Characterization of Human Motor Unit Action Potential from Surface EMG

Anju Dwivedi[#1], Dr.A.K. Wadhwani[#2]
PG Student[#1], Professor[#2], Measurement and Control,
Dept. of Electrical Engineering, MITS Gwalior – 474005.
[1]dwivedianju1991@gmail.com
[2]wadhwani_arun@rediffmail.com

Abstract— **Electromyography (EMG) is an experiment-based method for evaluating and recording a series of electrical signal that emanate from body muscles and motor units are the smallest functional units of our movements. EMG is widely used in various fields to investigate the muscular activities. Since EMG signals contain a wealth of information about muscle functions, there are many approaches in analyzing the EMG signals. It is important to know the features that can be extracting from the EMG signal. The ideal feature is important for the achievement in EMG analysis. Hence, the objective of this paper is to evaluate the features extraction of time domain from the EMG signal. The experiment was setup according to surface electromyography. This paper presents the detailed evaluation and classification of SEMG at different muscles of the body. The recorded data was analyzed in time domain to get the features. Then, time-domain feature extraction methods Average, RMS and SD are applied to signals. The results shows that the extracted features of the EMG signals in time domain can be implement in signal classification. These findings could be integrated to design a signal classification based on the features extraction.**

Keywords- **Surface electromyography (sEMG), motor unit action potential (MUAP), root mean square and standard deviation.**

I. INTRODUCTION

Electromyography is a very useful method in measuring muscle stimulation that has numerous applications in the diagnosis and treatment of diseases as well as the potential to enhance human abilities. Electromyography is the discipline that deals with the detection, analysis, and use of the electrical signal that emanates from contracting muscles.

This signal is referred to as the electromyographic (EMG) signal, a term that was more appropriate in the past than in the present. In days past, the only way to capture the signal for subsequent study was to obtain a ‘‘graphic’’ representation. Today, of course, it is possible to store the signal on magnetic tape, disks, and electronics components. Even more means will become available in the near future. This evolution has made the graphics aspect of the nomenclature a limited descriptor.

The main source of data is EMG from the target muscles which are the measurement of their electrical activity. There are two ways to record the EMG which are the invasive by using needle electrodes and non-invasive by applying the surface electrodes.

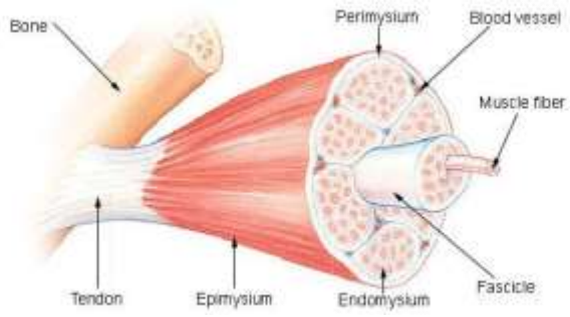

Fig. 1. Structure of a Skeletal Muscle

Depending on recording method, the EMG analysis can be varying. Due to surface Electromyography characteristics, this method has been more considered in recent works like stated examples. The amplitude of surface EMG (SEMG) signal is random and the range is 0-10mV and the frequency range is restricted to the 10 to 500 Hz that both are different in each muscle. So, depending on the muscle under investigation the methods for EMG analysis are diverse. Facial muscles which are considered as a new communication channel with computers produce signal with lower amplitude and almost similar frequency range. Raw recorded EMG signals are quasi random and has complicated form. They also contain significance information as well as contamination and workings with them have been always a tough task. Therefore, EMGs need to be analysis pre-processing, processing and post processing of signals can be seen as the three main steps. One of the most important and challengeable part in EMG processing is feature extraction which usually apply on raw signals in order to transform it into reduced representation set of features. There are three types of features in different domain; Time, Frequency and Time-Frequency distribution which each of these categories use in specific application.

