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Application of Neural Network in Diagnosing Neuromuscular Disorder using EMG Signal

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ABSTRACT:Since past few years, researchers have been concentrating on the classification of Electromyography Signal. This method is very convenient in diagnosing the neuro-muscular disorders, which consists of wide spread diseases affecting peripheral nervous system. Progressive muscle weakness is the major form of these disorders.

Out of various proposed methods, scholars are commonly focusing on Neural Network for its accuracy. And the basic variant feature, Motor Unit Action Potential is selected for classification.

Out of various available tools, this research uses Discrete Wavelet Transform as a tool for classification and for the training of N-Network, a multilayer feed forward neural network with back propagation algorithm is used.

KEYWORDS:Artificial neural network (ANN), Discrete wavelet transform (DWT), feed forward neural network (fNN), Motor unit Action Potential (MUAP), Amyotrophic Lateral Sclerosis (ALS), k-Nearest Neighbors (kNN), Electromyography (EMG).

I. INTRODUCTION

Nervous system works as a network, which passes electric signals to and fro between brain and body organs. These signals generate a potential, which is a function of time. A process called Electromyography reads and store signals present in skeletal muscles with respect to time. This research is presenting a method for identifying the neuromuscular diseases.

Out of the available types of electrodes available for recording the EMG signal, a concentric needle electrode is used to extract the EMG signal. This needle is a thin pointed sterile and is penetrated deep into the muscles under hygienic clinical environment. The patient under test is said to contract muscle constantly and intermittently while recording the EMG signal. The morphology of signal itself shows variation in amplitude of signal with contraction and relaxation of muscles. The signal's variation while contraction of muscle is called as Motor Unit Action Potential or MUAP. These signals are generated by muscles and goes to Central Nervous System CNS through motor nerve. This is shown in figure 1.

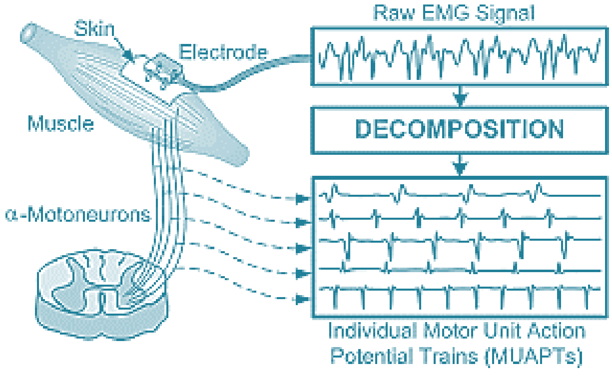

Figure 1.Procedure of recording of EMG Signal.

MUAPs detected from myopathic patients are characterized by high frequency contents, low peak-to-peak amplitude and MUAPs neuropathic patients are poly-phasic, low frequency, high peak-to-peak amplitude than the normal MUAPs. [1], [2]. This work shows a method to distinguish between myopathy, ALS and healthy patient signals. It uses a

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wavelet based classification scheme with Feed Forward Neural Network (FFNN) and Back Propagation Neural Network (BPNN).
This process starts with decomposing of recorded signal using DWT (discrete wavelet transform). For decomposing a software known as EMG-LODEC is specially developed for recording multichannel long-term signals. The wavelet based algorithm distinguishes single MUAP by superposing the input signal [3].

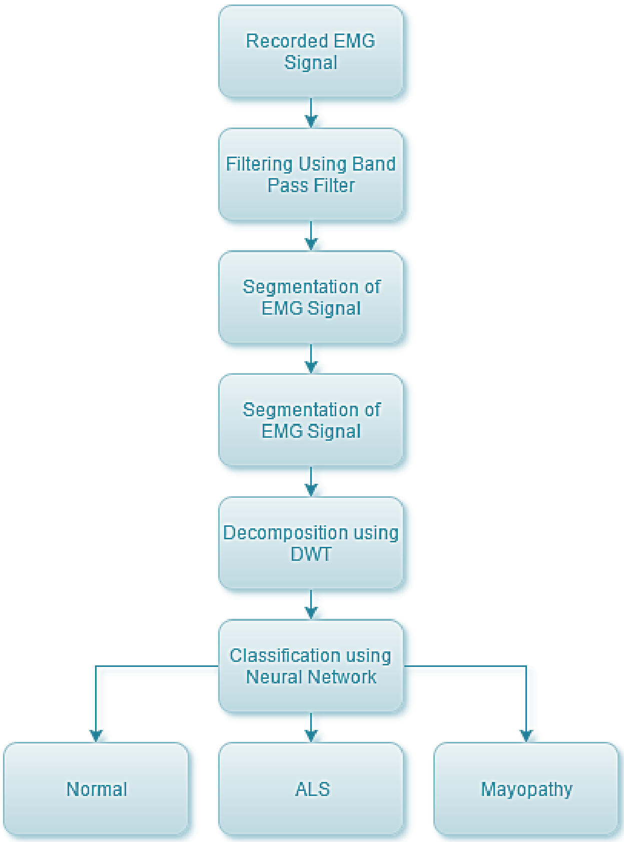

Figure 2. Steps showing method of EMG signal classification.

