Design and Development of Electromayography Measuring System

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Abstract**: The work in this paper is based on analysis of Electromyography (EMG). This EMG signal is electro diagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is measured using an instrument called an electromyography to produce a record called electromyogram. Most of the standard EMG measurement systems are expensive and not feasible for personal applications. Therefore, the work in this paper is focussed to design an EMG signal detection and classification model that can distinguish between different gestures of a human being. the application of wavelet transform is used to extract time-frequency based information from the signal followed by noise removal stage. Further, extraction of these significant information is used to extract EMG signal in Myopathy and Neuropathy. Numerical simulation of statistical parameters is used to validate the proposed model.**

Keywords**: EMG, Myopathy, Neuropathy, Standard deviation, Wavelet transform**

1.INTRODUCTION

EMG signal is an important physiological signal that reflects the electrical activity of skeletal muscles. It is generated by the contraction of muscle fibres, which is caused by the depolarization of muscle cell membranes. The EMG signal can be measured using electrodes that are placed on the surface of the skin or by inserting needle electrodes into the muscle tissue. It is a complex biomedical signal that contains information about the timing, amplitude, and frequency of muscle contractions. It can be used to study the neuromuscular system and is commonly used in clinical and research settings to diagnose and treat a variety of neuromuscular disorders. The interpretation of EMG signals can be challenging due to their complex nature, and requires specialized training and expertise. Factors such as electrode placement, muscle fatigue, and electrical interference can affect the quality of the EMG signal, and must be taken into account when interpreting the results. Overall, the EMG signal is an important physiological signal that provides valuable information about the function of skeletal muscles. It has numerous applications in clinical and research settings, and is an essential tool for studying the neuromuscular system and developing treatments for neuromuscular disorders.

The frequency range of EMG signals varies depending on the type of muscle activity being measured. Typically, EMG signals have a frequency range between 20 Hz to 500 Hz, with most of the energy concentrated in the range of 50 Hz to 200 Hz. However, the frequency range can extend beyond 500 Hz in certain situations, such as during high-frequency muscle activity or in pathological conditions. The amplitude or voltage of EMG signals is also variable depending on the level of muscle activity being measured. The amplitude of the EMG signal can range from microvolt to mill volts, with higher amplitudes corresponding to stronger muscle contractions.

It is important to note that EMG signals are often contaminated by noise and artifacts, which can affect the accuracy and reliability of the signal. To minimize noise and artifacts, it is important to use proper electrode placement, signal amplification, and signal filtering techniques. Additionally, EMG signals can be affected by factors such as muscle fatigue, muscle cross-talk, and electrode movement, which can also affect the quality of the signal.

Characteristic	Myopathy	Neuropathy
Primary site of pathology	Muscles	Nerves

Symptoms	Weakness, atrophy, myalgia	Numbness, tingling, weakness.
Causes	Genetic mutations, inflammation, infections, toxins, metabolic disorders	Diabetes, infections, toxins, autoimmune disorders, hereditary conditions
Diagnosis	Muscle biopsy, electromyography (EMG)	Nerve conduction studies, EMG
Treatment	Physical therapy, medications, surgery	Treating underlying cause, pain management, physical therapy

Table 1.1: Various types of EMG Signals [4]

Figure 1, shows EMG signal of healthy person which is downloaded from MIT BIH Arrhythmia Database, Physio net ATM [5].

