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An Explanatory Study of the Parameters to Be Measured From EMG Signal

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Abstract

Electromyography (EMG) is the analytical study of electrical activity produced by skeletal muscles. EMG is an example of modern human computer interaction which can be used in the field of medicines and engineering. Through this paper we are going to discuss about standard parameters which can be used to analyse EMG-Surface EMG (SEMG) /surface scanning EMG signals because these parameters reflects the physiological activity of the motor unit. In this paper, we will also discuss the history of EMG, types of EMG, characteristics of EMG signal, muscles involved in movements of hand, parameters which are used to analyse EMG signal, variety of applications where EMG signals can be used. This paper will provide the researchers a good understanding of EMG signal and its analysis. This knowledge will help them to develop more powerful and efficient applications.

Keywords— EMG (Electromyography), Muscles of Hand, Standard Parameters, Threshold Detection, Applications**.**

INTRODUCTION

EMG is the measurement of electrical current which are generated by the muscle fibers during their contractions which represents the neuromuscular activities. This signal is complicated and non-stationary signal which is controlled by nervous system because the nervous system is always responsible for muscle activity. The amplitude of EMG signal is very small (50μv to 1mv) with frequencies varying from 10Hz to 3000Hz [1]. This signal called the electromyogram (EMG) which can be measured by applying electrodes to the skin surface (Non-Invasive Method) or intramuscular/ indwelling (Invasive Method) within the muscle. Generally three types of electrodes can be used to acquire muscle signal: wire, needle and surface electrode. With different kinds of electrodes the EMG signal that obtained might contain different characteristics [2].

1) *Intramuscular (needle and fine-wire) EMG:* To perform invasive EMG, a needle electrode or a needle containing two fine-wire electrodes is inserted through the skin into the muscle tissue.
2) *Skin surface EMG:* To perform non-invasive EMG, electrodes are placed on (not into) the skin overlying a muscle to detect the electrical activity of the muscle.

From above two methods, skin surface electrodes are used because they are non-invasive. By using needle electrodes we can obtain good muscle selectivity and signal to noise ratio, so needle electrodes have been used in clinic diagnosis. Whereas the surface EMG signal usually contains the crosstalk signal originating from surrounding muscles. So it is difficult to analyse specific small muscle region by the surface EMG signal. But the surface EMG is very safe and easy to use [3].

2. Characteristic of EMG Signal:

1) The amplitude of the EMG signal is random in nature which can be represented by a Gausian distribution function and its amplitude can range from 0 to 10 mV (peak-to-peak) or 0 to 1.5 mV (rms)
2) The useable energy of the signal is limited to the 0 to 500 Hz frequency range, with the dominant energy being in the 50 - 150 Hz range.

3. Classification Of Muscles:

Muscles can be classified into three categories depending upon their involvement to a movement :

1) *Agonist muscles:* Agonists are also referred as prime movers because they are the muscles being considered that are primarily responsible for generating a specific movement because they initiate the movement and also generate most of the force.

2) *Synergist muscles:* Synergists muscles are also referred neutralizers because they help in neutralize extra motion from the agonists to make sure that the force generated works within the desired plane of motion. These muscles also assist the agonist muscles because they generate less force but contribute to the control of the movement.

3) *Antagonist muscles:* This type of muscles acts in opposition to the specific movement generated by the agonist and is responsible for returning a limb to its initial position.

But A movement occurs when the agonist and synergists contract while the antagonist is relaxing.

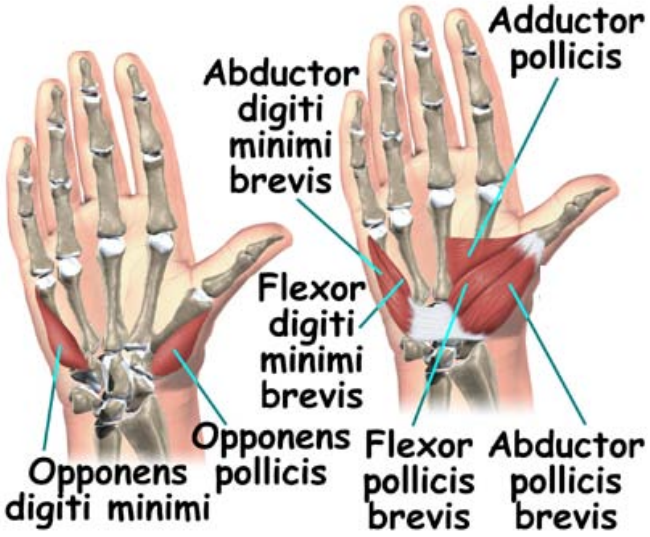

Fig. 1 Hand Muscles

TABLE I
MUSCLES INVOLVED IN MOVEMENTS OF WRIST

S.No.	Involved Muscles			
	Flexion	**Extension**	**Radial Deviation (Abduction)**	**Ulnar Deviation (Adduction)**
1	Flexor carpi radialis	Extensor carpi radialis brevis	Extensor carpi radialis brevis	Extensor carpi ulnaris

