Development of Diagnostic System for Identification of Neuromuscular Disorders from EMG

Gauri Pachori[#1], Dr. A.K. Wadhwani[#2]
PG Student#1, Professor#2 , Measurement and Control
Dept. of Electrical Engineering, MITS Gwalior – 474005.
Madhya Pradesh, India
[1]gauripachori13@gmail.com
[2]wadhwani_arun@rediffmail.com

***Abstract*— The purpose of an Electromyography (EMG) signal examination is to describe the localization, the severity and the type of the patient's neuromuscular disorders. The severity and type is usually inferred from the changes in the electrical activity recorded from muscles and nerves, the anatomical distribution of the changes provides clues for the localization of the disorders. EMG signals can be used for clinical, biomedical applications and modern human computer interaction. EMG signals acquired from muscles require advanced methods for detection, decomposition, processing, and classification. This paper provides researchers a good understanding for identification of Neuromuscular disorders from EMG. This knowledge will help them develop more powerful, flexible, and efficient applications.**

***Keywords*— Electromyography (EMG), Feature extraction, Motor Unit Action Potential (MUAP), Neuromuscular disorders, Segmentation.**

I. INTRODUCTION

The EMG signal is a biomedical signal that measures electrical currents generated in muscles during its contraction representing neuromuscular activities. Hence, the EMG signal is a complicated signal, which is controlled by the nervous system and is dependent on the anatomical and physiological properties of muscles. Biomedical signal means a collective electrical signal acquired from any organ that represents a physical variable of interest. This signal is normally a function of time and is describable in terms of its amplitude, frequency and phase. The EMG signal is a biomedical signal that measures electrical currents generated in muscles during its contraction representing neuromuscular activities. The nervous system always controls the muscle activity (contraction/relaxation). EMG signal acquires noise while travelling through different tissues. Moreover, the EMG detector, particularly if it is at the surface of the skin, collects signals from different motor units at a time which may generate interaction of different signals. Detection of EMG signals with powerful and advance methodologies is becoming a very important requirement in biomedical engineering. The main reason for the interest in EMG signal analysis is in clinical diagnosis and biomedical applications. The field of management and rehabilitation of motor disability is identified as one of the important application areas. The shapes and firing rates of Motor Unit Action Potentials (MUAPs) in EMG signals provide an important source of information for the diagnosis of neuromuscular disorders. Once appropriate methods for EMG signal analysis are readily available, the nature and characteristics of the signal can be properly understood and its implementations can be made for various EMG signal related applications. So far, research and extensive efforts have been made in the area, upgrading existing methodologies, improving detection techniques to reduce noise, and to acquire accurate EMG signals. It is quite important to carry out an investigation to classify the actual problems of EMG signals analysis and justify the accepted measures. The technology of EMG recording is relatively new. There are still limitations in detection and characterization of existing nonlinearities in the Electromyography (EMG, a special technique for studying muscle signals) signal, estimation of the phase, acquiring exact information due to derivation from normality. Traditional system has various limitations and considerable computational complexity and many show high variance. Recent advances in technologies of signal processing and mathematical models have made it practical to develop advanced EMG detection and analysis techniques.

II. DATA ACQUISITION

In order to record real time EMG Signal, the database was taken from department of Electrical Engineering of Madhav Institute of Technology and Science, Gwalior. The EMG signal was taken from the biceps brachii muscle using a concentric needle electrode. This data is loaded in MATLAB software. The sampling Frequency and duration of the signal were 20kHz and 5 sec respectively . We have taken different EMG signals (7 Normal (NOR) subjects, 8 subjects for both Myopathy (MYO) and Motor Neuron Disorder (MND)).

III. SEGMENTATION

The goal of the segmentation is to divide the EMG signals into inactive and active segments. The segmentation is only possible only for cases where the main peak of an MUAP is not distorted by overlapping by some parts of other MUAPs, because the selection of superimposed candidates is based on the amplitude of this peak. Segmentation is done to determine the number and shape of different MUAPs present, to know the approximate location of each peak and to know the amount of the MUAP waveforms throughout the EMG signal.