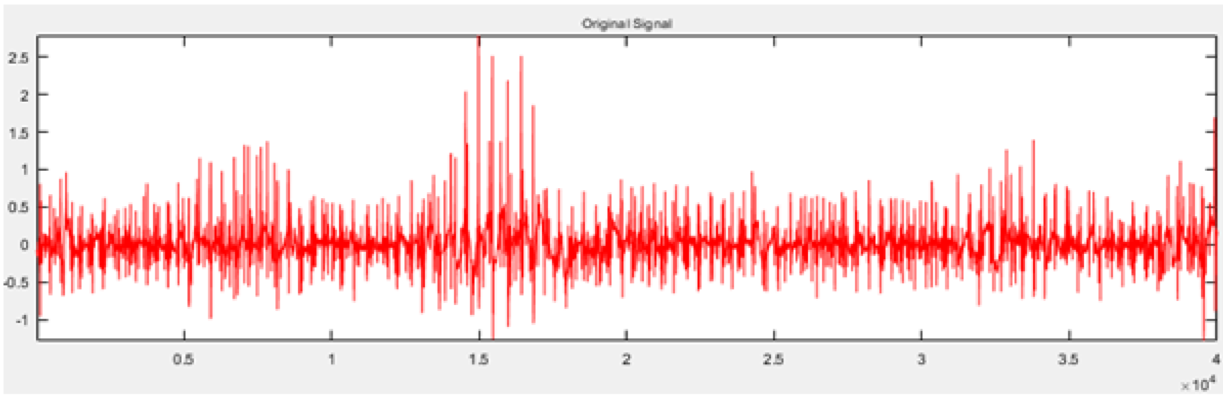


Fig 1: EMG Healthy Signal

Wavelet coefficients are used in signal processing to analyze signals at different scales and frequencies. In the context of EMG signals, wavelet coefficients can be used to extract features that can be used for further analysis, such as muscle activity patterns. The formula for computing wavelet coefficients for an EMG signal involves convolving the signal with a wavelet function, which is a small, oscillating signal that is centered at zero. The wavelet function is scaled and shifted across the time axis of the signal to obtain a set of coefficients at different scales and positions. [8]

The specific formula for computing wavelet coefficients for an EMG signal will depend on the choice of wavelet function and the implementation of the algorithm. One common approach is to use the discrete wavelet transform (DWT), which is a digital signal processing technique that decomposes a signal into a set of wavelet coefficients at different scales and positions. The DWT can be computed using a filter bank approach, where the signal is filtered with a low-pass and high-pass filter at each stage of the transform. The resulting coefficients are then down sampled to obtain a reduced set of coefficients at the next scale.

In summary, the formula for computing wavelet coefficients for an EMG signal involves convolving the signal with a wavelet function, and the specific implementation will depend on the choice of wavelet function and the algorithm used (such as the DWT). [6]

a[j] → Approximation coefficient

d[j]→ Detailed coefficient

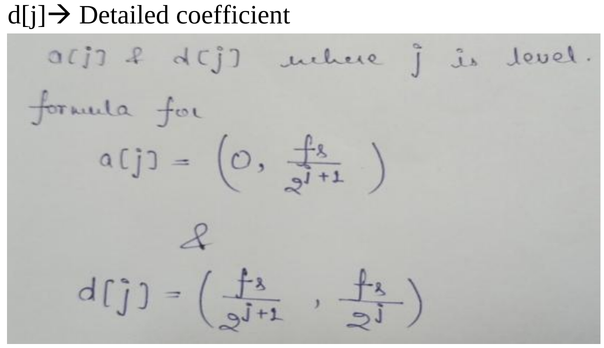


Fig 2 : Formula of Wavelet Coefficient

Table 1.2: Frequency bands of Wavelet Coffiicients at sampling frequency 4000 Hz

Level number	a[j] in khz	d[j] in khz
Level 1	(0, 0.5)	(0.5, 1)
Level 2	(0, 0.25)	(0.25, 0.5)

Level 3	(0, 0.125)	(0.125, 0.5)
Level 4	(0, 0.625)	(0.625, 0.125)
Level 5	(0, 0.0312)	(0.0312, 0.0625)
Level 6	(0, 0.0156)	(0.0156, 0.0312)
Level 7	(0, 0.0078)	(0.0078, 0.0156)
Level 8	(0, 0.0039)	(0.0039, 0.0078)
Level 9	(0, 0.00195)	(0.00195, 0.0039)

RELATED WORK

The design and development of an Electromyography (EMG) measuring system is important for several reasons:

