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FINAL YEAR PROJECT REPORT

EMG CLASSIFICATION BASED ON FEATURES REDUCTION USING FUZZY C-MEANS CLUSTERING TECHNIQUE

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

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ABSTRACT

This paper illustrates the features reduction technique for Electromyography (EMG) classification by using Fuzzy C-Means Clustering (FCM) technique. There are two types of EMG study which are diagnosis EMG and Kinesiological EMG. The diagnosis EMG is study about the characteristics of the motor unit action potential for duration and amplitude while for the Kinesiological EMG is about the movement analysis of the muscle activity. This work will focus more on Kinesiological EMG that used two types of electrode which are surface electrode and fine wire. The EMG signal is a measure of electrical current during the contraction of the muscle. EMG classification is not an easy task due to the signal contains a lot of uncertainties that leads to a high dimensional feature vector. The objective of this work is to extract the time domain features from the EMG signal and to perform the features reduction technique before classifying the EMG signal based on different pattern using FCM. In this work, five subjects that use right hand as dominant and without previous illness record are selected. Then, the subjects will be asked to perform 5 different patterns which are lateral, tripod, tip, power and extension. The EMG signal is collected at the forearm muscle. It is expected that FCM could perform EMG feature reduction to classify the upper limb muscle based on the different pattern.

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ABSTRAK

Kertas kerja ini menggambarkan teknik-teknik pengurangan klasifikasi dalam Electromyography (EMG) dengan menggunakan teknik Fuzzy Kelompok C-purata (FCM). Kertas kerja ini menggambarkan EMG mempunyai dua jenis kajian iaitu EMG diagnosis dan EMG Kinesiological. Kertas kerja ini menggambarkan EMG diagnosis ialah kajian tentang ciri-ciri potensi tindakan unit motor untuk jangka masa dan amplitud manakala bagi Kinesiological EMG adalah mengenai analisis pergerakan aktiviti otot. Kertas kerja ini akan memberi tumpuan kepada Kinesionological EMG yang menggunakan dua jenis elektrod iaitu elektrod permukaan dan wayar halus. Kertas kerja ini akan mengukur arus elektrik semasa berlakunya pergerakan pada otot. Kertas kerja ini menggambarkan klasifikasi EMG itu bukan satu tugas yang mudah kerana isyarat yang mengandungi banyak ketidaktentuan yang membawa kepada dimensi wayar vektor ciri yang tinggi. Objektif kajian ini adalah untuk mendapatkan ciri-ciri domain masa dari isyarat EMG dan melaksanakan teknik ciri pengurangan sebelum mengklasifikasikan isyarat EMG berdasarkan pola yang berbeza dengan menggunakan FCM. Dalam karya ini, lima orang individu yang menggunakan tangan kanan sebagai dominan dan tanpa rekod penyakit sebelum ini yang dipilih sebagai bahan uji kaji. Kemudian, subjek akan diminta untuk melaksanakan 5 corak yang berbeza iaitu lateral, tripod, tip, kuasa dan sambungan. Isyarat EMG akan diukur pada bahagian otot lengan. Ia dijangka bahawa FCM boleh melakukan EMG pengurangan ciri untuk mengklasifikasikan otot lengan atas berdasarkan corak yang berbeza.

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CHAPTER 1

INTRODUCTION

This chapter will give a brief explanation about the project background, problem statement, objectives and the scopes of this thesis. Then, the objective was set to get the goal of this project. Lastly, project scopes will ensure the limitations will always be on the track.

1.1 Background

Research on EMG classification is essential in the field of medical research and human technology interaction. It required a strong foundation of the neuromuscular system, impact of the tools used during signal acquisition in order to collect meaningful data and signal processing technique. One of the commonly application related to this study is prosthetic device

Fuzzy logic has been applied to many fields in the control system. The idea of fuzzy logic is from Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Fuzzy logic is based on degree of truth whether 1 or 0. The EMG is commonly used in various fields to investigate the muscular activities. During the contraction of the muscle, it will produce the EMG signal and the electrical activities are detected [3]. The control of prosthesis and other assistive equipment is one of the most important applications of EMG signal classification [2]. It will record the electrical activity from the skeletal muscle and evaluates the data [3]. According from the theory of Peter Konrad [4], there have two types of electrode which are surface (non-invasive) and intramuscular (invasive) electrode to measure the EMG signal. The advantage when using the intramuscular (invasive) electrode is the signal from the muscle that is show more accurate. The active electrode it has built-in the amplifier and filter that will increase the noise while

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doing the experiment [6]. Then, for the passive electrode [7], there have no built-in the amplifier and filter but this electrode has the electrode gel. While, the surface of non-invasive electrode is the surface just only to apply on the skin and not inserted to the skin. So, the signal show is less accurate compared to the signal when using the invasive electrode.