In segmentation, the EMG is cut into the segments of possible MUAP waveforms and the low activity signal is eliminated. MUAP waveforms and the low activity signal is eliminated. The segmentation technique algorithm calculates threshold depending on maximum value of the complete signal. Peaks over the calculated threshold are considered as the candidate MUAP. The threshold is taken as maximum peak/5. A window with a consent length of 120 points is taken and slide across the point, which crosses the threshold. Then this interval is examined if a peak exists in this window then the window of 120 points is taken around this peak otherwise these 120 points are saved as candidate MUAP.

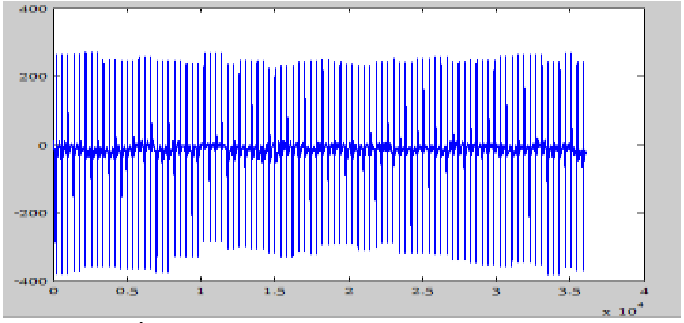

Fig1: EMG Waveform

IV. CLASSIFICATION TECHNIQUE

Statistical Pattern Recognition Technique:

The statistical pattern recognition technique is based on the Euclidean distance. Euclidean distance is determined to identify groups of similar waveforms using a constant threshold. The
MUAP waveform that is having minimum distance or having maximum similarity from the reference waveform is considered belonging to the same class. The steps of decomposition
technique are as follows: -

1) Start with first waveform, x, as the reference waveform; being the first member of the class.
2) Calculate the Euclidean distance, d x , between the x and the other entire segmented waveforms y i . Calculate

$$l_x = \sum_{i=1}^{n} x_i^2$$

Where n=400 is the number of samples ,i is the ith sample of the waveform x, l x , is the length of the vector of waveform x, and

$$dxy = \sum_{i=1}^{n} (xi - yi)^2$$

3) Find those waveforms which have

$$dxy \le 0.125 * lx$$

If number of identified waveforms >2, then form a new MUAP class and calculate its average waveform and store.

4) The new references from the remaining segments and go to step 2 and determine the Euclidean distance. If it satisfies take the threshold criteria, and then MUAP class is determined accordingly.

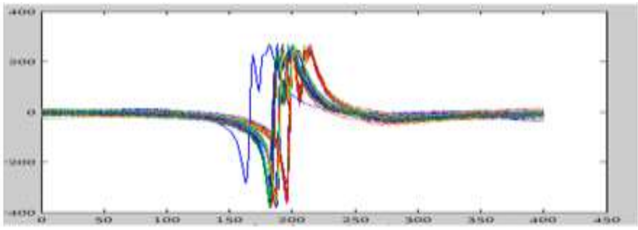

Fig 2: Segmented waveform for NOR Subject

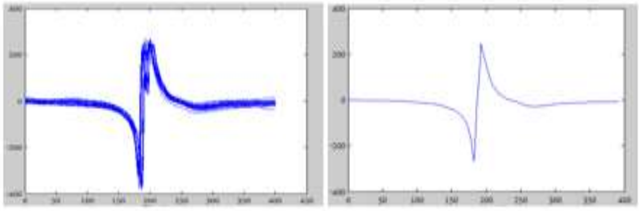
Fig 2(a): Class 1 MUAP & Fig 2(b): Averaging of Class 1

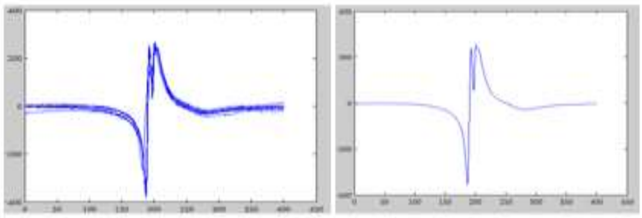
Fig2(c): Class 2 MUAP & Fig2 (d): Averaging of Class 2

