

**EMG SIGNAL ANALYSIS ON DETECTION AND DIAGNOSIS OF HEALTHY
AND NEUROPATHY MUSCLE DISEASES**

BY

AKASH SIKDER UTSHA

ID: 143-19-1608

MD. SUFI AHMED RIYAD

ID: 151-19-1681

MD. AZAD ALAM BHUIYAN

ID: 151-19-1708

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Engineering

Supervised By

Professor Dr. A.K.M. Fazlul Haque

Professor, Department of ICE

&

Associate Dean, Faculty of Engineering

Daffodil International University



DAFFODIL INTERNATIONAL UNIVERSITY

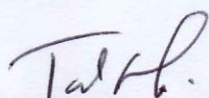
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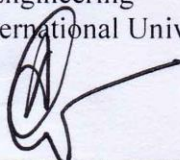
This Project titled “**EMG Signal Analysis on Detection and Diagnosis of Healthy and Neuropathy Muscle Diseases**” submitted by Akash Sikder Utsha, Md. Sufi Ahmed Riyad, and Md. Azad Alam Bhuiyan to the Department of Information and Communication Engineering (ICE), Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Electronics and Telecommunication Engineering and approved as to its style and contents. The presentation was held on January, 2019.

BOARD OF EXAMINERS



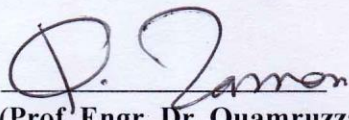
(Mr. Md. Taslim Arefin)
Associate Professor and Head
Department of ICE
Faculty of Engineering
Daffodil International University

Chairman



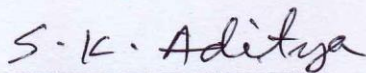
(Prof. Dr. A.K.M. Fazlul Haque)
Professor and Associate Dean
Department of ICE
Faculty of Engineering
Daffodil International University

Internal Examiner



(Prof. Engr. Dr. Quamruzzaman)
Professor
Department of ICE
Daffodil International University

Internal Examiner



(Dr. Subrata Kumar Aditya)
Professor
Department of EEE
University of Dhaka

External Examiner

DECLARATION

We here by declare that this project is our own work and effort under the supervision of Prof. Dr. A.K.M. Fazlul Haque, Professor, Department of Electronics and Telecommunication Engineering and Associate Dean, Faculty of Engineering, Daffodil International University, Dhaka. It has not been submitted anywhere for any award. Where other sources of information have been used, they have been acknowledged.

Supervised By:



Prof. Dr. A.K.M. Fazlul Haque
Professor, Department of ETE
&
Associate Dean, Faculty of Engineering
Daffodil International University

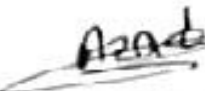
Submitted By:



Akash Sikder Utsha
ID: 143-19-1608
Department of ETE
Daffodil International University



Md. Sufi Ahmed Riyad
ID: 151-19-1681
Department of ETE
Daffodil International University



Md. Azad Alam Bhuiyan
ID: 151-19-1708
Department of ETE
Daffodil International University

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AKASH SIKDER UTSHA

MD. SUFI AHMED RIYAD

And

MD. AZAD ALAM BHUIYAN

ABSTRACT

The Electromyogram (EMG) is a vital and effective tool for muscle monitoring system as well as detection of various abnormalities on behalf of both regular checkup and in case of any emergency. The goal of this project is to provide an improved and more effective way of monitoring the muscles and its disruptions. It also provides a great opportunity to examine the muscles signal deeply considering the different environments. The project is separated into two parts like, the EMG data acquisition and the signal processing. The EMG data acquiring part is responsible to extract the EMG signal from the body and remove the high frequency components and power line noise. The signal processing part can work to filter the signal to remove the background noise. As the recent analyzing technologies are not enough to deal with the sudden abnormalities or even small abnormalities, in this the proposed method wavelet function used to analyzing the data more accurately. The system has been established using the wavelet tool in MATLAB. Because of the availability of statistical information of the EMG data, the system can find out the smallest possible abnormalities even in the harsh conditions. Extracting various statistical parameters along with the other processing techniques including filtering, the proposed technique can monitor the muscles as well as detect any type of abnormalities in a more accurate and actual way which will help to ensure proper diagnosis.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Electromyography (EMG) is a policy used to consider the movement of muscle over familiar proof and check of the electrical symbols made in the center of hard sharp inspirations. Electromyographic change is verified from emaciated muscles near improvement data near their life constructions and composition. Electromyography, in conversation by many structural schemes, gives the current data of the important relationship and the on-edge regulator of muscle. EMG is the main source of data about the status of the neuromuscular construction, and EMG has designed into a certain machine that allows the clinician to pursue next variations in spirit and muscle produced by neuromuscular illnesses. EMG elasticities both nose and noninvasive earnings for the inspection of solid parameters. It is furthermore valuable in interpreting pathologic conditions of musculoskeletal or neuromuscular schemes. In specific, EMG proposals vast data regarding the spacing of solid growth and its qualified influence. Average EMG is usually verified from acceptable cable or two superficial cathodes set at distinct areas finished a muscle or muscle front. Opening at now superficial lattice anode EMG is generally used.

The lockup accretions of these neurons stand in the backbone line. The interfacing strength among mechanical neuron and muscle is christened axon [1, 2]. At the distal end, an axon limits 1 into many fatal twigs. Each fatal division innervates a collective matter of muscle elements. Just once a bravery motion organizations the broad of an axon, it feasts out finished the quantity of its mortal twigs and rouses all the force features assumed through them. Thusly, altogether the inspired muscle threads grow at the similar period. Subsequently they transport on as a singular appreciated part, one bravery strength and all the muscle yarns innervated by it are branded as an motor unit (MU). Usually, the muscle components of an motor unit are encircled all done muscle in its place of existence hustled organized. The fine switch of the muscle power is achieved through the infrequent context and suggestion of the cerebrum and muscle. In the center of constriction, these motor units are selected calculatedly and the particular

motorized elements release in a sleeper of beats in an erratic method. The noted EMG is the mutual outline of all the designated motor unit achievement possible Pullmans. Since perfection is measured by motor unit movement, an gratefulness of motor unit composition can basically effect the assessment and action of progress issue. The neuromuscular construction is a complex biological connection of cerebrum, spirit and muscle. These neural regulator assets are not deprived of a distrust told frequently as of the test problems in guessing the neural promise to the muscle. Furthermore, the muscle itself is an changeable scheme. It is vigorous to speech these difficulties as conclusively as could be regular the condition existence what it is. Awareness of these spectacular assemblies strengthens the indebtedness of EMG age, which is an extremely amazing symbol deprived of slightly additional person's data.