To detect the muscle activities, the traditional EMG uses a fine needle while the surface EMG is using the surface electrode [5]. The main point of the EMG is to optimise the signal to ratio of noise [10]. The noises that exist while performing the experiment the raw EMG signal Electromyography can be divided into two types which are ambient noise and transducer noise. The ambient noise is the noise that produces from the computers and power line [10]. The performance of signal classification in time domain features are chosen compared to frequency domain and time- frequency domain because low noise environments and their lower computational complexity [8]. The time domain also has the disadvantages that are the data will assumed in stationary state for the non-stationary properties of the electromyography (EMG) signal that the raw EMG signal not in time domain of the featured of the extraction [9] [11].

1.2 Problem Statement

There are several problems based on the Electromyography (EMG) classification based on features reduction using fuzzy c-means clustering technique. First of all, EMG classification is not an easy task due to the signal contains a lot of uncertainties that leads to a high dimensional feature vector because it controlled by the nervous system and depends on the movement of the upper limb muscle. Based on the result of the EMG signal is the important way to detect the condition of the nerves or muscle.

This project is to classify the EMG signal based of the upper limb muscle for different pattern movement of muscle based on features reduction using fuzzy c-means clustering techniques. The signal has different EMG signal for each section. From the input signal that detect at the electrode, this project would be able to display output signal for each section on the MATLAB. Usually, EMG machine that are used is very expensive, but in this project, the EMG Data Acquisition used to acquire the signal is the cheaper one due to cost savings.

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1.3 Objectives

The objectives as shown below:

i. To extract the time domain features from the EMG signal.
ii. To perform the features reduction technique
iii. To classify the EMG signal based on different pattern using Fuzzy C-Means (FCM).

1.4 Scope of Research

The scopes of this research are:

i. Data acquisation device for Electromyography signal used is NI myRIO and muscle V3 as a preamplifier.
ii. LabVIEW myRIO toolkit is for data display and recorder
iii. The feature extracted signal using the time domain which are root mean square (RMS), mean absolute value (MAV), standard deviation (STD) and variance (VAR).
iv. The muscle that is concentrated on forearm muscle only.
v. The criteria of target subject are male or female that is used right hand as a dominant and without previous illness record.
vi. Investigate for the five different of pattern.
vii. There are 5 subjects based on criteria in Table 1.1:

Table 1.1: The Criteria of Target Subject

Specifications	Male or female that are used a right hand as dominant
Weight	50kg to 60kg
Pattern that applied to the muscles	Lateral, Tripod, Tip, Power and Extension
Health condition	Normal

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1.5 Motivation and Significance

For the motivation and significance in this research, the motivation is to classify the Electromyography (EMG) signal. The signal is come from the human muscle. Then, the signal must be classify into several type of pattern. The EMG signal must be extract into time domain features which are Root Mean Square (RMS), Mean Absolute Value (MAV), Standard Deviation (STD) and Variance (VAR).

The technique used in the research is Fuzzy C-Means Clustering Technique (FCM). The technique used to classify the signal for every pattern.

1.6 Report Outline

In this report will go through into 5 chapters:

Chapter 1:
In this chapter, discuss about the project background which is explain about the project. Then, the problem statement of this project and the scope of the research also will be discussed.

Chapter 2:
In this chapter, reviews of the previous researches project that are related with this project will be discussed. The information will be become additional source for the project in to be able more successful. To have a brief understanding of the researches related to the project, a few literature reviews had been done. This chapter will describe the related to the literature reviews.

