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Time Frequency Based Evaluation of Surface Electromyogram Signal Using Non Invasive Technique

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Abstract
It is well known that Surface Electromyography is activity generated due to a muscle activity and these signals can be easily acquired from surface of skin of the body using non-invasively technique and research with various algorithms for control of upper arm prostheses have been reported. In this investigation the Surface Electromyogram signal's study for upper arm muscles with different operation of arms were presented. Myoelectric signals from said muscles were extracted using Labview based soft scope simulated code. Acquiring Surface Electromyogram data from selected locations were interpreted for various feature extractions using various time and frequency domain parameters for computation of data in a way to analyze the effectiveness of recorded signal.

Keywords: *Electromyogram signal, Simulation, RMS, Median frequency, interpretation, signal processing, arm motions.*

I. INTRODUCTION

Electromyogram signal is a measure of electrical currents generated in muscle for measuring its responses. The nervous system controls the muscle activity i.e. contraction or relaxation of muscle. Because of its random nature, signal is controlled by the nervous system and is dependent on the anatomical and physiological properties of muscles. Surface Electromyogram sensor at the surface of the skin collects signals from different motor units at a time generated due to interaction of different action potential signals. Due to the complexity of Surface Electromyogram signal, powerful and advance methodologies of analysis are becoming a very important requirement in biomedical engineering [1-2].

Electromyography provides easy access to physiological processes that cause the muscle to generate force, produce movement and accomplish the countless functions to interact with the world around us. It provides many important signals which are still to be understood to extract important information. Signal acquisition using non invasive technique with its processing has been a challenging labor preferred as it does not require any medical qualification [3].The membrane potential in the muscle is about -90 mV with the range of measured Surface Electromyogram potential lying between 0 to 10mV (peak to peak) with frequency range of 2 to 10 kHz having the most relevant information below 500 Hz [4-5].

The effect of force contraction at different levels on median frequency of Surface Electromyogram has been reported in various studies. Researchers have shown that under isometric conditions there exists linear relationship between median frequencies of Surface Electromyogram and force contraction [6]. The formal scheme of this paper is organized in following manner: the basic theory behind Surface Electromyogram signal production from muscles and its acquisition using LABVIEW, subsequent signal conditioning and processing, then the feature extractions and finally results and conclusion.

II. THE FORMAL SCHEME

A. Surface Electromyogram signal Acquisition

Surface Electromyogram signals were collected using non invasive electrodes at skin surface from the above elbow arm which have further been used for upper limb prosthetic control. A good acquisition of the Electromyogram signal is a prerequisite for good signal processing. The placement of electrodes of proper location is an important issue as Surface Electromyogram signal amplitude is influenced by electrode location.

Two positions, namely Biceps Brachii and Triceps Brachii were identified for signal acquisition in this experiment.

B. Signal Processing

The raw signal extracted using non invasive electrode consists of various kind of noise, so signal conditioning and processing is required in order to reduce artifacts and getting important information for data analysis. Signal processing is implemented using LABVIEW as this platform provides many mathematical tools for analyzing signal characteristics. Signal is amplified and passed from band-pass filter with high CMRR and gain in order to reduce motion artifacts (HPF) and noise (LPF) [4], [7].

C. Feature Extraction and Analysis

Different parameters are calculated for Surface Electromyogram signal acquired from all the subjects. The calculation of parameters that extracted is as follows:

a. Root mean square: The root mean square is a statistical measure of the magnitude of a varying quantity. It is especially useful when variants are positive and negative. RMS value is a quantity used to quantify ac quantities. Hence signals with higher energy have higher RMS values. It is defined as:

$$V_{rms}=\sqrt{\frac{(x_1^2+x_2^2+x_3^2+\ldots\ldots\ldots\ldots+x_n^2)}{n}}$$

b. Median Frequency [8]: Median frequency (MDF) is described as the frequency which divides the power contained in the signal into two equal halves. The unit of measurement is Hz.

c. Standard Deviation: It is the measurement of variability or diversity used in statistics and probability theory. It shows variation or dispersion from the average (mean, or expected value). A low standard deviation indicates that the data points tend to be very close to the mean whereas high standard deviation indicates that the data are spread out over a large range of values. It is given by the equation:

$$SD=\sqrt{\frac{\sum(x_i-u)^2}{n-1}}$$

d. Energy: It is also defined as simple square integral (SSI). It is the summation of square values of the amplitude of sEMG signal samples and is given by the equation:

$$E=\sum_{n=1}^{N}|x(n)|^2$$

e. Power Spectrum**:** For a given signal, the power spectrum gives a plot of the portion of a signal's power (energy per unit time) falling within given frequency limits. Power spectrum of signal gives peaks at the fundamental harmonics. Quasi periodic signals give peaks at linear combinations of two or more irrationally related frequencies (often giving the appearance of a main sequence and sidebands) and chaotic dynamics gives broad band components to the spectrum.