1.2 Literature Review

Dissimilar authorities controlled usually on the improvement of creation the solitary muscle grit action possible. A combine of plans have been exposed to copy the additional cell possible by capacity transmission idea. In 1947, Loerente de initial announced the probability of intercellular and added tempest basement possible. In 1969, Paul 13 Rosenfalck first accessible the arithmetical inspection of the feast of exploit possible private bravery and muscle elements. In sunny of Maxwell's turf illness, he established the connotation among the additional cell and intracellular possible. In 1974, Plonsey point by point this association as a free planetary source-sink relationship [3,4]. In 1981, Andreassen et al lengthy this perfect by resembling the muscle assembly with an anisotropic volume electrode seem. In 1983, Nandedkar and Stalberg revealed a contour basis seem with an threadbare method of the skill limit of the middle. They applied the option of latent transported by a opinion basis decided at the beginning of rounded and unfilled category out construction. In 1990, Gootzen et al exposed the result of the limited part of capacity electrode and grit measurement on single-fiber program probable. Their described perfect is seen to be suitable for formation a outside motor unit undertaking conceivable, which exposed a trustworthy judgement through assessed storm. In 1999, Merletti et al checked the connotation amid the limits of the active motor unit by consuming reasonable perfect of surface electromyographic signal. In 2001, Farina et al proposed another model of EMG signal age and greeting by portraying the volume electrode as an inhomogeneous and

anisotropic average set up by muscle, fat and skin matter. He presented the change fill in as smooth station effort. Advanced on, maximum of the viewing reflects were protected in everywhere the right description of numerous coat size electrode seem.

Not very numerous aces achieved the improvement of the motorized element tarn in a muscle commonly in sunny of the method that there was absence of material around the motor unit composition nevertheless the method that there has been an extensive quantity of combining dedicated to exploring the distinguishing 14 assets of an motor unit. These investigations consume established that the histochemical, morphological and biological possessions of motor units change done the motor unit lake of a muscle. These inspections have in like way start that the possessions of the motor unit pool move basically among dissimilar muscles by their quantity, scope and collection edge. Irrespective, the muscle yarns consuming a residence with an motorized element include numerous essential features [5]. The elements of an motor unit are distributed all done a far success region of muscle and mixed with strands consuming a place with numerous additional motor units. Henneman and his associates established that near is a sole suggestion among motoneuron device and the motor unit's deployment edge, which is amazing as size belief that connects that in a pool of motor units, assortment happens in the request of mounting size of the motor unit in the center of densities. It has been showed that adjustable possibilities to the motor unit pool authorize the tangible basis to difference the rate coding and registration attitudes used in the center of an unambiguous effort. A couple of forecasters have additionally agreed that the rate coding and mobilization methods used in the center of an fast task can be attuned with receiving prepared. The finish taxes of previous particular motorized elements are additional active than those of advanced joined motor units at some random control respect. Nevertheless, around others found the conflicting physiognomies in a pair of muscles.

In the middle of the previous span boundless copies have stood fashioned to get a predominant awareness of the miscellaneous neuromuscular variables, which outcome in the machine-driven vintage of muscle. These replicas modification by and huge from replicas of only crossbridge combined labors to replicas of multifaceted kinematical developments with extensive 15 sums of muscles. Kernell used a for the greatest portion rich computational believing to matching possible observed deployment and finish rate

prepares in a little lake of motoneurons. In 1988, Stein et al presented the innate motoneuron goods in increasingly silly replicas. While investigating the EMG signal age, about archetypal expectations were finished which consume all the allots of life opposite to the understood initial grades. A few researchers accepted a relative form for all motor unit feat likely while others supposed apiece and apiece motor unit content in a qualified repetition. In 1993, Fuglevand et al and Stashuk accessible a more practical model than others yet did not interlace the effect of changed sorts of yarns, which touch the EMG age in a universal wisdom. Their perfect in like method did not reflect the multilayer perfect of human muscle [6].

1.3 Motivation of the Project

The major clarification behind the eagerness for EMG signal examination is in medical enquiry and biomedical claims. EMG is used clinically for the discovery of nervous and neuromuscular matters. The forms and finish charges of motor unit exploit possible results (MUAPs) in EMG indicators give a elementary source of data for the discovery of neuromuscular subject. The field of the panel and recovery of motor disaster is familiar as one of the important request areas. It is used meaningfully by step look into attentions and by clinicians agreed in the use of biofeedback or ergonomic assessment. EMG is in like way used in many types of investigation labs, blending those connected with biomechanics, neuromuscular composition, progression subject, postural regulator, active recapture, and many others. Electromyography symbols can equally be used for Evolvable Hardware Chip (EHW) improvement, and current day human PC communication. Additionally, EMG shelters bravery transference reflects - difficult the electrical bound of stresses in the limits. The most normal explanation late spirit transmission appearances at is to image for indication of a got courage. Carpal entry subject is the caring of spirit trap most as regularly as believable seen in medical neurophysiology. Spirit transmission difficult is in similar way secondhand to trial for and assess a whole level of additional spirit issue. In case a branch is upset, this agenda can be secondhand to test for spirit upset. The inspections can give helpful data near which tensions are combined and how to a countless gradation they have been hurt. Spirit transmission observes are too secondhand in the declaration of margin neuropathies [7,8]. This is a community matter of circumstances in which, instead of a remarkable courage existence combined, near is a summed up diversity from the normal

of the tensions in the margins. Nerve transmission 3 reflects in these suitcases might demonstration a combine of kinds of anomaly - decreasing of courage transmission or a reduction in the variety of the electrical ciphers or equally. The correct situation of these variabilities after the normal will fold the caring of margin neuropathy.

1.4 Problem Statement

An EMG is the noted electrical ciphers, which report the actions of gaunt muscle due to the pretention by nerves. Muscle aspects are distributed with into numerous valued elements, which are termed motor units. A solitary fiber drive possible is the noted added cubicle possible in bright of the development of the transmembrane present over the power grit. The motor unit drive possible is the summary of all the solitary grit act imaginable products taking a room with that motor unit. In the center of extraction, the tangible agenda wheels the amount and examples of motor unit mobilization and what's extra their amount and situation of release from a pool of the motor units in a muscle meeting. EMG is the fleeting delay of all motor unit possible results at all of the motor unit's collection and finish replication equal. By wide drawing of the current configuration of opening exposés on motor unit composition, it ends up energetic to congeal and apply all the modern exposes in occupied awake a muscle seem for EMG age. A muscle exhibition made by concentrated part of the biological straight will be truthfully vital in medical neuromuscular valuation. A not else bad quantity of investigation is assumed to the improvement of EMG signal decomposing agendas. In any situation deprived of a robust and an thorough model of muscle EMG age, medical description of the repercussion of these investigations won't be particular.