Chapter 3:
The chapter 3, the explanations about the flow chart of the project from the beginning to the end of the project. For this chapter, it will explain the principles of the methods and techniques that are using by the previous researcher. The selected techniques must be chosen to approach the objective of this project. The data will be record from the experimental setup. Then, the Gantt chart also discuss in this chapter.

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Chapter 4:

In this part, the discussion of the project and the result will show. The analysis of the result also discussed in this chapter.

Chapter 5:

Finally, the last chapter is about the conclusion of this research and recommendation is discuss.

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CHAPTER 2

LITERATURE REVIEW

2.1 Electromyography (EMG)

There are many types of technique to detect the muscle. The electromyography (EMG) are commonly used in various fields to investigate the muscular activities [2].EMG signal is a biomedical signal that measures electrical activities from the skeletal muscles. It can be measured during the contraction of the muscle exhibiting neuromuscular activities. During the contraction of the muscle, it will produce the EMG signal and the electrical activities will detect [3]. The control of prosthesis or other assistive equipment is the most important application to applying the different pattern of EMG signal [2]. It will record the electrical activity from the skeletal muscle and evaluates the data [3]. The disadvantage of the EMG is when to recorded the data because the surface of the electromyography is usually more susceptible to artifact that is intramuscular EMG. The electric current of the EMG signal can be measured by the electrode [3]. According from the theory of Peter Konrad [4], there have two types of electrode which are surface (non-invasive) and intramuscular (invasive) electrode to measure the EMG signal. The intramuscular electrode needed a needle or fine-wire electrode that must be inserted into the skin that will make the electrode to be invasive to the skin [2]. The advantage when using the intramuscular (invasive) electrode is the signal from the muscle that is show more accurate. While, the surface of non-invasive electrode is the surface just only to apply on the skin and not inserted to the skin. So, the signal show is not accurate compared to the signal when using the invasive electrode. To detect the muscle activities, the traditional EMG uses a fine needle while the surface EMG is using the surface electrode [5]. When the electrode is placed, the one of the factor that affects the raw signal of EMG is the noises that are present. Therefore, when to do the experiment, make sure the surrounding in the less noise

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that will affect the data. The main point of the EMG is to optimise the signal to ratio of noise [10].

2.2 Noise in Electromyography

The noises that exist while performing the experiment the raw EMG signal Electromyography can be divided into two types which are ambient noise and transducer noise. The ambient noise is the noise that produces from the computers and power line [10]. Then, the transducer noise is from the ionic to an electronic. The types of noise in transducer are D/C and A/C voltage Potential [10]. The noise that is caused by differences in the impedance between the skin and the electrode is D/C (Direct Current) Voltage Potential. For the noise that is generated by fluctuations in impedance between the conductive the skin and transducer is A/C (Alternating Current) Voltage Potential. The effective ways to overcome the noise between the conductive transducer and the skin is use the silver/silver chloride (Ag-AgCl) electrode that are consists a thin layer of silver chloride material and silver metal surface plated.

2.3 The Electrode

They are two types of electrode are commonly use which are passive and active electrodes. The active electrode it has built-in the amplifier and filter that will increase the noise while doing the experiment [6]. Then, for the passive electrode [7], there have no built-in the amplifier and filter but this electrode has the electrode gel. In the study carried out by P. Laferriere et al [2], to obtain the EMG signals on the skin‟s surface, the electrode needs to use electrode gel because that has some problems of the surface of the electrode, silver/silver chloride (Ag/AgCl) electrode that cause the skin irritation and allergies. The electrode gel is provide the electrolytic gel that that can overcome the problem because that can react as a chemical which is interface between the skin and the metallic part of the electrode [10]. The dimension of electrode for EMG in the direction of the fibres that suggested is 10mm diameter [10]. The advantages when using the surface electrode is it is easy to apply while the contraction of the muscle and user friendly [7].

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Figure 2.1: Disposable Ag/AgCl electrodes and the active surface electrode

2.4 The Location of the electrode

The surface electrode is placed at the forearm muscle. The experiment is using one input channel and three of the electrode. The three of electrode are two positive electrode and one ground electrode. The reference electrode which is the ground electrode that will locate at the bone and the other two electrodes must be near in 1cm only that is shown in figure 2.2. For the step of the experiment, firstly the subject‟s skin surface must be cleaned on forearm muscle. It is to reduce the skin impedance. Then, the skin in impedance will be measured. When the skin gets a light red colour, it shows good skin impedance condition [2]. Table 2.1 below shows the impedance ranges that are recommended.