2	Flexor carpi ulnaris	Extensor carpi radialis longus	Extensor carpi radialis longus	Flexor carpi ulnaris
3	Palmaris longus	Extensor carpi ulnaris	Flexor carpi radialis	
4	Flexor digitorum superficialis	Extensor digitorum	Extensor pollicis brevis	
5	Flexor digitorum profondus	Extensor pollicis longus		
6		Extensor indicis		

STANDARD PARAMETERS TO BE MEASURED FROM EMG SIGNAL

EMG signal can be analysed with different standard parameters which are as following:

1) Amplitude related parameters
2) Frequency related parameters
3) Time related parameters

If we want to analyse any of above parameter then we have to convert our raw EMG signal into rectified EMG signal first.

1) Amplitude related parameters:

We can measure following parameters from the EMG trace:

1) *EMG peak:* It is the maximum value of amplitude which can be measured from rectified EMG signal that can muscle generate.

2) *Mean:* This parameter tells about the strength of muscle for which we are analysing EMG and its endurance too.

3) *Area/IEMG:* IEMG means Integrated EMG. It is the mathematical integral of the EMG amplitude, which corresponds to the area under the curve, for a given period of time. It tells about the amount of energy produced during that period of time.

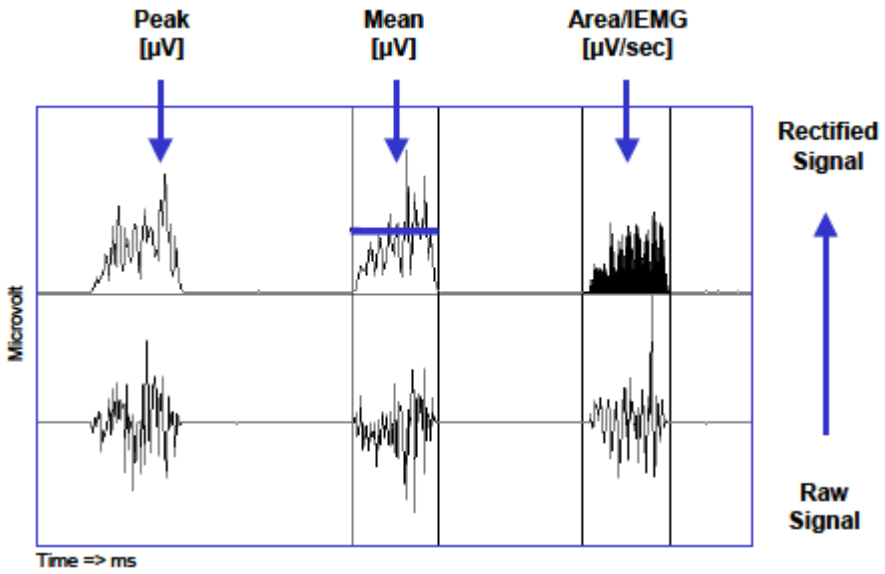

Fig. 2 Raw EMG and its Rectified form

4) *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.

2) Frequency related parameters:

To calculate these parameters firstly we have to transform the EMG signal in the time-domain to the requency-domain, by using the FFT of the EMG signal to provide the power spectrum (PS) or the power spectral density (PSD).

1) *Mean Frequency:* It is the mathematical mean of the spectrum curve. It is an average frequency which can be calculated by taken the sum of product of the EMG power spectrum and the frequency divided by the total sum of the power spectrum (e.g. Oskoei & Hu, 2008; Phinyomark et al., 2012a). As per definition it may be defined as:

$$MNF = \sum_{j=1}^{M} f_j P_j \Big/ \sum_{j=1}^{M} P_j ,$$

Where *fj* is the frequency value of EMG power spectrum at the frequency bin *j*, *Pj* is the EMG power spectrum at the frequency bin *j*, and *M* is the length of frequency bin.

2) *Median Frequency:* This is the important parameter which divides the total power spectrum into two equal parts. MDF is also defined as a half of the total power and it may be defined as :

$$\sum_{j=1}^{MDF} P_j = \sum_{j=MDF}^{M} P_j = \frac{1}{2}\sum_{j=1}^{M} P_j$$

3) *Total power spectrum:* It may be define as the integral part of the spectrum curve. Its equation can be expressed as:

$$TTP = \sum_{j=1}^{M} P_j = SM0$$

So MNF and MDF are act as powerful tool to detect fatigue in target muscle using EMG. MNF and MDF should increase as the muscle force or load increases. MNF and MDF should increase as the muscle length or joint angle decreases.

3) Time related parameters:

This is the important class of EMG parameters addresses timing characteristics within the EMG signal and in ratio other biomechanical signals or movement events.