In this paper, we propose that the features extracted from acquired raw EMG contribute to the different muscular contraction classification. A surface electrodes array is being used as a data acquisition system to acquire EMG raw data. The data acquisition system which we are using to extract EMG provides us to extract some features such as Root Mean

Square (RMS), Average and Standard Deviation methods to extract the features [2].

II. FEATURE EXTRACTION

RMS: It means Root Mean Square and it represents the mean power of the signal. RMS is used to rectify the raw EMG signal and convert it into amplitude envelops. It can be used to measure the activation timing of a muscle. It can also to verify the signal quality and detect the presence of artifacts. RMS can be used for biofeedback and to measure the resting level of a muscle.

Standard Deviation: Standard deviation (SD) measures the spread of data from the mean. In signal processing, SD represents noise and other interference. It is used in comparison to the mean. This leads to the term: signal-to-noise ratio (SNR), which is equal to the mean divided by the standard deviation. Better data means a higher value for the SNR.

Average: A-EMG is also called the average rectified value, average integrated EMG. A-EMG is the same as the I-EMG but divided by the time period to find the average value.

III. EXPERIMENT AND DATA ACQUISITION

Our EMG data was collected at the Biomedical Laboratory in Electrical Engineering Department of Madhav Institute of Technology & Science College in Gwalior. The data we consider consists of 9 EMG sessions from 9 different subjects measured in one or more different muscles. All of the subjects are female. The mean age of the subjects is 24.56. The currently available data are from the hand muscle, leg muscle and face muscle.

Hand EMG:

A. Subjects

Three normal and healthy female subjects were participated in this study. The subjects were selected according to dominant hand; right-handed, and weight; above 50 kg. The subjects are voluntary and have signed a consent form before the experiment is conducted.

B. System Design

This experiment uses basic system for acquiring bio signal. Starting from electrodes, data acquisition until signal processing was designed in order to give feedback to user. Fig. 2 below shows the block diagram of designed system in this experiment.

The system design includes the sEMG self-adhesive sensor that used as transducer to capture the EMG voltage signal. It was attached to the specific muscles of the wrist. Three sensors were used in this experiment for a subject. Independent measurement can be obtained from the hand movement without moving the shoulder.

The captured EMG signal from the sensor then being digitized by the sEMG data acquisition system; Trigno Wireless EMG System (Delsys Inc.). The sEMG data acquisition system is used to record EMG signals from the subjects. The EMG signals were obtained by using the Trigno Wireless EMG Transmitter, which sends the signals via wireless transmission to the Trigno Wireless PC-Interface Receiver that forward the data via USB to the computer at a sampling rate of 1500 samples per second. A computer was used as digital signal processing system that do the process in this experiment; which is digital filtering and features extraction.

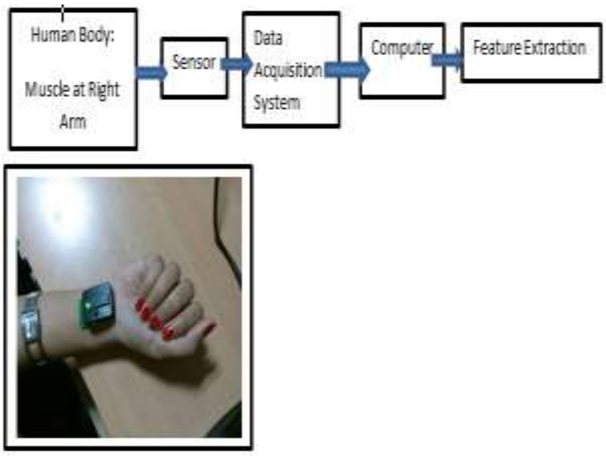

Fig. 2. Block diagram of Hand system.