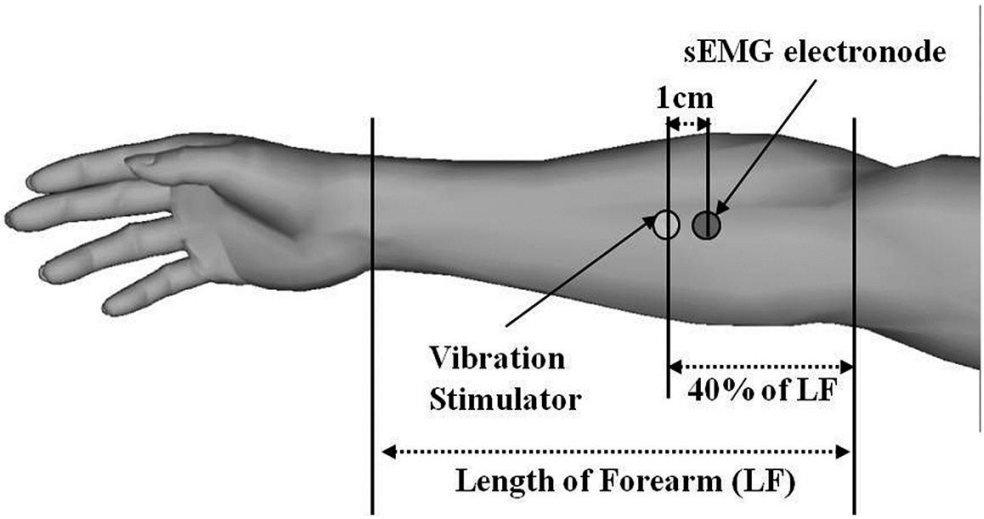

Figure 2.2: The Location of the Electrode in 1cm

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Table 2.1: The Condition of the Skin Impedance

Impedance Range(KOhm)	Recommendation
1-5	Very good
5-10	Good
10-30	Acceptable
30-50	Less good
>50	Should be avoid

2.5 The Signal Features Extraction of Electromyography (EMG)

In this project, there are three features extraction technique that have been considered. The signal features extractions of Electromyography (EMG) are time domain, frequency domain and time-frequency domain. The extracted features of the EMG signals in time domain is the less percentage error for the ideal feature. The EMG signal can be extracted to time domain because the objective of this project is to evaluate the better features of the extraction. Based on the features of the extraction, the EMG signals in time domain can be implement in signal classification [2]. The time domain features are used in signal classification because it is easy and have quick implementation. The features are calculated based on raw EMG time series, so it does not need any transformation. The time domain features assume the data as a stationary signal. The performance of signal classification in time domain features are chosen compared to frequency domain and time-frequency domain because low noise environments and their lower computational complexity [8]. The root mean square, (RMS) and mean absolute value, (MAV) also can be used with standard deviation (MAV) to get a useful time domain features. The time domain also has the disadvantages that are the data will assumed in stationary state for the non-stationary properties of the electromyography (EMG) signal that the raw EMG signal not in time domain of the featured of the extraction [9].