Improved Understanding of Muscle Function: [4]

- EMG signals provide valuable information about muscle function, including muscle activation patterns, muscle fatigue, and muscle coordination. By accurately measuring and analysing these signals, researchers and clinicians can gain a better understanding of the underlying mechanisms of muscle function, leading to improved treatments and therapies for muscle-related conditions.
- Diagnosis and Treatment of Muscle-related Conditions: EMG signals can be used to diagnose and monitor a wide range of muscle-related conditions, including muscle diseases, neuromuscular disorders, and musculoskeletal injuries. By providing accurate and reliable measurements of muscle function, EMG measuring systems can help clinicians develop personalized treatment plans for patients with these conditions.

The applications of designing and developing an Electromyography (EMG) measuring system are broad and diverse, with potential uses in healthcare, technology, and sports performance. Some common applications of EMG measuring systems include: [4]

- Diagnosis and Treatment of Muscle-Related Conditions: EMG signals can be used to diagnose and monitor a wide range of muscle-related conditions, including muscle diseases, neuromuscular disorders, and musculoskeletal injuries. EMG measuring systems can provide accurate and reliable measurements of muscle function, helping clinicians develop personalized treatment plans for patients with these conditions.
- Prosthetic Limb Control: EMG signals can be used to control prosthetic limbs, allowing for more natural and intuitive control interfaces. By developing more advanced EMG measuring systems, researchers and clinicians can improve the accuracy and efficiency of prosthetic limb control, improving the quality of life for individuals with limb loss.

The advantages of designing and developing an Electromyography (EMG) measuring system are numerous and include:

- Accurate Measurement of Muscle Function: EMG measuring systems provide accurate and reliable measurements of muscle function, allowing researchers and clinicians to better understand the underlying mechanisms of muscle function and develop more effective treatments and therapies for muscle-related conditions.
- Non-Invasive Measurement: EMG measuring systems are non-invasive and do not require surgery or other invasive procedures. This makes them a safe and convenient method for measuring muscle function, reducing the risk of complications and improving patient comfort. [4][7]

METHODOLOGY

The methodology of EMG analysis with wavelets is a powerful technique for investigating the electrical activity of skeletal muscles. It provides detailed information about the frequency content of the EMG signal, which can be used to study muscle function, movement, and disorders.

Wavelet analysis is a mathematical technique that allows for the decomposition of signals into their frequency components over time. By using wavelets, EMG signals can be analyzed at different scales to extract information about the frequency content of the signal [8][9].