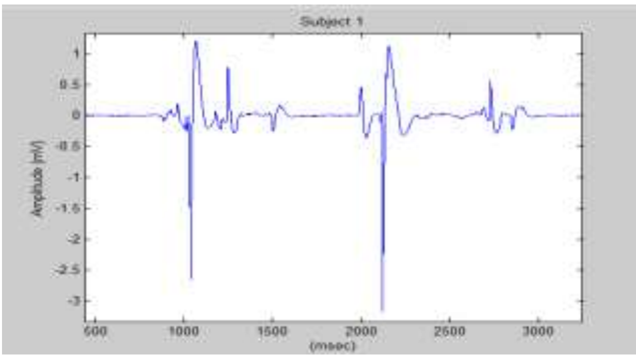

Fig. 3. Hand EMG for Subject 1

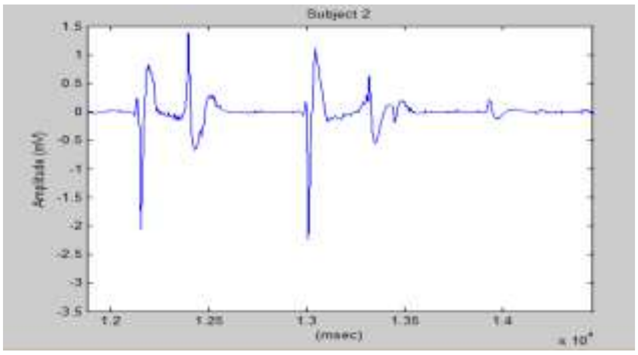

Fig. 4. Hand EMG for Subject 2

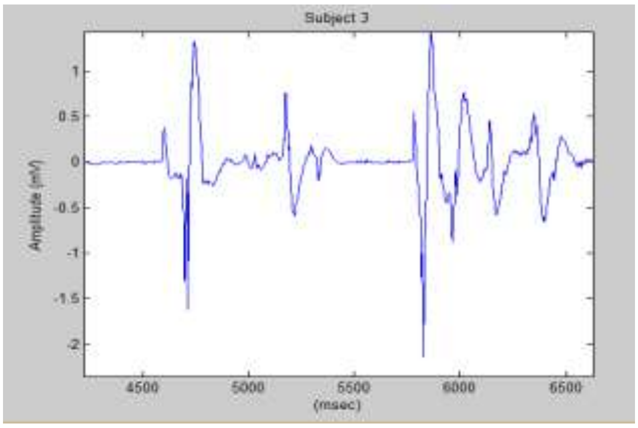

Fig. 5. Hand EMG for Subject 3

TABLE I
FEATURE EXTRACTION FOR HAND EMG (mV)

	Average	**RMS**	**SD**
Subject 1	0.0221	0.0211	0.0211
Subject 2	0.0011	0.0011	0.0011
Subject 3	0.0415	0.0413	0.0413

Leg EMG:

A. Subjects

Three normal and healthy female subjects were participated in this study. The subjects were selected according to dominant leg and weight; above 50 kg. The subjects are voluntary and have signed a consent form before the experiment is conducted.

B. System Design

This experiment uses basic system for acquiring bio signal. Starting from electrodes, data acquisition until signal processing was designed in order to give feedback to user. Fig. 6 below shows the block diagram of designed system in this experiment.

The system design includes the sEMG self-adhesive sensor that used as transducer to capture the EMG voltage signal. It was attached to the specific muscles of the foot. Three sensors were used in this experiment for a subject. Independent measurement can be obtained from the leg movement.

The captured EMG signal from the sensor then being digitized by the sEMG data acquisition system; Trigno Wireless EMG System (Delsys Inc.). The sEMG data acquisition system is used to record EMG signals from the subjects. The EMG signals were obtained by using the Trigno Wireless EMG Transmitter, which sends the signals via wireless transmission to the Trigno Wireless PC-Interface Receiver that forward the data via USB to the computer at a sampling rate of 1500 samples per second. A computer was used as digital signal processing system that do the process in this experiment; which is digital filtering and features extraction.