II. FEATURE EXTRACTION BY USING EMG DECOMPOSITION

Initially the EMG signal is filtered using band pass filter with pass band between 10 Hz to 3 KHz. The signal being a composite signal consists of active and inactive components. By windowing only active components are extracted. Segmentation of EMG signals is carried out by finding the peaks of the MUAPs, then a window of 180 sampling points is centered at the identified peak, size of window depends on sampling rate [4]. In case of myopathy MUAPs become low in amplitude and short in duration, while for the neurogenic disorders, MUAPs exhibit higher amplitude and longer duration than normal [5]. Thus only the dominant segment of MUAP is used for feature extraction. A set of algorithms is usually adopted to perform a quantitative description of the signal and a parameter extraction from the signal conditioning to the measurements of average wave amplitudes, durations, and areas, [6].
Discrete wavelet transform (DWT) is an efficient time-frequency approach that is being used for processing biomedical electrical signals. Thus, for EMG, DWT provides the time and frequency information simultaneously [7]. Wavelet function is calculated using equation (1).

$$X(a,b) = \frac{1}{\sqrt{b}}\int_{-\infty}^{\infty} x(t)\Psi\left(\frac{t-a}{b}\right)dt \qquad (1)$$

The parameters ‘a’termed as the dilationparameter and‘b’ asthe translation. This research uses Daubechies-4 wavelet up to the 10th level for only 262134 samples are available for this research. The feature set has coefficients cd1 to cd10

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and ca10 and levels 1 to 10. The EMG signal is maximum between range of frequencies from 0.5 Hz and 40 Hz. The intensity of wavelength coefficient energy is much high in bands ca10, cd10, and cd9. Due to low SNR in frequency bands of levels from 1 to 8 and coefficients from cd1 to cd8, they are ignored. High frequency components lie in the coefficients from cd9 and cd10 while low frequency component lies in ca10. The features extracted from decomposition is fed to the neural network for classification.

III. DISCRETE WAVELET SCHEME

The EMG Signal isfedto two convolution functions i.e. a LPF and a HPF. Each produces an output having length half of actual input.The output of LPF is given by equation (2).

$$y_1[k] = \sum_n x(n)h_0[2k-n] \quad (2)$$

Whereas the output of HPF is given by equation (3).

$$y_2[k] = \sum_n x(n)h_1[2k-n] \quad (3)$$

Where y1 and y2 are known as an approximate and detail component respectively. The results of these filtersare down sampled by a factor of 2 and from 1-level decomposition up to 10 levels. This reduces the samples from 262134 to 262, which is suitable for training of neural network.

IV. NEURAL NETWORK FOR CLASSIFICATION

This research uses the efficient and accurate classifier, the neural network.It hascomplex and rich structure& it learns from previous experience. The classification accuracyincreases with training iteration of the neural network. This paper shows use of Multilayer Feed Forward Neural Network with Back Propagation Algorithm.
Every result is stored in the form of connection weights as an experience for future results. The informationobtainedfrom experience is stored in the form of connection weights. These weighs updates after every training. To achieve the desired level of training, successive training attempts are to be made. In this paper, total 14 hidden neurons are used. The simplified network i.e. back propagation neural network is shown in figure 3.

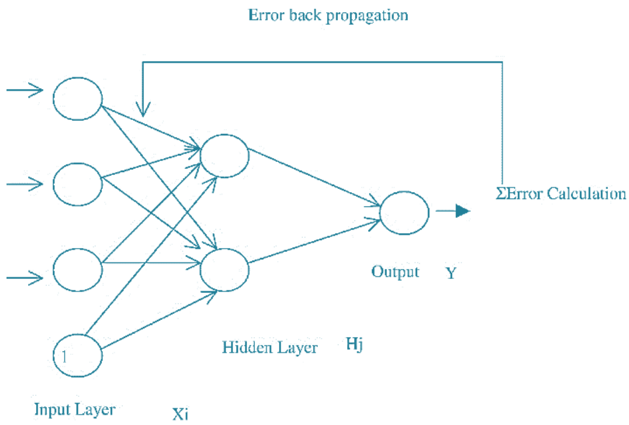

Figure3.Back Propagation neural network

V. K-NN TECHNIQUE

The k-NN is an acronym for k-Nearest Neighbour. A case in which the effect of error is constant for every class, the estimated class of an unknown sample is selected to be represented in the group of its K nearest neighbors. The training samples are taken without considering any priori assumptions. Classification of a new sample starts with calculation of the distance to the nearest training case. The polarity of potential of this point classifies the sample. This classifier selects the k nearest points and assigns the polarity of the majority. ‘k’ with large value minimizes the cost of noisy