III. METHODOLOGY

Activities Performed: Subjects were seated on a chair. Each subject was asked to perform four different movements for different muscles activation. These four different movements are as follows:

- ✓ P1- Arm was in rest with downward position parallel to body.
- ✓ P2- Hand was moved upside. This position is called flexion elbow.
- ✓ P3- Arm was rotated in clockwise direction.
- ✓ P4- Arm was rotated in anticlockwise direction.

Experiment: Five healthy male volunteers, age 22-28 year, weight 55-90 Kg's and height of 170 to 180 cm participated in the complete part of this study. They were not informed of what the experiment was about. The Surface Electromyogram signal was acquired from two upper-arm muscles, the biceps and triceps brachii as shown in Fig. 1 through non invasive electrodes placed on the midline of muscle belly using NI DAQ card and LABVIEW based soft scope code.

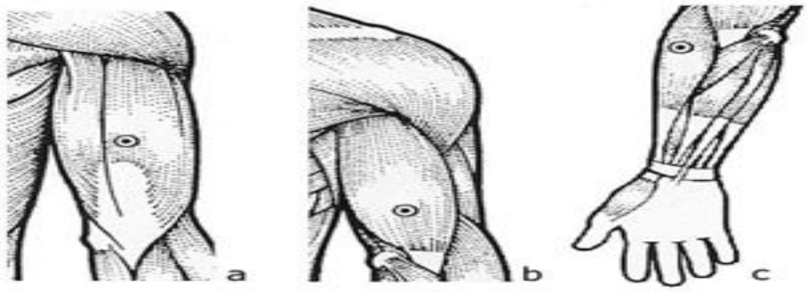


Figure 1 SEMG Sensor placement for biceps and triceps positions for AE [9]

The samples were saved with specific name in the workspace. LABVIEW has large number of functions for numerical analysis and design and visualization of data. It is a graphical development environment with built in functionality for data acquisition, instrument control, measurement analysis, and data presentation.

About 1024 samples were recorded for the time window of 3000ms of the soft scope in the workspace. A program was made to filter the signal in the frequency band 70 to 280 Hz in order to minimize movement artifacts and aliasing effect. The different parameters were then calculated. The general schematic of proposed system is illustrated in Fig. 2. In order to understand Surface Electromyogram signal's behavior, the experiment was carried out in two phases. In first phase, the arm is at "rest" without moving hand (No Surface Electromyogram) and in second phase, it is with different movements (with Surface Electromyogram).

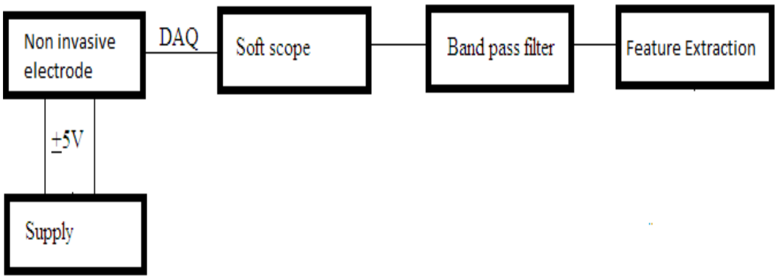
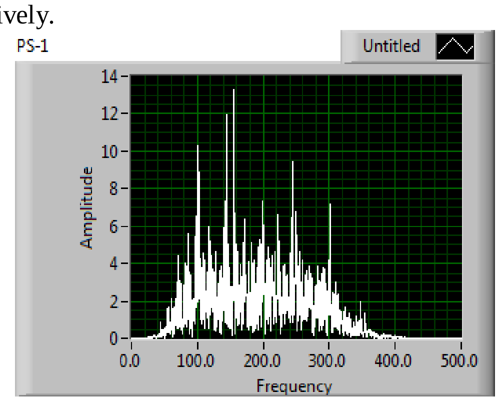


