DETECTING THE USEFUL ELECTRO-MYOGRAM SIGNALS–EXTRACTING, CONDITIONING & CLASSIFICATION

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Abstract

Surface EMG is an important signal containing the information in form of electrical signals referred as myoelectric signals, used in designing & development of many prosthesis and clinical researches applications .Various methods can be applied to study or getting the useful data.

Keywords- SEMG (surface electromyogram) ; ANN

1. Introduction- The **Surface EMG** signal includes the information on the voluntary movement generated from motor area. It is the control source for almost all powered upper-limb prosthetic devices. [1].Muscle contraction produces an increased nervous fibers excitability, which may determine a spontaneous EMG activity. [2], [3] That manifests itself as organized group of spikes-multiplets with relatively regular amplitudes & interspike intervals as shown in Fig. 1

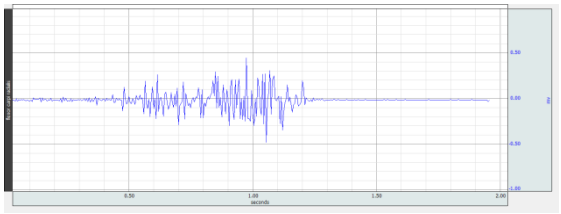

Fig.1 EMG activity showing spikes-multiplets

This EMG activity can easily be sensed at surface of skin as myoelectric signals. These signals are complex signals produced by summation of hundreds of muscle fibers; many stimulated by separate nerve fascile muscle tissues which are responsible for the contraction & relaxation are due to extensibility, elasticity. They produce motion by initiating an impulse in the neuron to the muscle. This neuron is called a **Motor neuron** and these impulses are called muscle action potential. An EMG signal is the train of motor unit action potential showing the muscle response to neural stimulation. Thus combination of muscle fiber action potential from all the muscle fibers of a single motor unit action potential(MUAP) can be detected from the surface of skin.[4] as in fig.2

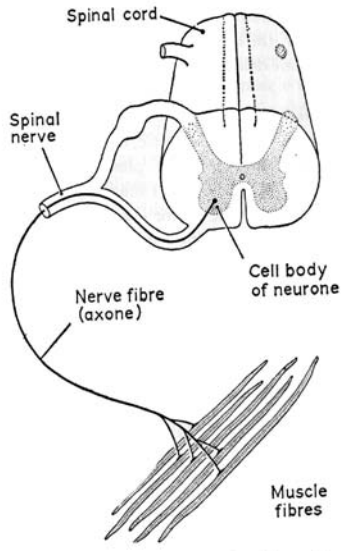

Fig.2-Scheme of Motor unit(After Basmajian,1955a)

A number of prosthetic hands and some hand orthoses have been developed to operate from EMG signals picked up through surface skin electrodes [5]. The human voice, including whistles and the like has been proposed & used as a signal source. Much research at present is devoted to machine recognition of human speech for voice-operated typewriters & speaking directly to the computer. Enticing as the idea may be, many years must pass before thoughts will be transformed directly into meaningful electric signals.

The analysis of the SEMG can be broadly categorized into two:-

1. Decomposition of SEMG into MUAPS

2. Gross & global parameters.

Sec.2 explains the detection of SEMG signal and then its conditioning. Sec.4 leads to feature extraction which is fed to classifier to discriminate the proposed hand motions or tasks.

2. Extracting SEMG signal

The SEMG signal generated by the muscle fibers is captured by the conductive electrodes placed on surface of skin, then amplified& filtered by the sensor before being converted to a digital signal by the encoder. It is then sent to the computer to be processed, displayed & recorded by the software. Two main issues of concern that influence the fidelity of signal while detecting & recording the SEMG are: -

1.S/N ratio

2. Distortion of signal,

which should be minimized [4] . since motor unit action potential occur at random intervals, so at any moment signal may be either positive or negative voltage. EMG signals acquire noise while traveling through different tissue. It is important to understand the characteristics of the electrical noise. Electrical noise, which will affect EMG signals, can be categorized into the following types:

1. *Inherent noise in electronics equipment*: All electronics equipment generate noise. This noise cannot be eliminated; using high quality electronic components can only reduce it.
2. *Ambient noise:* Electromagnetic radiation is the source of this kind of noise. The surfaces of our bodies are constantly inundated with electric-magnetic radiation and it is virtually impossible to avoid expo-

sure to it on the surface of earth. The ambient noise may have amplitude that is one to three orders of magnitude greater than the EMG signal.

