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A Review paper on EMG Signal and its Classification Techniques

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Abstract—

Electromyography (EMG) signal is electrical disclosure of neuromuscular activation, which gives permission to different physiological processes which makes the muscle to develop force and gives movement and allow us to interact with the world.
In this paper, we have discussed different steps in analyzing the EMG signals. The first step is to analyze the surface EMG signal from the subject's forearm using wavelet packet transform and extract features using the singular value decomposition. In this way, a new feature space is generated from wavelet packet coefficients.
The second step is to call the different feature values into multi class Support Vector Machine as a classifier, to recognize different degrees of freedom like open to close, close to open etc.
This paper will give in depth insight in the field of EMG signal.

Index Terms—EMG signal, DWT, fuzzy classifier, feature extraction

I. INTRODUCTION

Around the world, there are large number of hand amputations due to diseases, accidents and war. There are many difficulties in their daily life, so it needs to design a prosthetic control hand such as control nature, easy to use, signal stability and painless to solve the problem [1]. Electromyography technique is used for controlling such prosthetic hand. It represents the recorded electrical activities produced by skeletal muscles. The electrical activity generated during the contraction of skeletal muscles are called as EMG signals or Electromyography signals. These signals are called the biomedical signals as they measure the muscle response representing the neuromuscular activities [2]. EMG is applied to the study of skeletal muscle. The contraction of skeletal muscle is initiated by impulses in the neurons to the muscles and is usually under voluntary control. Skeletal muscle fibers are well supplied with neurons for its contraction. This particular type of neuron is called a" motor neuron" and it approaches close to muscle tissue but is not actually connected to it. One motor neuron usually supplies stimulation to muscle fibers [3].

Surface Electromyography signals (SEMG) is a type of bioelectrical phenomenon as the activity of muscle is associated on the surface of skin. Skin surface contains an abundance information regarding the muscle movement. SEMG can records biological signal generated on the skin surface during the muscle movement with the help of electrodes, so that these signals can be used to control the prosthetic or robotic hand [4].

II. EMG SIGNALS

EMG signals are the electrical responses generated during the contraction of a skeletal muscle. It measures muscle response or electrical activity in response to nerve's stimulation of the muscle. During the measurement, one or more small needles(or called invasive electrodes) are inserted through the skin into the muscle. The electrical activity picked up by the electrodes is then displayed on an oscilloscope (a monitor that displays electrical activity in the form of waves). EMG signals can also be taken by noninvasive electrodes. EMG measured by noninvasive electrodes is called surface EMG signals [5]. A pictorial view of EMG signals is shown in figure 1.

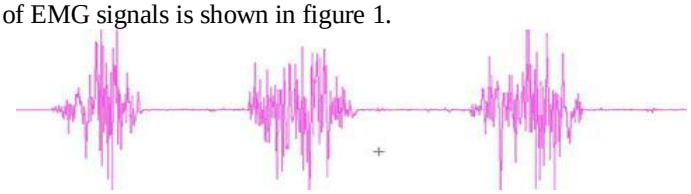

Fig 1: EMG Signal

After an electrode has been inserted, patient may be asked to contract the muscle, for example, by lifting or bending his hand. The action potential (size and shape of the signal) that this creates on the oscilloscope provides information about the stability of the muscle to respond when the nerves are stimulated. As the muscle is contracted more forcefully, more and more muscle fibers are activated producing action potentials.

III. USE OF EMG SIGNALS

EMG signals have been used in such application as controlling active prosthesis, wheelchairs, exoskeleton robots, rehabilitation, silent speech recognition, and controlling video games as it can be measured on a human skin surface with noninvasive electrodes [6]. In commercially available prosthetic devices EMG signals have been exploited for a

proportional control strategy. To improve its usability, a control strategy based on the classification of EMG signals has been widely studied, in such a strategy, a classifier is constructed for the surface EMG signals to recognize the intended human movements using classified movements to generate the corresponding behavior of the device. The EMG signal is also used to help to detect neuromuscular abnormalities [7].

IV. HOW TO USE EMG SIGNALS

The EMG signals cannot be used in the raw form. To use these signals first of all signal conditioning is done to reduce noise and to make more signal strength. After this there are some stages which should be followed by all control systems that are based on EMG signals. These are:-

A. Data Acquisition and Data Segmentation

In this stage, signal is acquired from body and is filtered to reduce noise produced by other electrical activities of body.