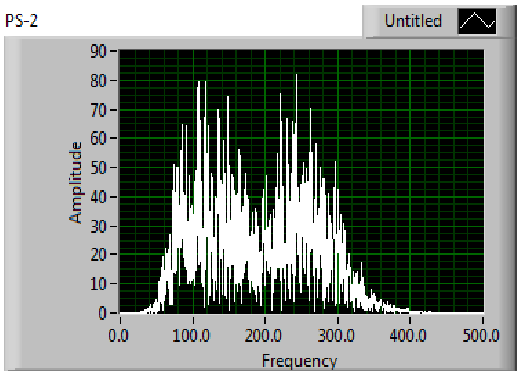
Figure 2 Block diagram of the system

IV. RESULT

The observations were taken from different subjects from two different points with different movements and are tabulated in figure 3 & 4. It is clear that there value of Root mean square amplitude are more than in rest position from both muscles. From figure 3 and 4, it is evident that there is change in V_{rms} value for flexion elbow (P2) movement for both biceps and triceps muscles as compared to rest (P1) position. Figure 5 and 6 shows that Vrms for clock wise (P3) movements is higher than anti-clock wise (P4) movements with biceps muscle and for triceps muscle anti-clock (P4) has higher value compare to clk (P3) movement respectively.



Power spectrum of EMG with muscle in rest state



Power spectrum of EMG with muscle in contraction state

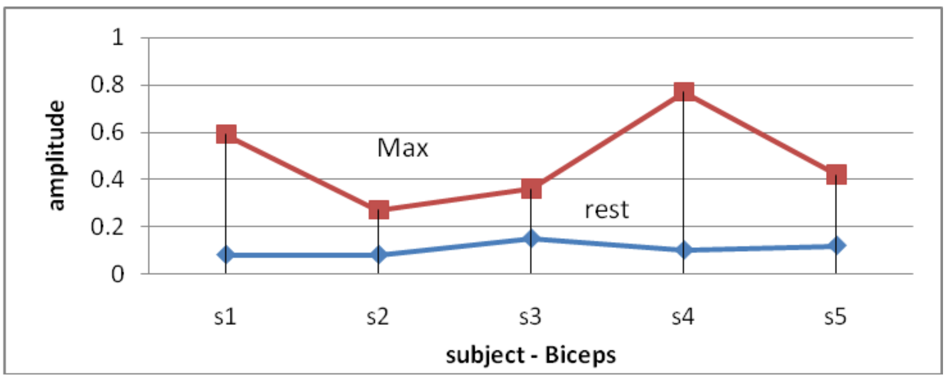


Figure 3 Results for activity P1 and P2 for biceps muscles

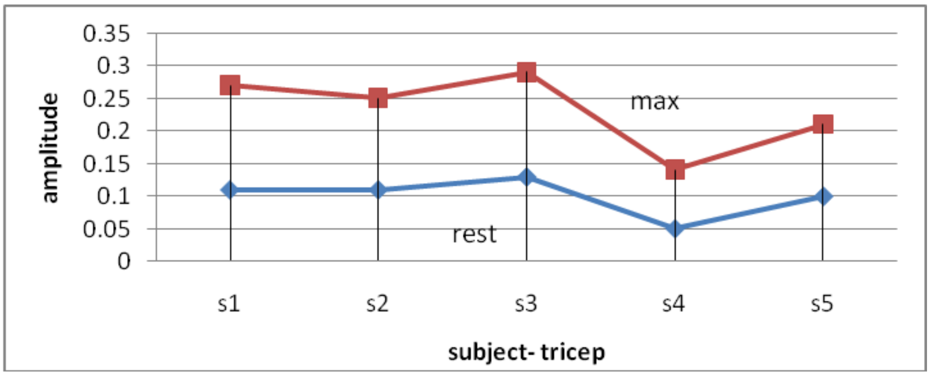


Figure 4 Results for activity P1 and P2 for triceps muscles

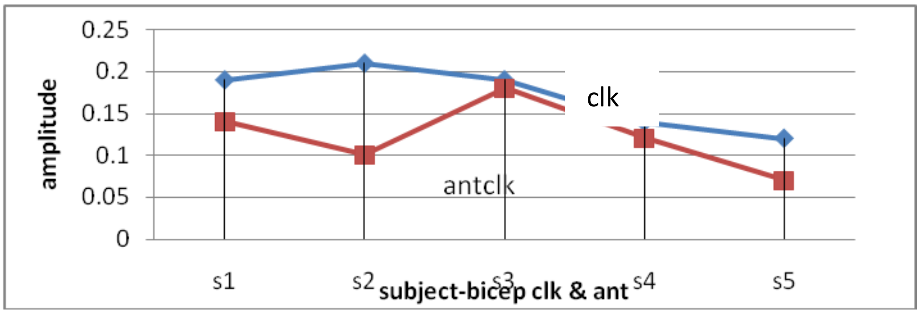


Figure 5 Results for activity P3 and P4 for biceps muscles

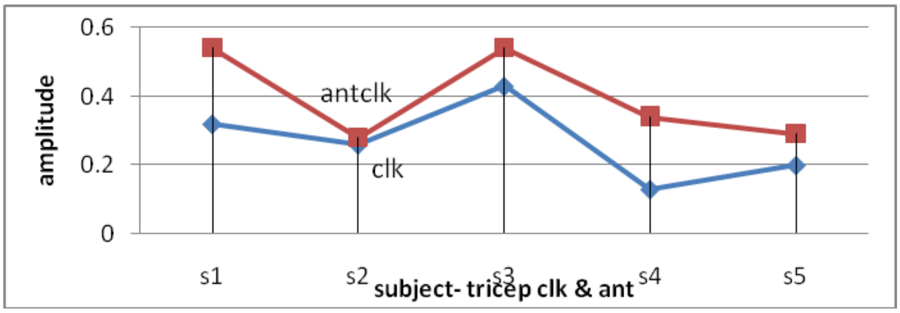


Figure 6 Results for activity P3 and P4 for triceps muscles

Table 1. Comparison of Parameters

Parameters	No Surface Electromyogram	With Surface Electromyogram
V_{rms}	0.08	0.59
SD	0.0627	0.5882
Median Freq. (*1000)	0.1305	0.2429
Energy (*1000)	0.0118	1.0363

V. CONCLUSION

Surface Electromyogram signal is random in nature and some-how the complete study of these signals is complex. The work done on these signals at different locations with different movements will act as helping tool for future work to control artificial arm for above elbow. It can be concluded that biceps muscle is dominant for P-2 (elbow flexion) movements where as triceps muscle is dominant for P-4 (anti clockwise) movements, whereas