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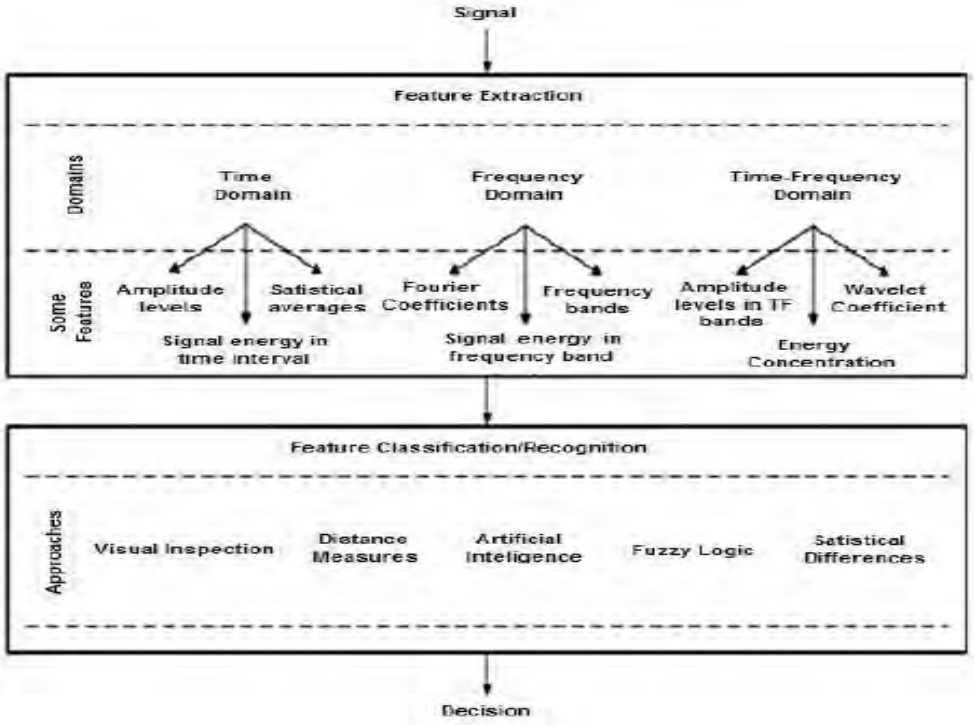

Figure 2.3: Signal Processing For Pattern Classification in Typical Application

2.6 Fuzzy C-Means features reduction clustering technique

From the thesis [11], it says that compared to Neural Network, the fuzzy logic system give more consistent classification results. Besides that, fuzzy logic also has incentive to over-training. The accuracy rate EMG classification is given below:

Table 2.2: The Typical EMG Classification Accuracy Rate

The Typical EMG Classification Accuracy Rate	
Method	Accuracy Rate
Neural Network	84%
Fuzzy Logic System	85%

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In biomedical, fuzzy logic system can be used for EMG signal classification [11]. To emulate human decision making more closely, fuzzy logic is more preferable than ANN [11]. In this thesis, the fuzzy C- Means Clustering (FCM) is used. To identify the grouping from the large data is the objective of clustering to make the data briefly. This method as an improvement on earlier clusters methods.FCM shows the clustering technique of the group data points into a specific number of data point in the dataset in a different clusters. When the data point that too close to the centre of the cluster it will have a high degree of membership function while the data point that is far away from the centre of the cluster will have a low membership function. Fuzzy Logic Toolbox command line function fcm performs FCM clustering starts with an initial guess for the cluster centers, which are intended to mark the mean location of each cluster. The initial guess for these cluster centers is most likely incorrect. Then, fcm assigns every data point a membership grade for each cluster. By iteratively updating the cluster centers and the membership grades for each data point, fcm iteratively moves the cluster centers to the right location within a data set. This iteration is based on minimizing an objective function that represents the distance from any given data point to a cluster center weighted by that data point's membership grade. The information by fcm to help to create the fuzzy inference system by creating the membership functions to represent the fuzzy classification for each cluster.

2.7 Review of Previous Related Works

Based on “Techniques of EMG signal analysis: detection, processing, classification and applications” paper [1], by M.B. I. Reaz, M. S. Hussain and F. Mohd-Yasin, it discuss about to illustrate the various methodologies and algorithms for EMG signal analysis to provide efficient and effective ways of understanding the signal and its nature. This paper provides a hardware implementation. The paper is focus on application of prosthetic grasp recognition, interaction of human control and prosthetic hand control. The EMG signal is the signal that measures the electric current when muscle is in contraction condition. The EMG signal in human muscle is a complicated because it has a lot of noise. The signal comes through the different muscle with different signal. The signal is control by the nerve system that is dependent on the properties of muscle. The clinical diagnosis and biomedical applications is the main part and the reason for EMG signal analysis to analyze the data. In the research, there are using two types of electrode. There are invasive electrode and non-

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invasive electrode. The invasive electrode is by using needle in electrode that are inserted in the muscle while non-invasive is the skin surface electrode that only work on skin surface of human body. There are many electrical noises that are affecting the data of EMG signal. There are inherent noise in electronics equipment, ambient noise, motion artefact and inherent instability of signal. There are some artificial intelligent techniques that are used for processing the EMG signal in the paper. The valuable information regarding the nerve system is carrying by EMG signal. The objective of this paper is to brief the information about the EMG and reveal the various methods to analyze the signal. There are discussing about the advantage and disadvantage about their technique for detection, decomposition, classification and process.