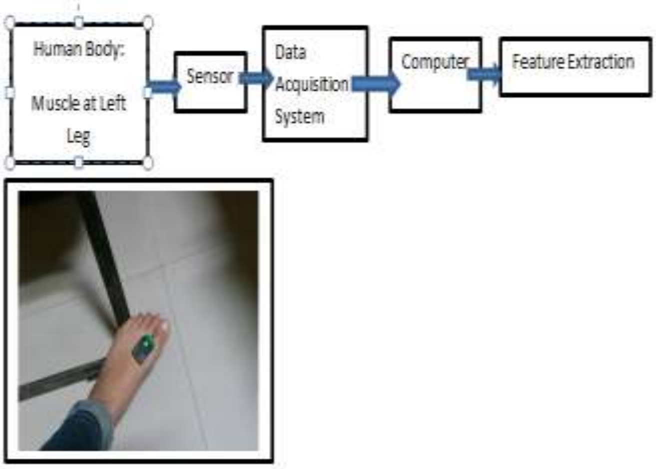

Fig. 6. Block diagram of Leg system

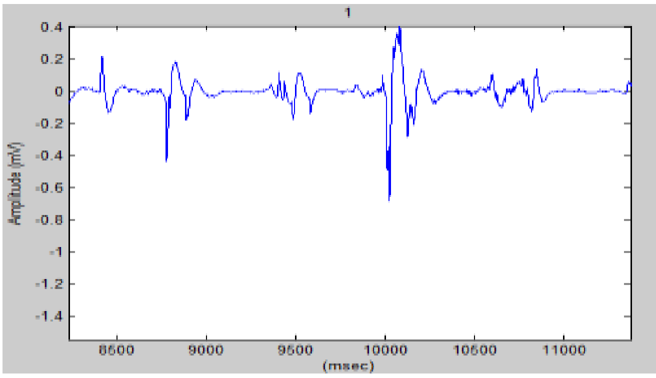

Fig. 7. Leg EMG for Subject 1

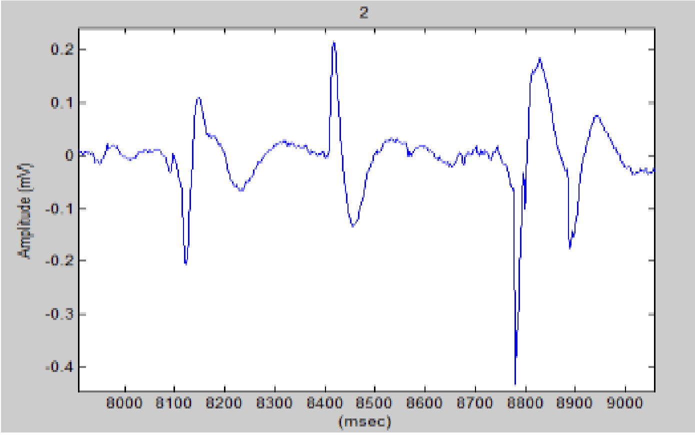

Fig. 8. Leg EMG for Subject 2

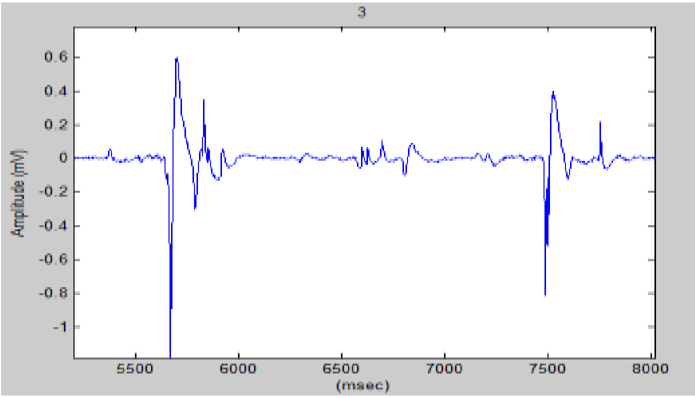

Fig. 9. Leg EMG for Subject 3

TABLE II
FEATURE EXTRACTION FOR LEG EMG (mV)

	Average	**RMS**	**SD**
Subject 1	0.8921	0.8901	0.8901
Subject 2	0.1973	0.1912	0.1912
Subject 3	0.2435	0.2411	0.2411

Face EMG:

A. Subjects

Three normal and healthy female subjects were participated in this study. The subjects were selected according to dominant face, forehead and weight; above 50 kg. The subjects are voluntary and have signed a consent form before the experiment is conducted.