3. *Motion artifact:* When motion artifact is introduced to the system, the information is skewed. Motion artifact causes irregularities in the data. There are two main sources for motion artifact:

   1) electrode interface and 2) electrode cable. Motion artifact can be reduced by proper design of the electronics circuitry and set-up.

4. *Inherent instability of signal*: The amplitude of EMG is random in nature. EMG signal is affected by the firing rate of the motor units, which, in most conditions, fire in the frequency region of 0 to 20 Hz. This kind of noise is considered as unwanted and the removal of the noise is important

EMG signal recorded by either invasive or non-invasive electrode (surface electrode), or implantable radio transmitter capable of long term operation can be used [6]. Amplitude range of an EMG signal is 0-10mv in 0-500 Hz. Of frequency range which when filtered to give more accurate EMG free from noise signal in between 15-150 Hz. Signal can be recorded by either BiomuseTM system manufactured by biocontrol system inc. or Biopac system MP150 US or any other system. During the EMG signal processing, only positive values are analyzed. When half-wave rectification is performed, all negative data is discarded and positive data is kept. The absolute value of each data point is used during full-wave rectification. Usually for rectification, full-wave rectification is preferred.

3. Signal Detection & Conditioning

EMG signal is a time series data, which is superposition of single MUAPs, artifacts & background noise. Signals are filtered to remove the artifacts using low-pass or notch filters. For the analysis of EMG, it can be modified either in time domain or frequency domain using various techniques. Such as FT, STFT, WT, statistical measures etc. [4]. Basic shapes of surface MUAPs can be represented by only a few wavelet functions [7]. One of the interesting feature of EMG signal is the no. of active motor units & the MUAP waveform. WT provides 2D time –frequency representation. It uses short window at high-frequency & long window at low frequency unlike STFT which uses a single analysis window. It is use to analyze the change of the frequency & phase in time series signal such as speech and bio-signals [8].

4. Feature extraction

Refinement of the detected signal done. Now as stated by the researchers in 1990's there is useful information in the transient burst of myoelectric signal. For this reason several features are extracted from the time domain features such as integrated EMG, VAR, average rectified, willison amplitude etc.

All these features are selected for their ease in computation. They are defined as:

$$\text{IEMG} = \sum_{K=1}^{N} |X_K| \qquad (1)$$

$$\text{VAR} = \frac{1}{N-1}\sum_{K=1}^{N} X_K^2 \qquad (2)$$

$$\text{WAMP} = \sum_{i=1}^{n} f(|X_{K-} X_{K+1|}) \quad \text{,where} f(X) = \begin{Bmatrix} 1, if \quad X > .3 \\ 0, otherwise \end{Bmatrix} \qquad (3)$$

5. Classification techniques

There are several possible classification techniques as summarized :-

a) Neuro –fuzzy
b) ANN
c) SVM
d) Minimum distance classifier

e) Blind source separation or by evolutionary algorithms.
For ex. In minimum distance classifier the single nearest neighbor technique bypasses the problem of probability distance completely & simple classifies an unknown sample as belonging to same class as the most similar or nearest sample point in training set of data .
While the classification procedure using ANN is implemented in three phases:

1. In the first phase unsupervised learning is applied based on one dimensional self-organizing feature map and competitive learning.
2. In the second phase, in order to improve classification performance, a self-supervised learning technique, the learning vector quantization is applied.
3. In the third phase, the actual classification takes place.

CONCLUSION

The aim of this paper was to give brief information about EMG & reveals the various methodologies to analyze the signal. This study can help in designing any hardware for prosthesis, research laboratories, biomechanics, postural control , EHW chip development, human machine interaction, etc. Clinical applications of EMG as a diagnostics tool can include neuromuscular diseases, low back pain assessment, kinesiology and disorders of motor control. EMG signals can be used to develop EHW chip for prosthetic hand control. Grasp recognition is an advanced application of the prosthetic hand control.

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