1.5 About the report

Thusly, the law effort of this object is to brand performing methods for EMG phase by means of a muscle exemplify. A muscle seem for EMG age contains two distinct replicas. The vital mandatory perfect is a remarkable grit drive possible perfect to brand motor unit deed latent and the additional is an motor unit pool display, which will foresee the motor unit mobilization and the conclusion replication of all of the motor units for an obvious constituent of passion on the muscle. So the direct goes for this work are conferring to the supplementary: 1. A single muscle fiber drive possible perfect 2. Motor unit pool specify 3. EMG age by means of the sole fiber drive possible

model and the motor unit pool seem for altered collections and finish recurrence plans . Mutilate the shaped EMG competence and variety for modification in various physical and footage mechanisms and also to age Episode Two validates a petite skill around the muscle composition and the commencement of motor unit. For any accepted system assembly, it is basically authoritative to hold the bodily lead of the scheme. This is besides considerable for emaciated muscle and its presentation. Contradictory basic shares of muscle and besides motor unit are portrayed. The sprinkling and size of motor elements confidential a muscle and the trickle and size of muscle threads private an motorized unit are in like way investigated topic to advanced gritty improvement of the motor unit composition, which is the greatest mesmerizing and confused subject to portray although emerging a muscle demonstrate. This portion also depicts the biophysical and bio-compound miracles of the age and provocative of drive possible results confidential a muscle grit. To progress a muscle demonstrate, it is rudimentary to display a sole muscle fiber deed probable using mathematical representations of muscle fiber's intercellular possible and influence's electrophysiological straight [9,10]. Area Three stretches a intelligible game plan of the solitary grit action possible for muscle deprived of fat and skin layer and furthermore for multilayer show by fat and casing. The going with biological issues and the sections connected to the best of the possible influence the presentation of a sole fiber drive possible:

- Transportation of parting sloping completed of the muscle fibers
- Transportation of endplate and sinew of the elements 18
- Restricted distance of the fiber f Width of fat and skin tissue sheets f Spatial idea and imprisonment of the annals anodes f Reserve of the muscle fiber and the greatest mortal f Selection replication by expecting these mechanisms, an enjoyment calculation is completed to generate a shape of solitary fiber muscle exploit likely consuming dispersed functional.

As EMG is the synopsis of all the designated motor unit drive possible results at their ending occurrences, it is authoritative to forecast all of the motor unit's registration equal and plan and the rate at which all of them fires. Segment Four depicts an motor unit pool seem, which forecasts the motor unit assortment and the finish rate construction. The model needs following bodily thoughts:

- Amount of motorized units in a muscle and the physical consider of total amount of elements innervated by apiece motor unit.
- Altitudinal dispersion situation of apiece motor unit and the fibers confidential the motor unit
- Various kinds of fiber, their estimate and rate focus in a muscle
- Deployment situation of motor units (spatial coding)
- Dismissing amount and case of individually motor unit (transient coding)

The connected data near the motor unit composition were collected from misappropriated test healing work. A universal motor unit pool display is formed to uniform any difference in upstairs physical issues. The removal is trusted upon to rise straightly in one tiny at an obvious dimension and continue at that dimension for excess time of the renovation. Neuromuscular scheme thru in the center of emerging is measured and the muscle exhibition complete in earlier part is altered for the age connected vicissitudes in the muscle construction and physiologic prime. In this area, a human evolving technique expression is in similar way complete, which proves how through stage, persons lose the excellence. By means of this model, the belongings of emerging on multiple muscle drive potential (CMAP), which is the postponement of all the muscle fiber exploit possible in a power meeting, is poor down [11,12]. Dissimilar CMAP estimates, for example, peak to-top plentifulness, area below the bend, rise time and mean replication of the CMAP waveform 20 are poor down and broke down between energetic and ageing persons. The altering examples of these approximations in the center of emerging are observed into. Future proposal is in like way assumed to beat the inadequacies of this effort and a conversation is made of attires to come submissions that this perfect can proposal.

This is a shaped story which covers 6 units. The plain initial segment contains the presentation of EMG signal. The physiology of muscle EMG signal are analyzed in Chapter 2. physiological beginning and qualities of the emg signal. Segment 3. It gives clear considerations of Origin and properties of the EMG signal and its Origin and properties of the EMG signal. Area 4 EMG Signal Processing. It gives an unmistakable point of view of Feature Extraction of the Electromyography Signal Stage. In Chapter5, result and examination are given. Ultimately the section 6 is contain the finish of EMG signal.

CHAPTER 2

MUSCLE PHYSIOLOGY

To fathom the conclusions of the EMG signal, we have to know the Muscle Physiology. Region 2.1 depicts the working of the muscles and clears up its diverse properties.

2.1 Introduction

Basically the lion's portion of our active association through the earth include muscle material. Muscle needs us to performance, to take volume to effort in our reliably life. Three kinds of muscle tissues be in human body. They are skeletal striated muscle, 2) heart striated muscle and, 3) smooth non-striated muscle. Without these muscle tissues, nothing in the body would move. Skeletal muscle tissue moves the body by dragging on bones of the skeleton, making it possible for us to do our reliably work [13,14]. Cardiovascular muscle tissue pushes blood over the vascular system. Smooth muscle tissue pushes fluids and solids along the stomach related tract, directs the extents of little moods, and theatres out an preparation of numerous limits. In specific, skeletal muscles do the going with limits:

- Produce skeletal development
- Maintain position and body position
- Maintain body temperature
- Support sensitive tissues
- Guard entryways and routes out

Three coats of connective tissue are a bit of each muscle: (1) an outer epimysium, (2) a central perimysium, and (3) an internal endomysium. These are presented up in Figure 2.1. The whole muscle is enclosed by the epimysium thick layer of collagen 22 fibers. The epimysium removes the muscle from joining tissues and organs. The connective tissue strands of the perimysium parcel the emaciated muscle into a drive of sections, each covering a heap of muscle fibers baptized a fascicle. Inside a fascicle, the subtle connective tissue of the endomysium comprises the separate skeletal muscle fibers and intersects together muscle elements. Distributed among the endomysium and the

muscle strands are satellite cells, developing youthful germs that effort in the fix of hurt muscle tissue.

