineering Workbench, is a programming environment in which you create programs using a graphical notation (connecting functional nodes via wires through which data flows). A program is made for reading the EMG signal which recorded by BIOKIT system. Time domain features of EMG signal like Vrms, Integrated EMG (IEMG), zero crossing rate (ZCR) and mean absolute value (MAV) are calculated using LabVIEW. The block diagram of the system is shown in Figure 4. The following steps involved for the analysis of the acquired SEMG signal.

3.1 Base Line Shifting

Generally human being produces static current which will interfere while recording SEMG signals. Due to this SEMG signal shifts upper side from the base line. This defect occurs due to the tension of the muscle, body movement and environmental noise. So base line of SEMG is shifted to zero line. As shown in fig. 5, 6.

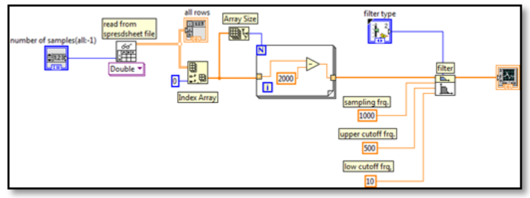

Figure 5: Block diagram of program for baseline shifting

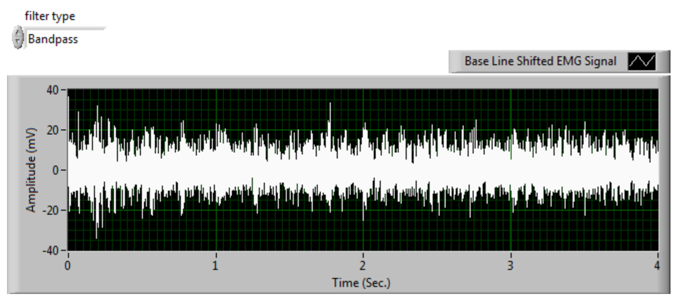

Figure 6: Front panel of program for baseline shifted at zero

3.2 Filtering

Butterworth band pass filter is used which is a combination of low pass filter and high pass filter. Here lower cut off frequency is set to be 10 Hz and higher cut off frequency is set to be 500 Hz. Most of the EMG signal contents lie in this region. High pass filter is used to attenuate DC offset noise voltage and low pass filter is used for removing environmental noise[14].

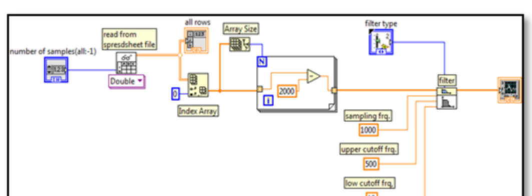

Figure 7: Block diagram of program for filtering

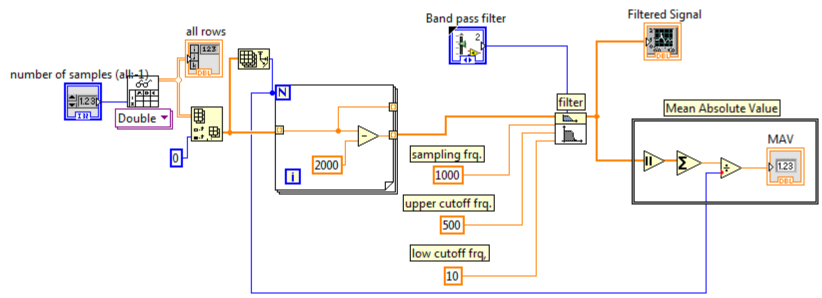

Figure 8: Block diagram of program to calculate mean absolute value

3.3 Feature Extraction & Calculation

Feature extraction of EMG was carried out for the purpose of analysis and classification which is based on some number of criterions. The various approaches to extract useful features from signals which is in time domain and frequency domain.

Many raw EMG signals have been represented in their time domain, which is simple amplitude versus time representation of the signals. Time domain features extracted from these signals. Myoelectric patterns can be represented by the following features.