Based on "Features Extraction of Electromyography Signals in Time Domain in Biceps Brachii Muscle" paper [2], by Wan MohdBukhari Wan Daud, Abu BakarYahya, Chong Shin Horng, MohamadFaniSulaima and RubitaSudirman, it says about to evaluate the features extraction of the time domain from the electromyography (EMG) signal. To select the ideal features is important in analyze the EMG signal. There was conducting the experiment to surface EMG for non-invasive assessment of muscle. To get the features, the data that recorded must be analyzed in time domain. From the paper, there are using three featuresbased o statistical features. Then, the features were evaluates to get the percentage of error for each feature. For determine the ideal feature, the feature that ishaving less percentage error is the best feature. To implements in signal classification, by extracted features of the EMG signals in time domain. This can be integrated to design a signal classification based on features extraction. The biomedical signal that measures electrical currents which is EMG signal is generated by skeletal muscle when the muscle in contraction neuromuscular activities. The biosignals of non-invasive measurement is important due to their abilities for the critical biomedical application. The surface EMG is the electrode that does not involve tools that break the skinand enter the human body. There are many application of EMG signal. For example, the application used to control the prosthesis or other assistive equipment. There are various types of electrode that being used to measure EMG signals which are surface electrode and needle electrode. The recommendation by the surface electromyography for the Non-Invasive Assessment for Muscle (SENIAM) project is use the surface electrode. There is having several stages for features extraction due to implements. It detects muscle contraction. There are Maximum Amplitude (MAX), Standard Deviation (STD) and Root Mean Square (RMS). In the

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research, the EMG data was measured during lifting their hand without load and with a dumbbell for 3kg and 5 kg. The amplitudes are directly proportional to the load. That means, the higher the loads, the higher the EMG signal. The ideal feature can be obtain by calculate the percentage error for each feature.

Based on "A Practical Introduction to Kinesiological Electromyography" paper [4], by Peter Konrad, the research is about Electromyography (EMG). EMG means technique to develop record and analyze the myoelectric signals. The EMG also known as the study of muscle function through the inquiry of the electrical signal the muscles emanate. The EMG signal is widely used for applied research, sport training, interaction of human body and rehabilitation. There are many benefits of EMG. For example, the EMG allows to directly looking into the muscle. Besides that, it can helps in decision making before and after surgery. Then, it can allow the analysis to improve sport activities for human sport. Next, the EMG also helps patients to train their muscle in biomedical system. It will detect the muscle response in ergonomic studies to improve the knowledge about it. The „raw" EMG signal is unfiltered signal that are detected at the muscle. The factors that influence the EMG signal. There are tissue characteristics, external noise and electrode and amplifiers. The procedure for skin preparation is removing the hair. This is important to improve the adhesion of the electrodes of sweaty skin types. Second procedure is cleaning the skin. The reference electrode must be paste at joints or boney area. When the skin preparation is complete, the skin impedance must be test. The impedance ranges that are recommended are 1 to 5 (KOhm). The impedance range greater than 50 that should be avoids and requires cleaning for the second time.

Based on "Wavelet Signal Processing of Human Muscle Electromyography Signals" paper [5], by Amur Hamed Mohammed Almanji, the thesis is about to identify action of human muscle action through EMG signal. There are several muscles that involve in this research. There are carried out from the experiments on triceps, biceps and flexor digitorum superficialis (FDS) muscles. From this paper, the result shows have futuristic engineering implications in biomedical engineering and bio robotic applications. The future work includes compromising two wavelets that have different properties on both frequency domains and time. There are the complex Shannon wavelet and the Meyer wavelet. The Shannon wavelet is having very good frequency resolution and it have slow decay in time domain. The Meyer wavelet is having the good frequency resolution and a

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