SIGN LANGUAGE RECOGNITION BASED ON ELECTROMYOGRAPHY (EMG) SIGNAL USING ARTIFICIAL NEURAL NETWORK (ANN)

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Abstract- EMG signal is a muscular signal. It can represent equally time & frequency domain. EMG provides measurement of muscular performance. Hence it is a direct representation of strength of health. It is used for identification & treatment tasks by comparing with normal person. EMG biofeedback can be instantaneous as compare to manual inspection. EMG signal used in management of prostheses & to improve the effectiveness of rehabilitation robotics. The motive of this paper is to describe the process of detecting different predefined hand gestures using artificial neural network (ANN). This different hand gestures used by deaf & dumb people to understand the things. The EMG sample signatures are extracted from the signals for all movement and then given to ANN for training & classification. A back-propagation (BP) network has been used for the recognition of sign, as it works well for different biosignal. The features like autoregression coefficient, fast Fourier transform, short time Fourier transform, wavelet transform coefficient, mean absolute value, root mean square, variance, standard deviation, Mean frequency, zero crossing and slope sign change are selected to train the neural network.

Keywords- Electromyography, Artificial Neural Network, Back-propagation (BP) Network

I. INTRODUCTION

Human computer interface is a dynamic research area because it is useful for disabled people or aged people. Hand gesture recognition is a main part of research in human computer interface. The gesture recognition is to develop a system that recognizes the gestures and they used to control the devices. The gesture taken from any motion of body but mainly they are taken from face and hand. Simple devices are used such as electrodes, vision based system etc. Mainly two methods for acquiring EMG signals i.e. invasive and noninvasive. Noninvasive means surface method which is mostly preferred but it is less accurate as compare to invasive. Invasive is painful as needles are inserted in body. For interfacing pattern recognition is important. As compared with the further biosignal EMG is a noisy signal and it includes complex types of noises due to environment, electromagnetic induction, Motion artifacts, interaction of different tissue. Sometimes it is difficult to get useful data due to skin layer or disabled person. Motion commands are used to control peripheral devices for that pattern signature are taken from every EMG signal and used for classification. Complex nature of EMG signal makes it classification difficult. Its most random nature make difficult to have a precise structural or mathematical model. Different types of ANN used for processing biosignal. We mostly use Multilayer Perceptron Layer containing one hidden layer and Back Propagation algorithm for training. Some of the research works are decision tree, multi stream hidden markov models, combinational neural networks, decision level classifier fusion and different kind of fuzzy classifiers are also used. The hidden markov models have to make large assumptions and large amount of data is required for training, hence it cannot be used in real world applications. The decision tree overlaps when the numbers of classes are large and the error accumulates from level to level in large trees.

II. SIGNAL ACQUISITION

The surface EMG signals are acquired for various hand movements using software RmsEng EPMK-II. The placement of electrode is very important, the optimal position of electrode is found after performing several trials.

Three lead electrodes are used. The single channel differential electrodes placed on flexor carpus ulnaris muscle and the reference electrode on the wrist. The sampling frequency was 1000 Hz and gain selected 46 dB The EMG signals obtained for different voluntary movement of subject’s hand & fingers in different directions (A to E shown in Figure 2).

The average time required to perform each movements was around 500 milliseconds. Each EMG Signal set has been collected for 1.30 seconds. For processing only 1.00 seconds data is considered. Its most random nature make difficult to have a precise structural or mathematical model. Different types of ANN used for processing biosignal. We mostly use Multilayer Perceptron Layer containing one hidden layer and Back Propagation algorithm for training. This error function must be continually reduced so our output reaches that of the desired output. To achieve this we adjust the weights on the links between layers. By reducing error desired output is obtained.
III. METHODOLOGY

A. Processing of EMG signals
EMG signals which have very sensitive nature tainted by external noise sources and artifacts. If we use this contaminated signal result will be much reduced which is not advantageous. The noises can be grouped as motion artifacts, power line noise, electrode noise, ambient noise, and inherent noise the electrode noise, motion artifacts can be indifferent by placing the electrodes an appropriate position and using good quality equipment. The band pass filter with frequency range of 20-500Hz is used to remove the motion artifacts, electrode noise and power line noise and it’s quite difficult to remove the other types of noises lies in the dominant frequency range of EMG as shown in figure (4,5). Later on the EMG signal is denoised using wavelet method. Since the wavelet can restrict both time and frequency components. The Fourier transform gives only the frequency mechanism hence the wavelet transforms is used. Moreover the wavelet transform gives high quality frequency decision at high frequencies, so the noise workings in the desired signal can be isolated. As EMG signal is multifarious in character proper selection of feature is important. Some of the research works are decision tree, multi stream hidden markov models, combinational neural networks, decision level classifier fusion and different kind of fuzzy classifiers are also used. The hidden markov models have to make large assumptions and large amount of data is required for training, hence it cannot be used in real world applications. The decision tree overlaps when the numbers of classes are large and the error accumulates from level to level in large trees.