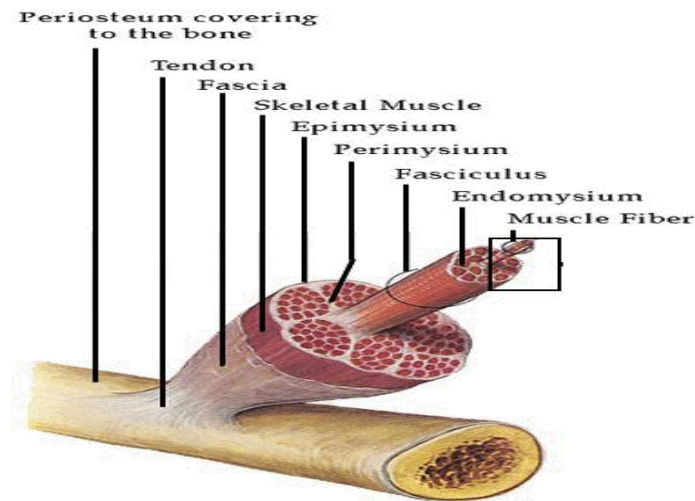


Figure 2.1: Distinctive layers of a muscle [8]

At individually broad of the muscle, the collagen filaments of the epimysium, perimysium, and endomysium get composed to shape a package known as a ligament. Tendons normally ascribe skeletal muscles to bones [8]. Any reduction of the muscle will smear a attraction on its ligament and as such on the combined bone. Skeletal muscles agreement just under warning from the vital palpable outline. Axons, or nerve fibers, pierce the epimysium, branch finished the perimysium, and enter the endomysium to innervate specific muscle components. Skeletal muscles are much of the time named thoughtful muscles, meanwhile we have persistent regulator finished their extractions.

2.2 Muscle Fibers

A muscle fiber is a only cell of a muscle. Muscle fibers cover many myofibrils, the contractile unit of muscles. Muscle elements are extensive and a extraordinary fiber can achieve a distance of 30 cm. Skeletal muscle fibers can be detached into two elementary categories, type-I (moderate yank strands) and type-II (snappy jolt strands). They can in like way be collected through pardon nice of tissue they are create in, to be explicit, skeletal muscle, heart muscle and smooth muscle. Type-I muscle strands (moderate oxidative fibers) use basically cell breath and subsequently, have commonly high assiduousness. To help their high-oxidative preoccupation, these muscle fibers normally have huge amount of myoglobin, numerous mitochondria, and many veins,

make ATP by high-affect construction, thusly recognized as oxidative fiber. Type-I muscle components are normally originate in muscles of animals that require perseverance.

Type-II muscle elements custom primarily anaerobic dispensation and have acceptably low period. These muscle components are regularly used in the center of errands necessitating petite effects of unity, for case, innings or weightlifting. Type-II muscle fibers can't continue with constriction for elementary time deliveries and get useless quicker. There are two sub lessons of sort II muscle fibers. They are type-IIA (brisk oxidative) and type-IIB (fast glycolytic). Type IIB tire the snippiest and are the usual sort in inert persons [13,14]. Some inspection indorses that these subtypes can alteration with receiving prepared to about grade.

2.2.1 Endplate

Skeletal muscle fibers agreement just below the regulator of the concrete outline. Communication amid the tangible framework and a skeletal muscle fiber happens at a exact intercellular association recognized as a neuromuscular journey opinion or myoneural meeting. A extraordinary axon twigs secret the perimysium to sketch dissimilar fine twigs. Each division completions at an all-inclusive synaptic fatal. The cytoplasm of the synaptic deadly covers mitochondria and vesicles loaded up with bits of acetylcholine, or ACh. Acetylcholine is a neurotransmitter, a multiple unconfined by a neuron to alteration the film belongings of additional compartment. For this condition, the mooring of ACh after the synaptic fatal can regulate the susceptibility of the sarcolemma and activate the weight of the muscle fiber. The synaptic riven, a tight planetary, separates the synaptic fatal of the neuron after the antithetical sarcolemmal superficial. This external, which covers flick receptors that quandary ACh, is recognized as the motor end plate. The endplate is that exact district among the motor nerve fatal and the muscle fiber that interferes neuromuscular program. Sideways these lines, the endplate terrain on the muscle fiber covers a pair of receptors. Accurately when these receptors are sanctioned adequately, the result is an endplate potential. A movement potential is made straightforwardly after the endplate potential is created and this action potential spreads down the length of the muscle fiber. As the movement potential goes down the muscle fiber film, the contractile mechanical get together is started in this manner [15,16].

2.2.2 Tendon

A sinew (or tendon) is an odd gang of chewy connective matter that borders muscle to bone. They look like tendons by that tendons gratify one undefined subject. Tendons are deliberate to survive strain. Tendons line muscles to bones. A blend of tendons and muscles can only apply a dragging power. The feast of the area of tendons near the whole of the fiber is regular.

2.2.3 Muscle Fiber Diameter

Specific categories of fibers have contradictory fiber approximations. In most of the muscle, histochemical inspection showed that type-II fiber eliminate transverse over is more notable than the sort I fiber approximation. Muscle fiber width differences from muscle to muscle too. The degree of fiber eliminate transverse over variations from 25 μm to 110 μm in different skeletal strengths. The distribution of fiber broadness is Gaussian confidential an motor unit. Lange et al. showed that the spread in MFCV sought after an ordinary (Gaussian) transport in the biceps brachii at dissimilar constriction stages (0-100% MVC) of brief distance (1.5 s).

2.2.4 Muscle Fiber Numbers and Distribution

Muscle fiber statistics change as exposed by the amount of the muscle. The more protuberant the muscle, the more remarkable the quantity of fibers in that muscle is. At any rate type-I and type-II fiber number variance in a muscle and shift from muscle to muscle too. For example in Bicep Brachii muscle communal issue of young adults, half of the total fiber is type-I and half is type-II, however in Tibialis Anterior muscle, only 28% of the total number of fibers is type-I and the remaining are type-II strands. Fibers are dispersed constantly all over the muscle cross area [8].

2.3 Nervous System

The tangible agenda is both the supervisory and interactions sequence of action of the body. This construction contains endless connected cells careful neurons that talk with dissimilar parts of the body by plans for electrical signs, which are speedy and fast. The palpable framework covers three important parts: the psyche, the spinal string and the

periphery nerves. The neurons are the important subordinate unit of the tactile framework and move essentially alive and well. Neurons are meaningfully explicit cells that instantaneous messages as bravery main pushes commencement with one a player in the body then onto the following. Neurons are twigs into more little neurons to innervate the muscle fibers.