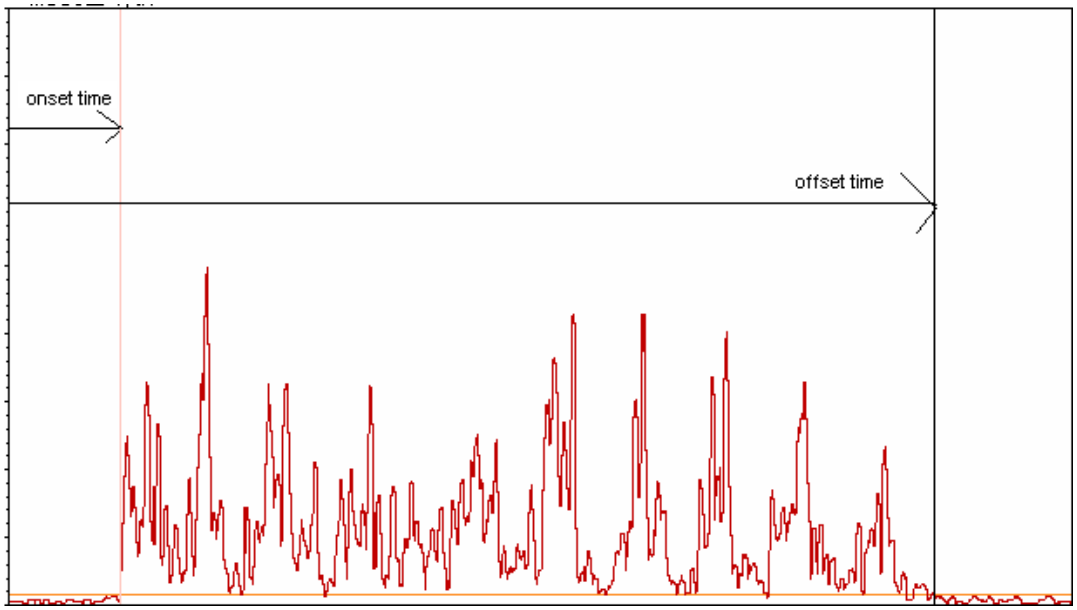

Fig. 3 Onset and Offset time period

1) *Onset Time:* This is also known as activation time which is the time taken by muscle to contract.
2) *Offset Time:* This is also known as deactivation time which is the time taken by muscle to go back to rest.

THRESHOLD DETECTION

Threshold value is necessary for the detection of muscle activity timing in electromyographic signal analysis. We can select threshold value by applying following methods:

1) The root mean square (RMS) envelope can be used as an indicator of the total muscle activation.
2) Standard deviation (SD) can also be used for selecting a threshold value.
3) To select a threshold value, we can use a percentage amount of the local peak activation found within the analysis period.
4) We can also select threshold by selecting a fixed value by defining a value within a certain microvolt level.

APPLICATIONS

1) EMG can be used to control of a virtual robot hand [4]
2) EMG analysis is widely used in biomechanics and movement control research to determine how the central nervous system controls muscular contraction to produce motion, and in clinical practice to diagnose the state of neural or muscle malfunction. The use of the Hilbert-Huang transform as an alternative method for the analysis of the surface electromyography signal for studying local muscle fatigue during sustained isometric constant force muscle contractions. [5-9].

3) As we know electric power wheelchairs are important for elderly and highly disabled user which is normally controlled by joy stick but now we can control this wheelchair by EMG too. Two main methods can be used in it- pattern recognition and hybrid recognition system. The detailed study regarding this can get from [10].
4) It has been proposed that the EMG signals from the body's intact musculature can be used to identify motion commands for the control of a prosthetic hand (Tucker and Liu 1999, Christodoulou and Pattichis 1999). Biomedical signals, especially EMG signals, have been processed by time–frequency transforms in order to extract more representative features to improve the rate of classification of motions [11].
5) EMG can be also used in Medical Research (Orthopedic, Surgery, Functional Neurology and Gait & Posture Analysis), Rehabilitation (Post surgery/accident, Neurological Rehabilitation, Physical Therapy and active Training Therapy), Ergonomics (Analysis of demand, Risk Prevention, Ergonomics Design, Product Certification and Sports Science (Biomechanics, Movement Analysis, Athletes Strength Training and Sports Rehabilitation)
6) PARKINSON's disease (PD) by using surface EMG and acceleration measurements. is a progressive neurodegenerative disorder characterized by four primary symptoms: resting tremor, rigidity, bradykinesia, and postural instability. Because there is currently no definitive test for PD, the diagnosis is based on the presence of clinical symptoms and the response to anti-Parkinsonian medications. The isometric and the dynamic EMG and acceleration measurements can be used for discriminating between PD patients and healthy persons [12-14].

CONCLUSIONS

In this paper, we described introduction, types of EMG, characteristics of EMG signal, muscles involved in movements of hand, parameters which are used to analyse EMG signal, variety of applications where EMG signals can be used. . It started with an explanation of EMG then followed on to a representation of their types. This paper will provide the researchers a good understanding of EMG signal and its analysis. This knowledge will help them to develop more powerful and efficient applications.. Finally, the paper discussed the application of EMG signals.

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