3.3.1 Mean Absolute Value

Mean Absolute Value (MAV) is similar to average rectified value (ARV). It can be calculated using the moving average of full-wave rectified EMG. In other words, it is calculated by taking the average of the absolute value of sEMG signal. It is an easy way for detection of muscle contraction levels and it is a popular feature used in myoelectric control application. It is defined as:

$$M = MAV = \frac{1}{N} \sum_{n=1}^{N} |x_n|$$

Where
x_n=EMG signal in a segment
N=Length of the EMG signal
M=MAV=Mean Absolute Value

3.3.2 Integral EMG (IEMG)

Integrated EMG (IEMG) is calculated as the summation of the absolute values of the SEMG signal amplitude. Generally, IEMG is used as an onset index to detect the muscle activity that used to oncoming the control command of assistive control device. It is related to the SEMG signal sequence firing point, which can be expressed as:

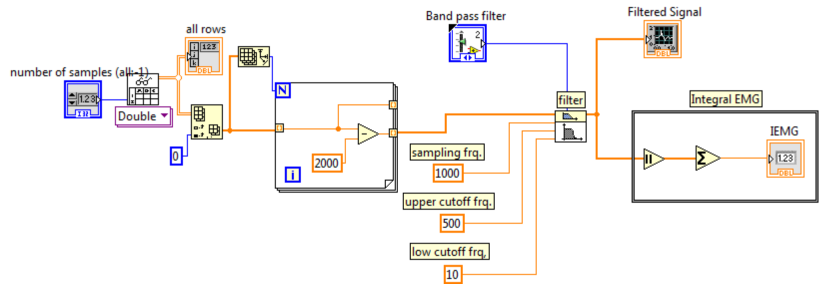

Figure 9: Block diagram of program to calculate integral value of EMG

$$IEMG = \sum_{n=1}^{N} |x_n|$$

Where
$IEMG$= Integral EMG
N= Length of the EMG signal
x_n= SEMG signal in segment

3.3.3 Root Mean Square (RMS)

Root Mean Square (RMS) is modeled as amplitude modulated Gaussian random process whose RMS is related to the constant force and non-fatiguing contraction. It relates to standard deviation, which can be expressed as:

$$RMS = \sqrt{\frac{1}{N}\sum_{n=1}^{N} x_n^2}$$

Where
RMS= the root mean square value
x_n= value of samples
n= no. of samples
Clancy et al.[15] experimentally found that the processing of MAV feature is equal to or better in theory and experiment than RMS processing. Furthermore, the measured index of power property that remained in RMS feature is more advantage than MAV feature[16].

3.3.4 Zero Crossing Rate (ZCR)

Zero-crossing rate (ZCR) expresses the number of times a signal crosses the axis of abscissas. The random temporal fluctuations of the EMG signal may serve as distinguishable feature. Hence, the ZCR is also considered as a distinguishable feature to comment on the detection of diseases.

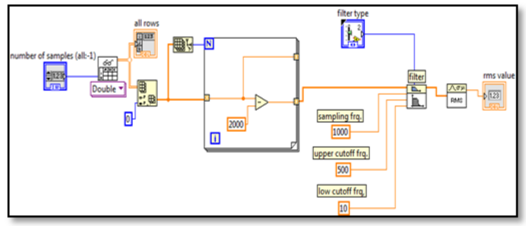

Figure 10: Block diagram of program to calculate RMS

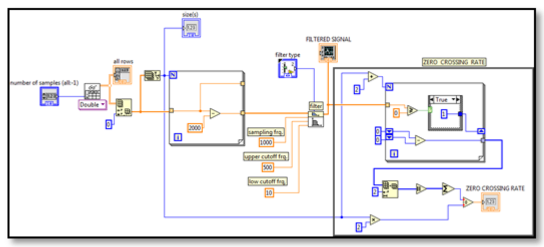

Figure 11: Block diagram of program to calculate zero crossing rate

$$ZCR = \frac{1}{2N} \sum_{k=1}^{k=N-1} |sgn[x(k)] - sgn[x(k-1)]|$$

Where

$$f(x) = \begin{cases} 1, & \text{if} x \geq 0 \\ -1, & \text{otherwise} \end{cases}$$

4 Result And Discussion

4.1 RMS Value of EMG (Vrms)

EMG signal rms value is used to calculate constant force and non-fatiguing contraction. From the Fig. 12, 13 it is analyzed that the EMG signals of rest muscles having small rms values as compared to the active or movement muscles for a single subject. Small and large variations are observed, when subjects grasp and lift the different weights.