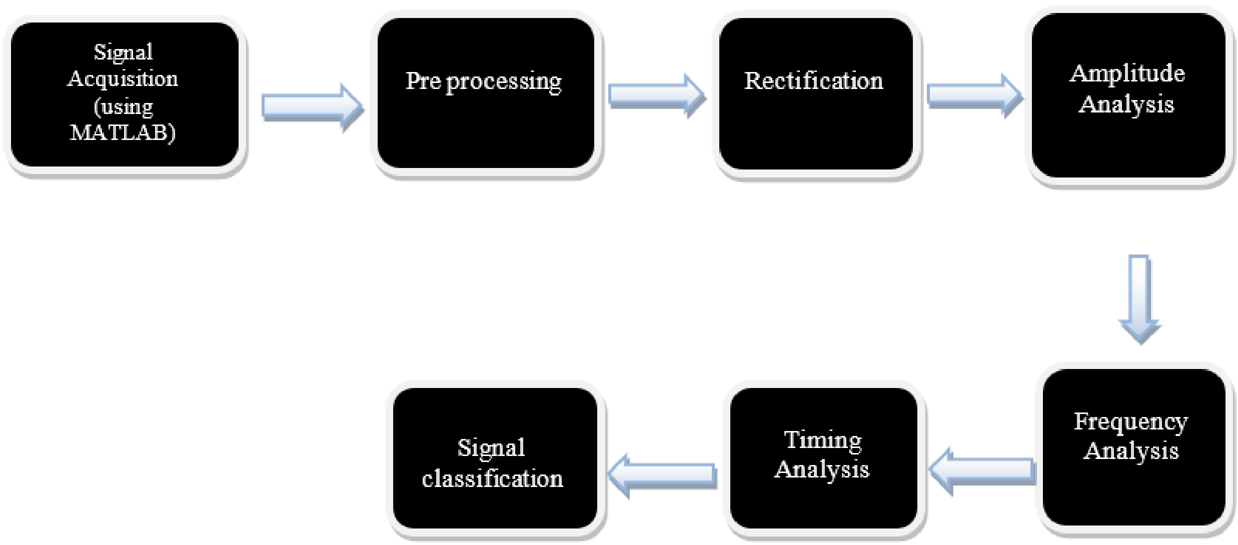


Fig 3: Work flow diagram for EMG signals processing

EXPERIMENTATION AND SIMULATION RESULTS

Figure (4) shows, imported various EMG signals in MATLAB workspace from MIT BIH arrhythmia database.

It consists of sampling frequency of 4000 Hz, gain of the signal and number of EMG samples are 1000 recorded in 0.00025.

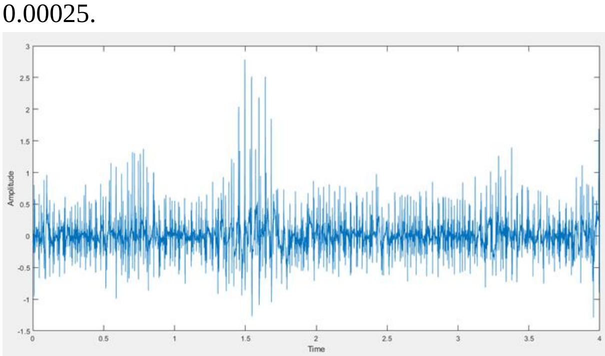


Fig 4 (a) EMG signal of Healthy Person

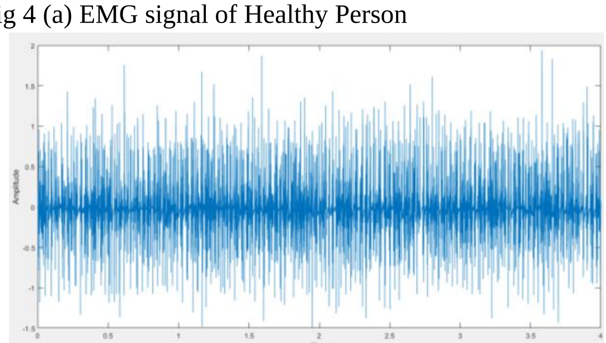


Fig 4 (b) EMG waveform of Myopathy signal

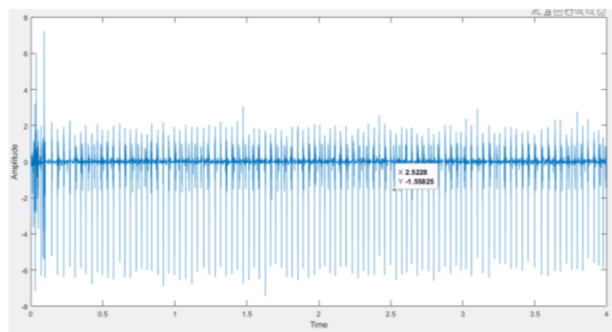


Fig 4 (c) EMG waveform of Neuropathy signal

Wavelet transform is applied on synthesized signal using Wavelet tool box in MATLAB, to denoise EMG signals.