B. Features Extraction and Dimensionality Reduction

This stage converts raw signal obtained from stage 1 into feature vector. The feature vector represents relevant structure in the raw data. Dimensionality reduction eliminates redundant information in the feature vector, generating reduced feature vector.

C. Feature Classification

It involves pattern recognition. Since a classification algorithm is applied to reduced feature vector in order to obtain categories.

D. Controller

This stage translates categories to control commands for execution.

(B)Feature Extraction

There are three types of features in EMG signal based control system. These are time domain, frequency domain, time-frequency domain features. Here time-frequency domain features are to be considered. Mostly widely used wavelet transform method is used.

B.i) Wavelet transform

It is a transform where a signal is integrated with a shifted and scaled mother wavelet function [8]. The continuous wavelet function can be represented as:

$$w_x\,(a,b) = \int x(t)\left(\frac{1}{\sqrt{a}}\right)\psi^x\left(\frac{t-b}{a}\right)\,\mathrm{dt}$$

Where x(t) represents the input signal,ψ^x represents the complex conjugate of mother wavelet function and($\frac{t-b}{a}$) is the shifted and scaled version of wavelet having time b and scale a.

B.ii)Wavelet transform

It is one of the most popular time-frequency representation techniques capable of representing a signal into two-dimensional function of time and frequency. It offers several advantages in comparison to other frequency transform such as Fourier Transform and Cosine Transform. As, in another technique called Short Time Frequency Transform (STFT), a constant resolution is used at all frequencies but the DWT being a multi-resolution technique offers localization both in time and frequency. Thus the DWT exhibits good frequency resolution at low frequencies and good time resolution at high frequencies [9]. Hence, DWT is chosen to extract features from surface EMG signal.

The DWT coefficients of a signal x(n) may be obtained as:

$$c(a,b) = \sum_{n=z} x[n]\,\psi_{a,b}[\mathrm{n}] \qquad (1)$$

$$\psi_{a,b}[\mathrm{n}] = \frac{1}{\sqrt{a}}\,\psi\left(\frac{n-b}{n}\right) \qquad (2)$$

Where a is scale, b is translation and ψ(n) represents discrete wavelet.

The DWT operation can be viewed by passing the signal x[n] through two complementary filters that is low pass filter having impulse response g[n] and high pass filter having impulse response h[n] and may be represented as:

$$y_g[\mathrm{n}] = \sum_{k=-\infty}^{\infty} x[k]g[2n-k] \qquad (3)$$

$$y_h[\mathrm{n}] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k] \qquad (4)$$

Thus DWT helps in analyzing the signal at different frequency band with different resolution.

(C) Feature classification

The output of feature extraction must be converted into linguistic terms which can be understood. So , it is necessary to classify the features. There are various methods involving the classification of features [10].

C.i) Fuzzy logic classifier

The fuzzy logic was introduced by in 1965 by Lotfi Zadeh. It is a mathematical tool for dealing with uncertainty, imprecision and information granularity. Fuzzy theory employs fuzzy sets, membership functions, rules, fuzzification, defuzzification. Fuzzy sets model the uncertainty associated with vagueness, imprecision and lack of information regarding the problem, involving the linguistic variables such as low, medium, high, often, few etc.

V. CONCLUSION AND FUTURE SCOPE

Now a days, huge number of people are getting disability in their hand due to accidents, Cancer like disease etc. So the work done in this direction will be a great boon for disabled and handicapped people. It is very tough to automate the artificial hand from EMG signal received. This technology is in its initial stage and lot of work has to be done in this field. Different softwares and algorithms has been developed and used to overcome the problem. But due to high cost of the artificial hands, it is not used by the normal human being. Therefore it is very important to reduce the cost and at the same time improve the technology.

The EMG signal received is very complex and foggy in nature. It is very complex in nature. Therefore investigator is interested to do the work in this field using the great tools like fuzzy logic and DWT.

The work has great scope. The work can be accomplished using software, microcontrollers etc. The different work done in software simulation can be burn in microcontroller to get the work done.

The is really great field to do some work in the field of humanities and technology also because it is really great work to give working artificial hand to some disabled persons.

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