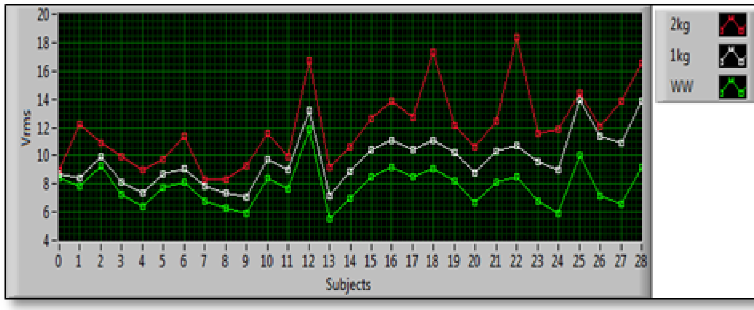

Figure 12: Root mean square values for grasp movement using different weights

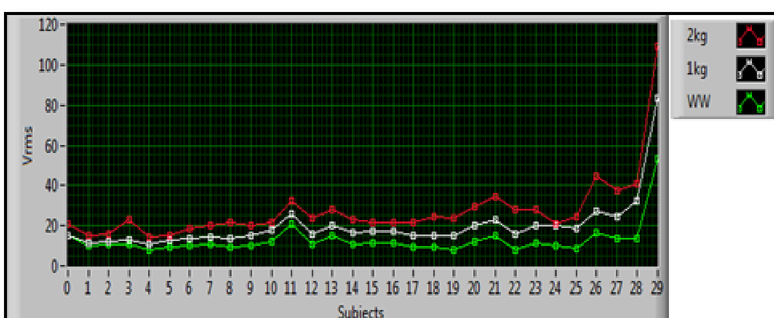

Figure 13: Root mean square value for lift movement using different weights

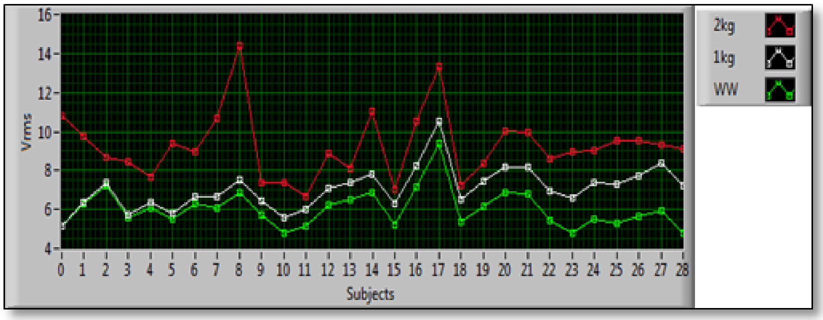

Figure 14: Mean absolute values for grasp movement using different weights

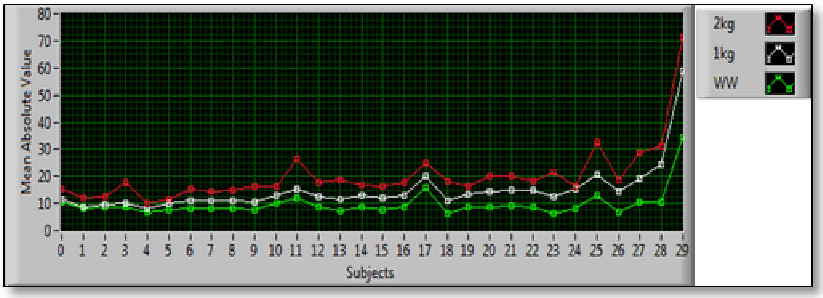

Figure 15: Mean absolute values for lift movement using different weights

4.2 Mean Absolute Value of EMG

The mean absolute value of EMG signal is used to find the contraction level of the muscles. From Fig. 14, 15 it is analyzed that contraction of muscles is more during lift and grasp the heavy weight as compared to the light weight. Mean absolute value is the moving average of full wave rectified of EMG signal. It is seen that as the weight increases, the mean absolute value of EMG signal also increased.

4.3 Zero Crossing Rate of EMG Signal

Zero crossing rate of EMG signal shows at which rate signal crosses the x-axis. From Fig. 16, 17 it is analyzed that zero crossing rate is decreasing with increase the weight. When muscles are in rest position, there is no variation in EMG signal. While muscles are active for movement then amplitudes of the EMG signal increases so that zero crossing rate decreases.