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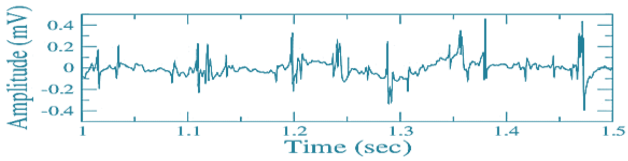
points of the training data set. The value of 'k' is selected by cross-validation. In this way, its Euclidean distance 'd'is estimated. Equation (4)takes the available training samples and classifies to the extent of the minimal distance.

$$q(x, y) = \sqrt{\sum_{j=1}^{n} \left(x_j - y_j\right)^2} \quad (4)$$

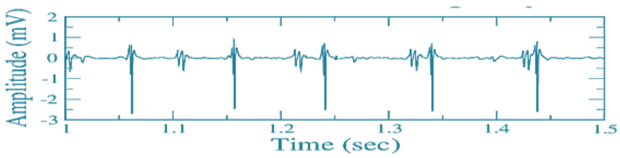
Every example of training with a class label is termed as a vector in a multidimensional feature space. The training portion of the algorithmincludes only recordingof the feature vectors and class labels of the training samples. The classification portion of the algorithm has 'k'as a user-defined constant, and an unlabeled vector is classified by giving it a label. Even thoughthe Euclidean distanceis applicable to continuous variables, it can be used as a distance metric.

VI. RESULT WITH DISCUSSION

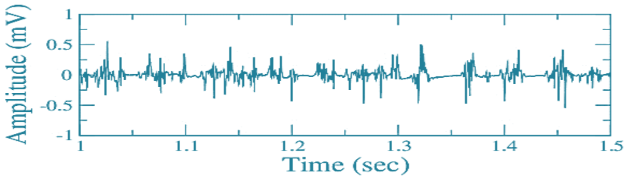
In this paper, features are extracted using DWT for the classification using neural network. The process of decomposition of the samples from ALS, Myopathy and Healthy person is done up to 10 levels, which is shown in figure 4.



(a)



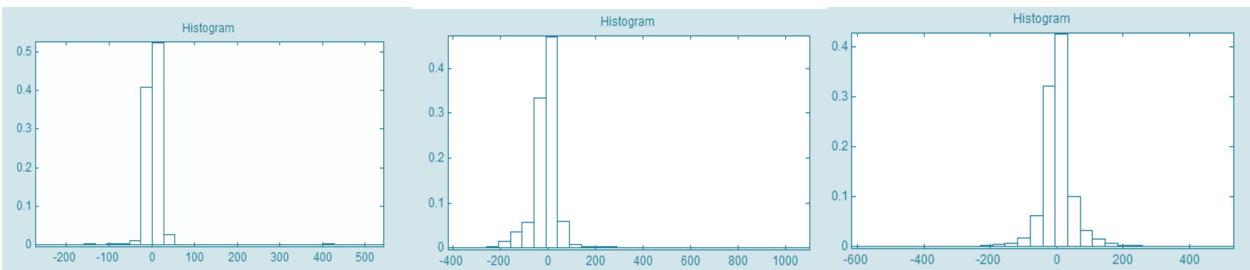
(b)



(c)

Fig. 4.EMG Signals of (a) Healthy (b) ALS (c) Myopathy

The number of samples available in the given signal decide the level of decomposition.For better accuracy level of decomposition can be increased by taking further more number of samples.
The morphology of histograms of given samples shown in figure 5 also distinguish the three classes.



(a) (b) (c)

Fig. 5.Histogram of (a) Healthy (b) ALS (c) Myopathy

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VII. CONCLUSION

The morphology of results itself distinguishing between Healthy, ALS & Myopathy. kNN and fNN classifiers will be used to differentiate between these three classes due to their greater accuracy. This work may be helpful to physicians for pre-examining the neuromuscular disorder.

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Syed Irfan Aliwas born in Nagpur, India, in 1982. He received the B.E. degree in Electronics and TelecommunicationEngineering from the RTM Nagpur University, Nagpur, India, in 2005, and pursuing the M.Tech in Electronics and Communication Engineering from the same university.

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