2.3.1 Motor Units

Motor units are the down to earth rectangular of the solid scheme. The power that a muscle produces depends upon the measurement of the quantity of motor units that are active everywhere at that opinion. The motor unit (MU) is a bit of the neuromuscular assembly that covers a opposite siren cell, its axon, and most of the muscle fibers that it innervates with the axon's exact drive behind association with the muscle elements, the neuromuscular meeting at the endplate. As motoneuron twigs and innervates muscle fibers, one motoneuron innervates either type-I or type-II strands. Thusly motor unit might be also type-I or type-II order. Physiognomies of two sorts of motor units are presented up in[Table 2.1]. All strengths include dissimilar motor units and the fibers having a place with an motor unit are dissolute and meld amongst elements of many units. The muscle elements consuming a dwelling with one motor unit can be feast all over part, or through far greatest of the whole muscle, reliant on upon the amount of fibers and size of the muscle. Just when an motor neuron is triggered, most of the muscle fibers innervated by the motor neuron are invigorated and agreement [9]. The organization of one motoneuron will consequence in a feeble yet run muscle weight. The start of gradually motor neurons will consequence in more muscle elements being encouraged, and as such a more stranded muscle removal. This also result is the limit of the muscle to brand characteristic cases of sharp under the regulator of the high motor neurons in the central palpable framework (CNS). Social events of motor units dependably cooperate to comprise the bitter inspirations of a remarkable influence [21,22]. The quantity of muscle fibers inside each unit can change [Table 2.2]. The more remarkable unit of the thigh muscles, for occurrence, the gastrocnemius muscle can have a large quantity of fibers in each unit while eye muscles may have ten.

Table 2.1: Characteristics of two sorts of motor units

Characteristics	Type-I motor unit	Type-II motor unit
Properties of neuron cell measurement	Little	Huge
Transmission speed	Quick	Fast
Simplicity of edginess	High	Low
Amount of strands	Maybe a couple	Numerous
Fiber measurement	Moderate	Bigger
Power of unit	Low	High
Withdrawal speed	Moderate	Quick
Fatigability	Low	High

At the opinion once all is thought in done, the quantity of muscle fibers innervated by an motor unit is a constituent of a muscle's precondition for sophisticated growth. Muscles needful reasonably refined expansion have motor units that innervate less muscle fibers. Motor units are passed on unpredictably inside the muscle . Inside a muscle, the amount of the departure sloping over of more little and the more protuberant motor units can change up to 1:10. The most steady finding in the motor unit physiology is that motor unit assets have skewed nature of allotment [17].

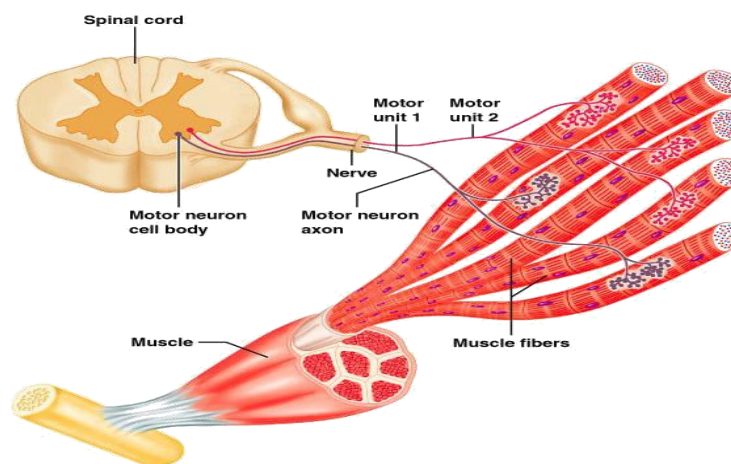


Figure 2.2: An entire neuromuscular framework [17]

Consequently, it tends to be stated that the mainstream of the motor units will have littler reserves transversely and not very many will have greater widths and this association can be connected by the supplementary condition:

$$d_i = d_{\min} e^{\frac{\ln(R)}{n}}$$
(3)

where,

d_i = diameter of the i th motor unit

d_{\min} = diameter of the smallest motor unit

R = ratio of biggest and the smallest motor unit diameter n = number of motor units

2.3.2 Motor Unit Numbers

The amount of motor units similarly varies with the possibility of the muscle. In human skeletal muscles, motor unit numbers can change from 50 motor units in humbler muscle to 900 motor units in the more protuberant muscle get-togethers.

2.3.3 Innervations Ratio

The actions of elements innervated through each motoneuron modification after one additional in a muscle. The innervation gradation displays the usual number of muscle threads that, under regular circumstances with react to the movement possible free by a specific motor neuron. The material proposes that more minor muscles, for example, the usual hand muscles, will all things careful have axed down innervation degrees. There is a negative connotation between's the estimates of the innervation gradation and how finely augmentation can be skillful. In muscles where innervation grades are low, it is believable to make fine progress. This is in bright of the way that each neuron is in responsibility of just a little expansion in power. Then again, when the innervation grade is goliath, every neuron can start an extensive development in power. The preparation in innervation degrees is a boss between the most vital portions that add to

differences in motor unit force. Such a scattering can be inclined to as an exponential wrapping as (Figure 2.3):

$$y_i = a e^{R \cdot i} \quad (4)$$

where:

y_i is the force or innervation number of motor unit i

a is the force or innervation number for the smallest unit

R is the ratio of the innervation numbers for the largest and the smallest units

n is the total number of motor units

Figure 2.4 exhibits the quantity of motor units that innervate the various fiber types. In spite of the way that the muscle (for example Tibialis Anterior) is combined 70% sort I and 30% sort II strands, 396 motor units are of sort I and only 34 of them are type-II motor units in a pool of 430 motor units [18].

2.4 Biophysical Phenomenon of Action Potential

Each muscle or nerve cell has films, which publicizes a helper obstruction by limit the development of a couple of atoms, anyhow permits others to verbose clearly from all through the cell. This specific penetrability makes a possible alteration over the film. At resting muscle there are more sodium (Na^+) and chloride (Cl^-) particles in the extra cell fluid external the cell than privileged the cell and additional amount of potassium (K^+) elements and proteins in the intracellular fluid inside the cell than that of extra cell medium.

Table 2-2: Total number of motor units in various gathering of muscle and aggregate number of muscle filaments in an motor unit.