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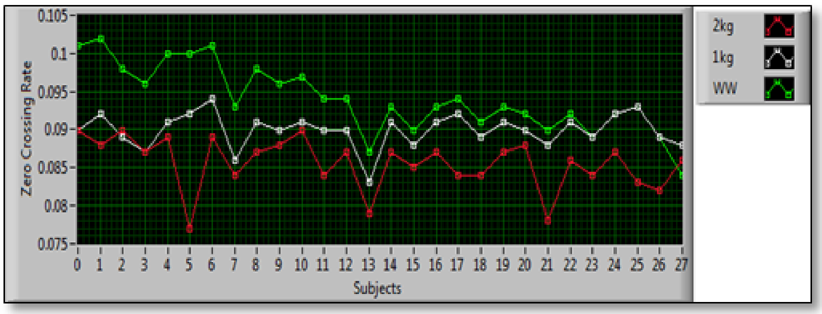

Figure 16: Zero crossing rate for grasp movement using different weights

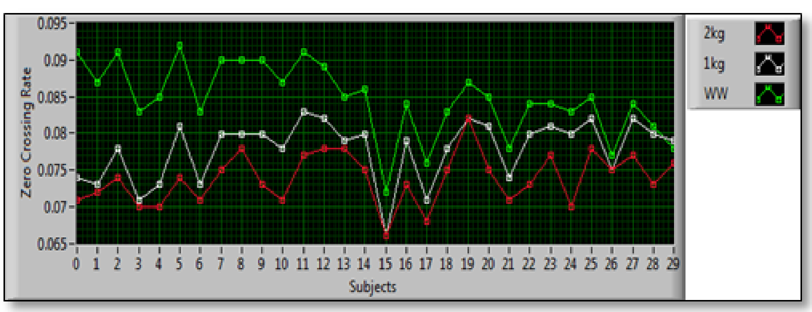

Figure 17: Zero crossing rate for lift movement using different weights

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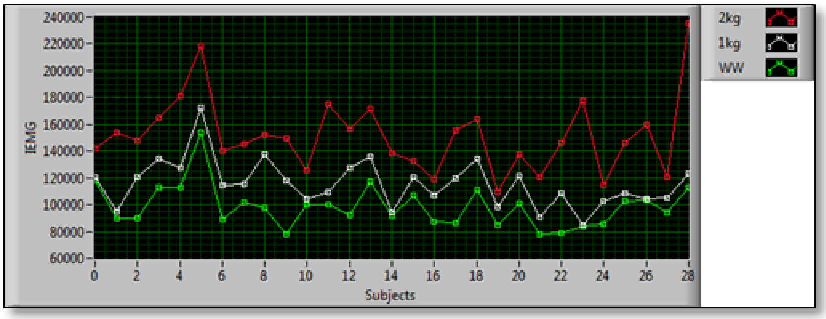

Figure 18: Integral value of EMG for grasp movement using different weights

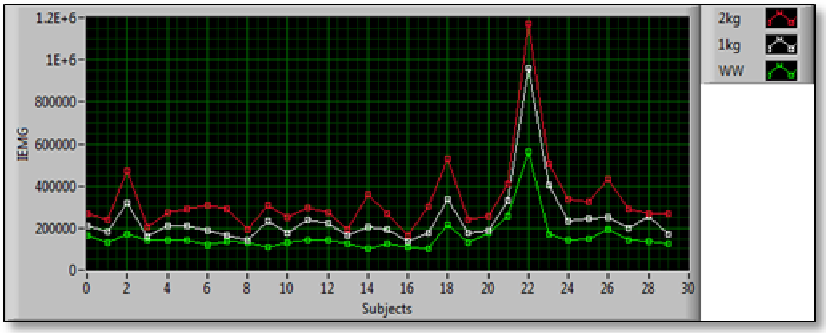

Figure 19: Integral value of EMG for lift movement using different weights

4.4 Integral Value of EMG Signal (IEMG)

Integral of surface electromyographic (EMG) signals detected during fatiguing submaximal contraction are often related to changes in neural drive. There is graph showing changes in the EMG integral due to contraction in the muscle during grasp and lift the different weights.

5 Conclusion

In the present study, observed that time domain features of EMG signal are varied with the varying the weights. The value of root mean square, mean absolute value and integral value of EMG signal of all subjects are increased with respect to the weight. While zero crossing rate of EMG signal of all the subjects decreases with respect to the weights. These results are found in both cases (i) grip the different weights and (ii) lift the different weights.

It is also observed that the quality of EMG signal is affected by routine activity of the subjects, which is reflected by the variation in root mean square value of the EMG signal.

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