B. System Design

This experiment uses basic system for acquiring bio signal. Starting from electrodes, data acquisition until signal processing was designed in order to give feedback to user. Fig. 10 below shows the block diagram of designed system in this experiment.

The system design includes the sEMG self-adhesive sensor that used as transducer to capture the EMG voltage signal. It was attached to the specific muscles of the forehead. Three sensors were used in this experiment for a subject. Independent measurement can be obtained from the smiling face.

The captured EMG signal from the sensor then being digitized by the sEMG data acquisition system; Trigno Wireless EMG System (Delsys Inc.). The sEMG data acquisition system is used to record EMG signals from the subjects. The EMG signals were obtained by using the Trigno Wireless EMG Transmitter, which sends the signals via wireless transmission to the Trigno Wireless PC-Interface Receiver that forward the data via USB to the computer at a sampling rate of 1500 samples per second. A computer was used as digital signal processing system that do the process in this experiment; which is digital filtering and features extraction.

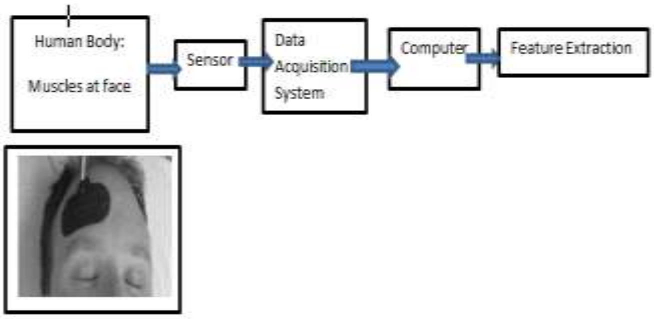

Fig. 10. Block diagram of Face system

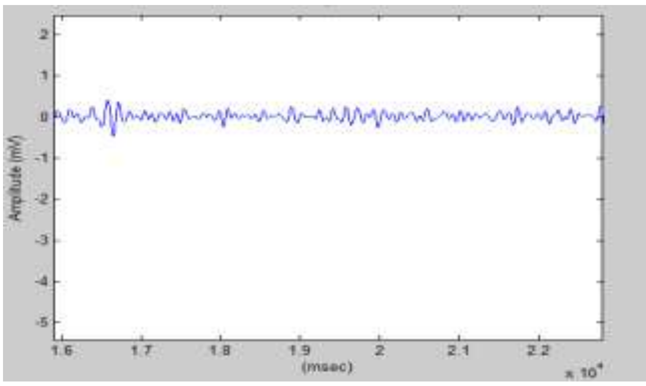

Fig. 11. Face EMG for Subject 1

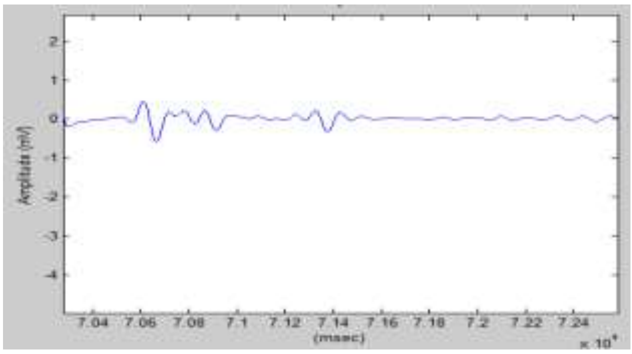

Fig. 12. Face EMG for Subject 2

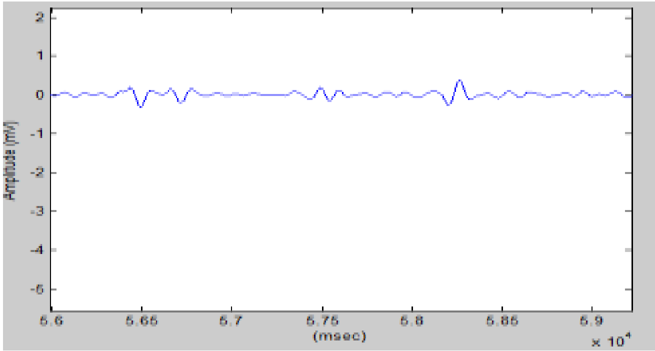

Fig. 13. Face EMG for Subject 3

TABLE III
FEATURE EXTRACTION FOR HAND EMG (mV)

	Average	**RMS**	**SD**
Subject 1	0.0111	0.0023	0.0023
Subject 2	0.0251	0.0158	0.0158
Subject 3	0.0205	0.0214	0.0214

IV. RESULTS AND DISCUSSION

The main goal of this paper was to find the ranges of feature extracted from EMGs between Average, RMS and SD.

TABLE IV
RANGE OF ALL THREE PARAMETERS OF EMG (µV)

	Range of Average	**Range of RMS**	**Range of SD**
Hand EMG	1.1-41.5	1.1-41.3	1.1-41.3
Leg EMG	197.3-892.1	191.2-890.1	191.2-890.1
Face EMG	11.1-25.1	2.3-21.4	2.3-21.4

From the above result we have seen that both RMS and SD are same because both value represents the deviation about its mean value.

V. CONCLUSIONS