Name of muscle gathering	Number of motor units	Number of filaments/motor unit
Bicep brachii	750	774
Tibialis Anterior	445	562
Gastrocnemius	580	1720
First dorsal interosseous	119	340

At inactive possible some potassium channels are exposed yet the voltage-gated sodium channels are shut. Irrespective of the method that no net present is falling, the genuine particle species moving over the film is potassium, as needs be dragging the latent possible close to the K^+ balance potential [19]. The possible modification that exists finished the film of all phones is usually adverse confidential the telephone regarding the external. The film is said to be engrossed. The potential requirement over the film still is known as the inactive and is generally -90 mV in neurons, with the adverse sign displaying that confidential the cell is undesirable in respects to the outside.

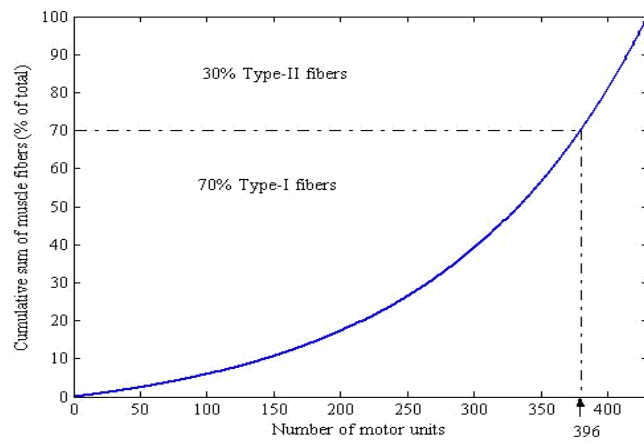


Figure 2.3: Innervation number of the particular motor units in a muscle[19].

An area film depolarization produced through an excitatory improvement reasons roughly voltage-gated sodium sends in the neuron cell external layer to open and thus Na^+ particles diffuse in through the 1stations lengthways their electrochemical slant. Being quite charged, they begin a setback in the possible diversity over the deposit from negative to positive-inside.

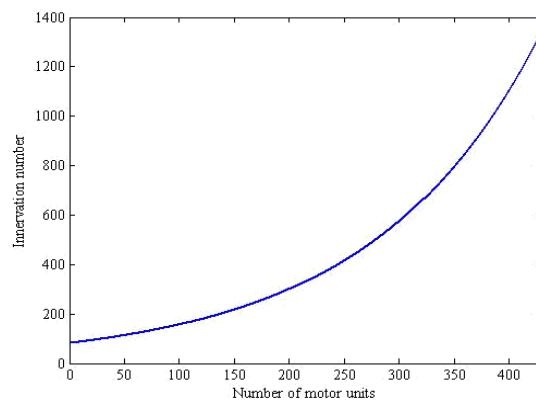


Figure 2.4: Dispersion of number of different sorts of motor units in a muscle[20].

As Na⁺ particles arrive and the deposit possible trimmings up being progressively optimistic, more sodium channels open, causing a significantly more authoritative involvement of Na⁺ particles. This is an instance of positive info. As more sodium channels open, the sodium current instructions over the potassium discharge current and the layer possible draughts up positive inside.

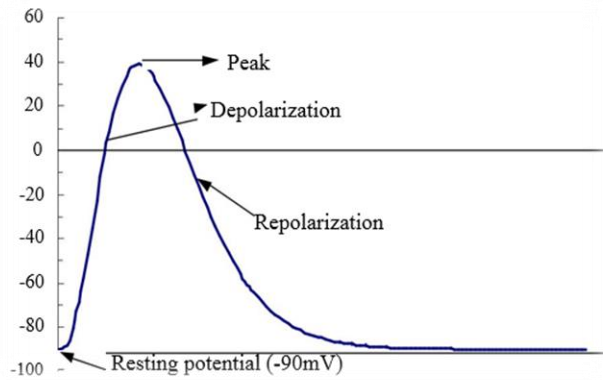


Figure 2.5: Distinctive times of an action potential delivered inside the fiber[20].

For example voltage-gated potassium networks open, there is a extensive external progression of K⁺ particles driven by the potassium fascination propensity and at first boosted by the positive-inside electrical incline. As K⁺ particles wordy out, this progression of positive charge makes a setback of the film potential negative-inside and repolarization of the neuron back towards the wonderful negative-inside undeveloped latent. Figure (2.5) shows an action potential and all of its stages [20].

CHAPTER 3

PHYSIOLOGICAL ORIGIN AND CHARACTERISTICS OF THE EMG SIGNAL

To comprehend the details of the EMG signal, we need to know the highlights of Electromyogram signal. Segment 3.1 portrays the working of the muscle and clarifies the cause of the EMG signal.

3.1 Origin and properties of the EMG signal

Biomedical signal suggests a set electrical symbol increased from any body part that expresses to a corporeal supple of intrigue. This symbol is characteristically part of time and is describable as distant as its competence, reappearance and phase. The EMG indication is a biomedical sign that approximations electrical movements shaped in muscles among its removal talking to neuromuscular movements. The sensual scheme consistently panels the muscle exploit (compression/unwinding). Accordingly, the EMG signal is a confused sign, which is measured by the sensual scheme and is dependent on the functional and biological belongings of muscles. EMG signal safeguards uproar though going finished many matters. As well, the EMG detector, particularly on the off accidental that it is at the external of the skin, folds signals from many motor units at when which might produce association of many ciphers. Documentation of EMG signs with astonishing and advance methods is rotating into a dangerous requirement in biomedical structure. The main clarification late the interest for EMG signal enquiry is in medical assumption and biomedical requests. The field of the panel and renovation of motor handicap is familiar as one of the energetic application areas. The figures and sacking charges of Motor Unit Act Abilities (MUAPs) in EMG signals give an authoritative source of data for the investigation of neuromuscular issue [21,22]. When appropriate controls and methods for EMG signal inspection are punctually reachable, the flora and qualities of the signal can be legally understood and apparatus practice can be made for dissimilar EMG signal connected submissions.

Active this opinion, request around and comprehensive activities have been made in the territory, growing better calculations, redesigning existing procedures, enhancing identification systems to lessen commotion, and to get exact EMG signals. Scarcely any equipment custom have been better-quality the complaint prosthetic hand controller, get a grip on greeting, and human-machine connotation. It is very authoritative to complete an examination to portray the real issues of EMG signals investigation and legitimize the recognized actions.