B. Features Extraction
The various features extracted by different researchers are mean absolute value (MAV), variance (VAR), standard deviation (SD), zero crossing (ZC), waveform length (WL), Willson amplitude (WA), mean absolute value slope (MAVS), mean frequency (MNF), median frequency (MDF), slope sign change (SSC), cestrum coefficients (CC), fast Fourier transform (FFT) coefficients, short time Fourier
transform (STFT) coefficients, root mean square (RMS), autoregression (AR) coefficients, integrated EMG (IEMG), wavelet transform (WT) coefficients, and wavelet packet transform (WPT) coefficients. In this work the feature extracted are fast Fourier transform (FFT), autoregression (AR) coefficient, Burg method for AR spectral estimation is based on minimizing the forward and backward prediction errors. In contrast to other AR estimation methods, the Burg method avoids calculating the autocorrelation function, and instead estimates the reflection coefficients directly. The Burg method ensures a stable AR model and is computationally efficient. Power spectral density (PSD) by Nonparametric method Welch, mean absolute value (MAV), standard deviation (SD), waveform length (WL), mean absolute value slope (MAVS), mean frequency (MNF), median frequency (MDF), zero crossing (ZC), crestum coefficients (CC), correlation coefficients (CR) these features are extracted for every movements and how they calculated given below.

3.2.1 Power spectral density (PSD):
Welch’s method yields a biased estimator of the PSD. The expected value can be found to be

\[
PSD = \frac{1}{L_0} \int_{-f_s/2}^{f_s/2} |F_p(f)|^2 \, df
\]

Where \( L_0 \) is the length of the data segments and \( U \) is the same normalization constant. As is the case for all periodograms, Welch’s estimator is asymptotically unbiased. \( f_s \) is sampling frequency and \( f \) is sinusoid frequency. For a fixed length data record, the bias of Welch’s estimate is larger than that of the periodogram because \( L_0 < L \).

3.2.2 Mean Absolute Value (MAV):
It is the average rectified value (ARV) and can be calculated using the moving average of full-wave rectified EMG. More specifically, it is calculated by taking the average of the absolute value of EMG signal. It calculated to find out muscle contraction levels. It is calculated as

\[
MAV = \frac{1}{N} \sum_{n=1}^{N} |x_n|
\]

Where \( N \) is the length of the signal and \( x_n \) represents the EMG signal in a segment.

3.3.3 Root Mean Square (RMS):
It is represented as amplitude modulated Gaussian random process whose RMS is related to the constant force and non-fatiguing contraction. It can be expressed as

\[
RMS = \sqrt{\frac{1}{N} \sum_{n=1}^{N} x_n^2}
\]

3.4.5 Standard Deviation (SD):
It can be used to find the threshold level of muscle contraction activity. The general equation used to find SD by

\[
SD = \sqrt{\frac{1}{N} \sum_{n=1}^{N} (x_n - \bar{x})^2}
\]

Where \( x^* \) is the mean frequency of EMG signal

3.4.6 Mean Frequency (MNF):
The mean frequency is that frequency where the product of the frequency value and the amplitude of the spectrum are equal to the average of all such products throughout the complete spectrum.

\[
MNF = \frac{\sum_{n=1}^{N} f_n d_n}{\sum_{n=1}^{N} d_n}
\]

Where \( f_n \) is the frequency of the spectrum

3.4.7 Zero Crossing (ZC):
It is the number of times the amplitude values crosses the zero y-axis. It provides the approximate estimation of frequency domain properties. It can be calculated as

\[
ZC = \sum_{n=1}^{N} \text{sgn}(x_n, x_{n+1})
\]

where \( |x_n| - x_{n+1} | \geq \text{threshold} \)

\[
\text{sgn}(x)=\begin{cases}1, & \text{if } x \geq \text{threshold} \\ 0, & \text{otherwise} \end{cases}
\]

C. EMG signal classification
For classification I have used Artificial Neural Network (ANN), which comes under the title soft computing. Soft computing includes number of techniques and methods used to solve any complex problem and difficulty same as human being. Human Being deals with any situation on basis of intelligence, common sense, consideration of analogies, approaches etc. It means soft computing is a family of problem resolution methods which is mainly guided by approximate reasoning and function involving search methods. We can say that soft computing is a basis of Artificial Intelligence. Before understanding how the ANN works we must know how the human brain working. Human brain is a highly complicated system which is capable to solve very complex problem. Main part of brain is neuron. Approximately 1011 neuron present in human brain which is connected by 1015 connections creates huge neural network.

![Artificial Neural Network](image)

Neuron sends impulses to each other through connection and these connections are responsible for brain work. The neural network also receives impulses from sensors of body and sends result to muscle. Due to which motion or speech is possible. ANN works similar to human brain. Basically two types of ANN are available one is single layer and other is multilayer. Single layer is limited to simple...
problem while for complex situation multilayer ANN is used. Multilayer ANN consists of three layers, input layer, hidden layer, output layer. In Backpropogation we know input and output function. To find given output function we adjust weights and number of hidden neurons.

IV. RESULTS

![Fig. 7 Error Histogram](image)

![Fig. 8 Training State](image)

![Fig. 9 Mean Square Error Graph](image)

![Fig. 10 Efficiency of classifications](image)

### TABLE I. Various features extracted for different movement

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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</table>

### CONCLUSION

The target of a project to extract different hand gesture based from EMG signals. The different features were extracted were classified using ANN. By using Back Propagation algorithm given signs are classified. Accuracy of result can be increased if more number of signals used. It can be studied that due to psychological properties of EMG signal it has great importance in diagnosis, human computer interaction & separation of different sign languages. But it has some limitations due to its accuracy in acceptance of EMG signal. The classified signal can be utilized for the controlling of any human computer centred systems or devices.

### REFERENCES