This study is proposed and targeted to researchers to look in details of the features that can be extracting from the EMG signal within hand, leg and face analysis on time domain. There are three features have been extracting from the EMG signals.

In this study we examined the influence of EMG signal changes elicited by electrode shift, changing amounts of user effort during muscle contraction, and muscle fatigue, on various time-domain EMG features. Although this study suggests three EMG feature sets that could offset the impact of the three studied disturbances, simple selection of these feature sets for EMG pattern recognition cannot fully solve the problem.

REFERENCES

[1] B. Pang, Konrad. Peter. 2005. The ABC of EMG: A Practical I Introduction to Kinesiological Electromyography. Noraxon INC. USA. Retrieved 15 September 2014, from http://www.demotu.org/aulas/controle/ABCofEMG.pdf

[2] Williams, J.M., Gundry, P., Richards, J. and Protheroe, L. (2013) A preliminary evaluation of surface electromyography as a tool to measure muscle fatigue in the National Hunt racehorse. *The Veterinary Nurse.* 4(9), pp. 566-572.

[3] A novel approach for precise simulation of the EMG signal detected by surface electrodes D Farina, R Merletti IEEE Transactions on Biomedical Engineering 48 (6), 637-646

[4] De Luca, C.J. Electromyography. Encyclopedia of Medical Devices and Instrumentation, (John G. Webster, Ed.) John Wiley Publisher, 98-109, 2006

[5] Leslie Cromwell, Fred J. Weibell, Erich A. Pefiffer, BIOMEDICAL INSTRUMENTATION OF MEASUREMENT, Prentice Hall of India Private Limited, New Delhi 1990

[6] ERIC K. RICHFIELD, BERNARD A. COHEN, Review of Quantitative and Automated Needle Electromyography Analyses, IEEE Transaction of Biomedical Engineering, vol BME-28, no. 7, pp 506-514, July 1981

[7] S.C. Saxena, A.K. Wadhwani, A Comparative Study of the Techniques for Decomposition of EMG Signals, IETE Journal of Research, vol.50, No.1,Jan-Feb 2004, pp87-102

[8] S. Andreassen, L. Arendt-Nielsen, "Muscle fibre conduction velocity in motor units of the human anterior tibial muscle: A new size principle parameter", *J. Physiol.*, vol. 391, pp. 561-571, 1987.