for P-3 movement both has moderate values. Figure 7 shows different calculated features with no Surface Electromyogram and with Surface Electromyogram giving relationship between median frequency and force of contraction. The result also shows that content of the signal are highly dependent upon the proper location of placement of electrodes. In future studies more advanced signal processing and evaluation techniques will be implemented for the interpretation of effectiveness of recorded signal.

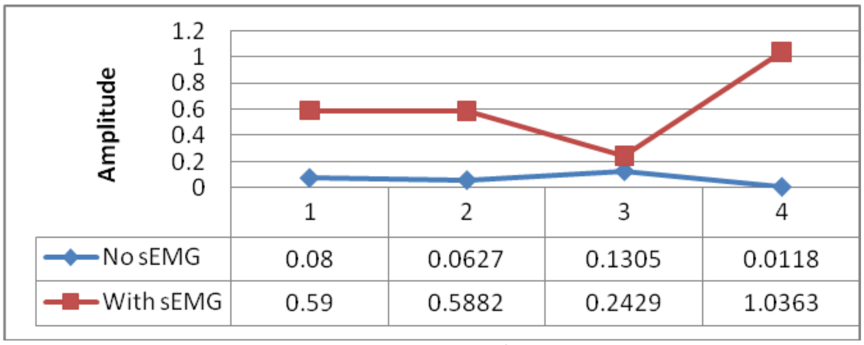


Figure 7 Comparisons of Parameter

REFERENCES

[1]. Reaz MBI, Hussain MS and Mohd-Yasin F. Techniques of EMG Signal Analysis: detection processing, classification and applications. IEEE Transactions on Biomedical Engineering, 10:11-35, 2006.

[2]. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1455479.

[3]. DeLuca CJ. The use of surface electromyography in biomechanics. Journal of Applied Biomechanics, 13: 135-163, 1997.

[4]. Jung Kyung and Kim Joo Woong. EMG Pattern Classification using Spectral Estimation and Neural network, SICE Annual Conference, Kagawa University, Japan, pages 1108-1111. 2007.

[5]. Micera Silvestro. Control of hand prostheses using peripheral information. IEEE reviews in BME, 3: 48-68, 2010.

[6]. K A Wheeler, H Shimada, D K Kumar and S P Arjunan. A sEMG Model with Experimentally Based Simulation Parameters, 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Argentina, pages 4258-4261, 2010

[7]. Zecca M and Micera S. Control of Multifunctional Prosthetic Hands by Processing the Electromyographic Signal. Critical Reviews in Biomedical Engineering, 30: 59–485, 2002.

[8]. DeLuca CJ and Roy Serge H. Median frequency of the myoelectric signal, effect of hand dominance. Eur. Journal of Appl. Physiology, 55: 457-464, 1986.

[9]. Cram R J, Kasman S G, and Holtz J. Introduction to surface electromyography, Aspen Publishers, 1998.