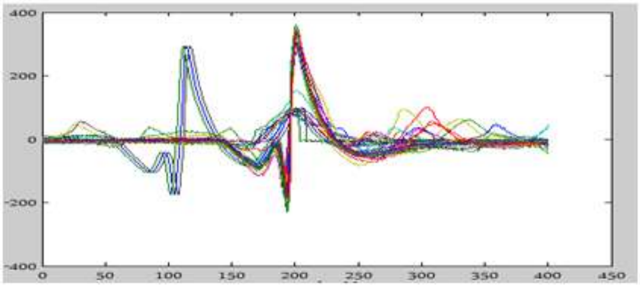

Fig 3: Segmented waveform for MYO subject

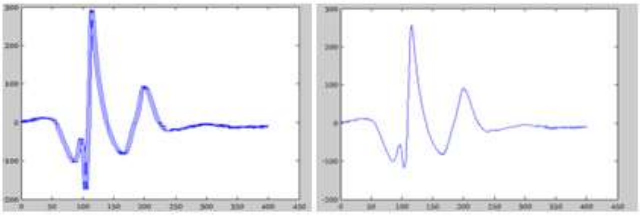

Fig 3(a): Class 1 MUAP & Fig 3(b): Averaging of Class 1

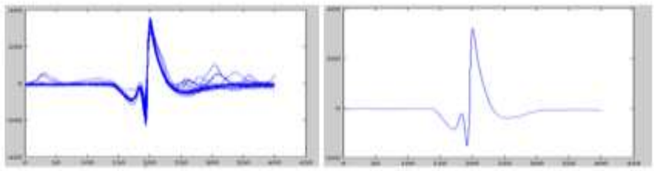

Fig 3(c): Class 2 MUAP & Fig 3(d): Averaging of Class 2

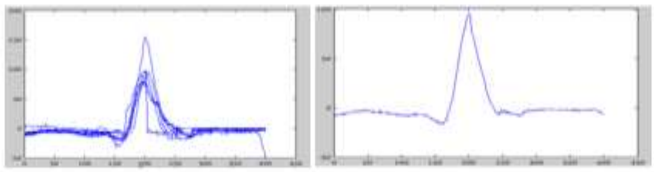

Fig 3(e): Class 3 MUAP & Fig 3(f): Averaging of Class 3

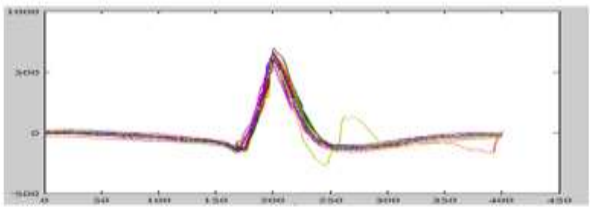

Fig 4: Segmented waveform for MND Object

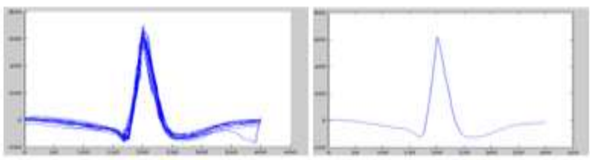

Fig4 (a): Class 1 MUAP & Fig4 (b): Averaging of Class 1

V. RESULTS

TABLE 1: TIME DOMAIN PARAMETERS (TDP):

Signal	Amplitude (mv) mean	Duration (ms) mean	Spike duration(ms) mean	Area (mV-ms) mean	Spike Area(mV-ms) mean
NOR	0.395	9.60	5.45	0.392	0.236
MYO	0.320	7.35	4.22	0.245	0.170
MND	0.622	13.55	6.90	0.840	0.530

Table 2: Frequency domain parameters (FDP)

Signal	Median frequency(HZ)	Maximum frequency (HZ)	Bandwidth (HZ)	Quality factor
NOR	420	215	528	0.48
MYO	622	406	764	0.66
MND	335	215	380	0.73

VI. CONCLUSIONS

A methodology for classification of EMG data with Normal, Myopathy and Motor Neuron Disorders is presented. This method, based on the Statistical Pattern Recognition Technique, and relevance analysis, is simple and do not require high computational cost compared with other works proposed in the state of the art. Achieved results show that this method is an alternative for extracting relevant features and classification for EMG signals. In this paper we extracted features amplitude, duration, spike duration, area, spike area, maximum frequency, median frequency, bandwidth and quality factor of each signal. The results were found to be satisfactorily as compared with the available literature.

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