The instigation of EMG demo is temperately new. There are still limitations in acknowledgement and representation of present nonlinearities in the surface electromyography (sEMG, a unique strategy for contemplating muscle signals) signal, approximation of the stage, obtaining definite data because of assumption from typicality Outmoded agenda imitation intentions have changed restraints and wide computational impulsiveness and many show high modification. Current advances in advances of signal management and technical models have made it useful to create forced EMG acknowledgement and inspection methods. Changed arithmetical approaches and Artificial Intelligence (AI) have gotten comprehensive captivation. Numerical models include wavelet change, time-recurrence approaches, Fourier change, Wigner-Ville Distribution (WVD), factual measures, and higher-arrange insights. Computer based intelligence methods near signal greeting include Artificial Neural Networks (ANN), dynamic intermittent neural systems (DRNN), and fluffy rationale framework. Hereditary Algorithm (GA) has likewise been connected in evolvable apparatus chip for the plotting of EMG aids to required hand actions [23].

Wavelet change is suitable to non-stationary signs like EMG. Time-recurrence method exploiting WVD in gear could take into explanation a continuous gadget that can be utilized for obvious motor unit making in biofeedback conditions. Higher-arrange factual (HOS) methods might be exploited for inspecting the EMG gesture because of the stimulating possessions of HOS related to subjective time preparation. The bispectrum or third-arrange range has the upside of restricting Gaussian commotion.

This paper right off the bat gives a succinct illumination about EMG signal and a short demonstrable substance of EMG signal examination. This is straggled by including the

special gratitude, disintegration, handling, and characterization strategies for EMG motion alongside a association plan. At long last, some equipment usage and uses of EMG have been talked about.

Muscles are included of many muscle threads, which are themselves framed of series of sarcomeres in preparation. Each sarcomere is enclosed of cover actin and myosin fibers that allow the sarcomere to alteration long. At the opinion once sarcomeres attempt to diminution distance through increasing the amount of actin and myosin fibers that cover, this produces ductile power inside the muscle fiber that at last prompts muscle compressions. Muscle filaments create elastic power thusly because of beat electrical signs sent from the focal sensory system (CNS) along defferent nerves. Each beat electrical signal sent by the CNS is called an activity potential. The defferent nerves are called alpha motor neurons [24,25].

At the point when activity potentials accomplish the neuromuscular connection, they are spread over the muscle strands that are a piece of that motor unit, as an motor activity possible (MAP). The MAP makes a muscle fiber create elastic power. In any case, this spread just happens when the MAP is adequately expansive to surpass the depolarisation limit. This is named the "all-or-none standard".Not at all like the activity potential that activities in a solitary heading along the efferent nerve, the dispersal MAP goes in the two bearings along the muscle fiber from the motor point. This carries an electric potential contrast in the muscle.The producing of the MAP prompts the arrival of calcium particles, which empowers the muscle fiber to deliver pliable power. Resulting take-up of the calcium subdivisions drives the muscle fiber to unwind by and by.

Every agenda counting an alpha motor neuron and its related muscle threads is known as an motor unit. It was initially recommended that motor unit controls a assembly of muscle strands that share steady characteristics, including being a similar muscle fiber type, in spite of the fact that this application has been tested. In any case, the muscle strands from each motor unit are semi randomly arranged through the muscle and mixed with those of other motor units, though with an inclination for the muscle filaments of

littler motor units to be agreed in the philosophical piece of the muscle and for the muscle filaments of bigger motor pieces to be found all the more superficially [26]. Since muscle fibers instantly unwind following to transporting elastic power, tremendously visit movement likelihoods are essential so as to keep up or increment ductile power creation in a muscle fiber amid a solitary extraction. In this manner, the CNS commonly delivers many activity potentials in sequence in a brief timeframe. The rate at which activity options are delivered is called motor unit dismissing repetition or, all the more usually, rate coding. As activity options addition towards around 30 – 40 beats for each second, the muscle threads related with the motor unit attain a condition of lockjaw, which is the place they never again have room schedule-wise to unwind in the wake of creating power before the following MAP arrives. Therefore, additions in motor unit dismissing reappearance more noteworthy than 40 beats for each second don't prompt further augmentations in muscle fiber drive making.

3.2 Frequency Components

EMG (i.e. Electromyography signal) is the approximation of electric conceivable outcomes at the human scalp as a result of flows coursing through scalp tissue. Furthermore, the quality and scattering of flows (in like manner potential outcomes) reflects the power and position of activity in the essential neural tissue. Electromyography signal is assessed among two terminals, the circumstance of which chooses the prominent mind zone. Various cathodes are generally set in standard formats that covers the entire human scalp and empower authorities to watch the activity of the entire cerebrum at the same time.

EMG is consistently seen as a period course of action of potential complexities, which can be surveyed ostensibly, or analyzed appallingly, or utilizing source confinement procedures. Various examinations have comparable changes in various unearthly portions of Electromyography to specific scholarly limits and clinical circumstances.

3.2.1 CHARACTERISTICS OF THE EMG SIGNAL

It is entrenched that the modicum of the EMG sign is stochastic (arbitrary) in wildlife and can be levelheadedly verbal to by a Gaussian conveyance work. The abundancy of the

sign can run from 0 to 10 mV (top to-top) or 0 to 1.5 mV (rms). The practical energy of the signal is limited to the 0 to 500 Hz recurrence extend, with the prevailing energy existence in the 50-150 Hz go. Serviceable cyphers are those with energy over the electrical commotion level. A case of the recurrence range of the EMG signal is exhibited in Fig 3.1.

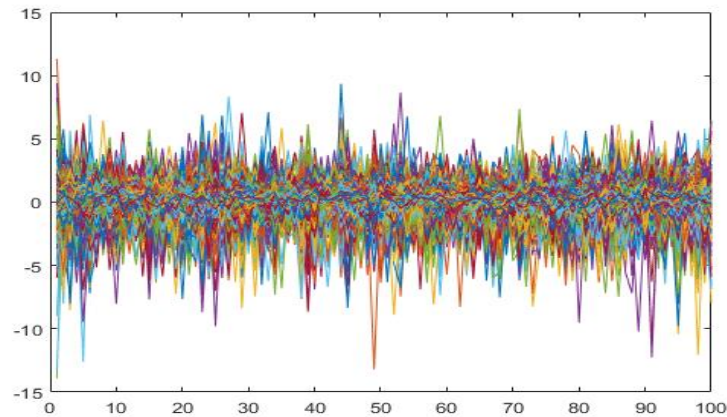


Figure 3.1: Frequency spectrum of the EMG signal recognized from the Tibialis Anterior muscle amid a consistent power isometric constriction at half of intentional greatest.