Figure 5: shows various wavelet decomposition level of EMG signal for a healthy person

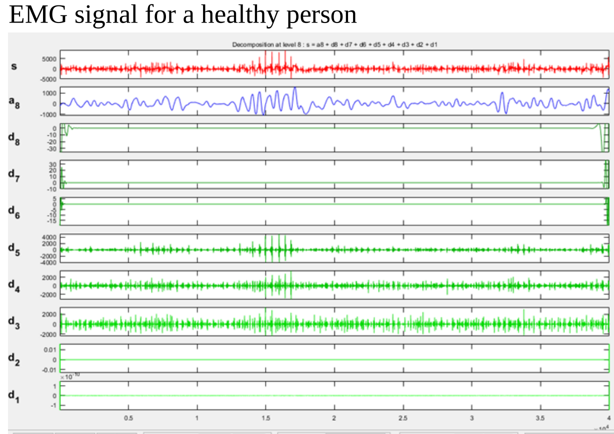
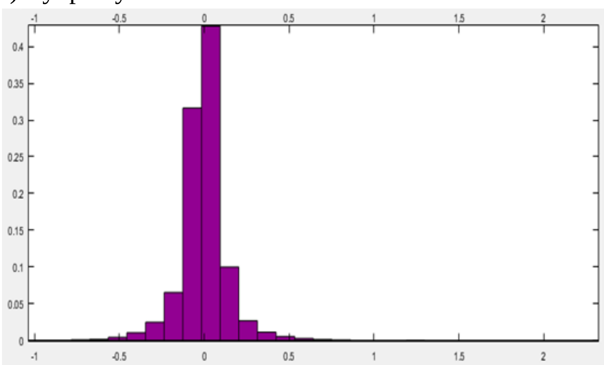


Fig (5): Wavelet decomposition level for healthy signal

	Healthy person	Myopathy	Neuropathy
Standard deviation	0.1458	0.1783	0.4534
MSE	0.08933	0.1143	0.1935
Median Absolute deviation	0.05423	0.06854	0.05718
Energy	94.63	92.88	96.12

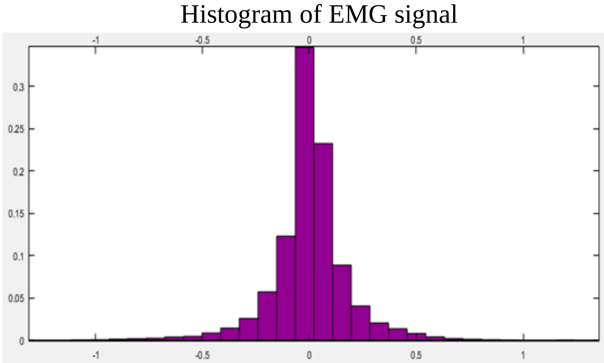
Table 1.3: Numerical simulation of statistical values on MATLAB (Wavelet Toolbox)

Fig 6: Histogram images of: (a) healthy, (b) Neuropathy, (c)Myopathy



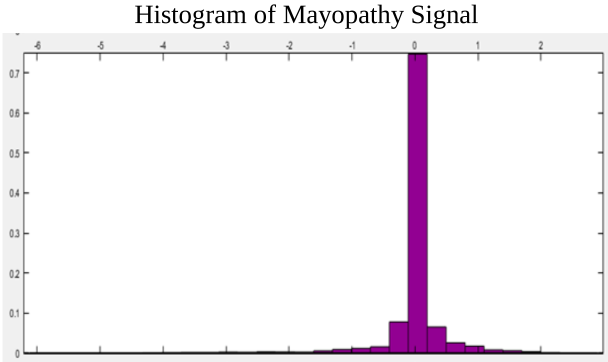
(a)

Histogram of EMG signal



(b)

Histogram of Mayopathy Signal



(c)

Histogram of Neuropathy Signal

CONCLUSION

The paper concludes that, this EMG analysis provides a powerful tool for identifying and characterizing muscle disorders. The features calculated from the wavelet coefficients can provide valuable information about the nature and severity of muscle disorders, and the analysis of wavelet coefficients can reveal subtle changes in muscle activity patterns that are not apparent in traditional time-domain or frequency-domain analyses. Further research is needed to validate the utility of wavelet-based analysis of EMG signals for clinical diagnosis and treatment of neuromuscular disorders.

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