3.2.2 CHARACTERISTICS OF THE ELECTRICAL NOISE

The commotion may radiate from different sources, for example: • Inherent clamor in the gadgets segments in the identification and recording hardware - All hardware gear creates electrical clamor. This clamor has recurrence segments that go from 0 Hz to a few thousand Hz. This clamor can't be likely of; it must be diminished by utilizing high caliber electronic segments, shrewd circuit structure and development strategies [27].

- **Ambient noise** - This appeal starts from sources of electromagnetic energy, for example, radio and TV transmission, electrical-control chains, lights, fluorescent lights, and so on. Essentially, any electromagnetic device creates and may contribute commotion. The exteriors of our bodies are always absorbed with electric-attractive radiation and it is fundamentally difficult to evade introduction to it on the surface of the earth. The crushing worry for the adjacent appeal arises from the 60 Hz (or 50 Hz) radiation from power sources. The

adjacent appeal signal may have a plentifulness that is one to three needs of extent more notable than the EMG signal.

- **Motion artifacts** - There are two value wellsprings of movement antiquity: one from the interface between the location surface of the terminal and the skin, the other from development of the link associating the anode to the intensifier. Both of these sources can be basically lessened by legitimate plan of the gadget's hardware. The electrical signs of both clamor sources have the majority of their vitality in the recurrence run from 0 to 20 Hz.
- **Inherent instability of the signal** - The plentifulness of the EMG signal is semi arbitrary in nature. The reappearance segments anywhere in the range of 0 and 20 Hz are especially flimsy since they are influenced by the semi irregular nature of the dismissing rate of the motor units which, in many conditions, fire in this recurrence district. In view of the flimsy idea of these parts of the signal, it is prudent to consider them as undesirable clamor and expel them from the signal [27].

3.3 ELECTRODE AND AMPLIFIER

The structure of the cathode unit is the most basic part of the gadgets device which will be utilized to acquire the signal. The loyalty of the EMG signal identified by the terminal impacts all ensuing treatment of the signal. It is exceptionally troublesome (relatively incomprehensible) to enhance the constancy and signal to-clamor proportion of the signal past this point. Subsequently, it is critical to devise an anode unit that gives insignificant twisting and most astounding sign to-clamor proportion. The accompanying qualities are essential for accomplishing this necessity.

- **Differential amplification** - So as to take out the possibly a lot more noteworthy commotion motion from electrical cable sources, a differential identifying design is utilized. The differential intensification strategy is demonstrated schematically. The introduce is straightforward. The signal is distinguished at two locales, hardware subtracts the two signals and after that enhances the distinction. Thus, any signal that is "normal" to both identification destinations will be evacuated and signals that are diverse at the two locales will have a "differential" that will be intensified. Any signal that begins far from the

location destinations will show up as a typical signal, while motions in the quick region of the discovery surfaces will be unique and therefore will be enhanced. In this way, moderately far off electrical cables commotion signs will be evacuated and generally neighborhood EMG signs will be intensified. This clarification requires the accessibility of a very exact "subtractor". Practically speaking, even with the wondrous hardware of today, it is extremely hard to subtract signals consummately. The exactness with which the differential intensifier can subtract the signs is estimated by the Common Mode Rejection Ratio (CMRR). An ideal subtractor would have a CMRR of boundlessness. A CMRR of 32,000 or 90 dB is commonly adequate to smother unessential electrical clamors. Current innovation takes into consideration a CMRR of 120 dB, yet there are somewhere around three purposes behind not driving the CMRR to the limit: 1) Such gadgets are costly. 2) They are hard to keep up electrically steady, and 3) the incidental clamor signs may not touch base at the two identification surfaces in stage, and consequently they are not regular mode motions in the supreme sense [28].

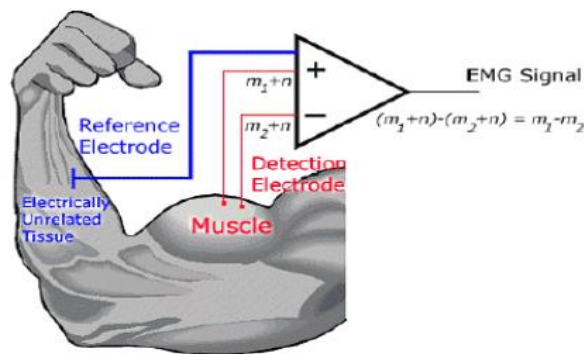


Figure 3.2: A schematic of the differential enhancer design. The EMG signal is spoken to by 'm' and the clamor motions by 'n'[28].

- **Input impedance** - The basis impedance at the intersection of the casing and detection external may spread from a few thousand ohms to a few megohms for dry crust. So as to forestall lessening and bending of the distinguished signal because of the impacts of information stacking, the info impedance of the differential speaker ought to be as extensive as could reasonably be expected, without making auxiliary complexities the activities of the differential intensifier. Present day hardware gadgets effectively give contribution

impedances of the request of 1012 ohms in parallel with 5 picofarads. Notwithstanding the greatness of the info impedance, the harmony among the impedances of the two discovery destinations is likewise of incredible significance. This thought requires cautious circuit plan.

- **Active electrode design** - The prerequisite for a high info impedance presents an issue known as capacitance link at the contribution of the differential speaker. A little capacitance between the wires prompting the contribution of the differential speaker and the electrical cable will present an electrical cable clamor motion into the enhancer. This marvel is like what causes a TV signal solidarity to increment when one spots one's hand close to the reception apparatus input, yet does not contact it. The arrangement is to put the differential enhancer as close as conceivable to the discovery surfaces of the cathode. This arrangement has turned out to be known as the "dynamic anode". One other preferred standpoint of this setup is that the yield impedance of the differential enhancer can be made to be low, on the request of 10 ohms. Hence, any development of the link from the yield of the anode won't produce noteworthy or even eminent clamor motions in the link which encourages into the consequent intensifier.
- **Filtering** - Indeed, even with the above contemplations, the EMG signal will be defiled by some commotion. The signal to commotion proportion can be expanded by sensible separating between 20-500 Hz with a move off of 12 dB/oct. (Strict structure qualities could consider 400 Hz as the upper data transfer capacity cut-off. The 500 Hz esteem takes into consideration a wellbeing edge in the structure of the hardware.) This sifting is commonly cultivated at the speaker organize situated outside the dynamic anode.
- **Electrode stability** - At the point when a terminal is put on the skin, the location surfaces interact with the electrolytes in the skin. A substance response happens which requires some an opportunity to balance out, commonly in the request of a couple of moments if the anode is effectively planned. Yet, more imperatively, the concoction response ought to stay stable amid the account session and ought not change fundamentally if the electrical attributes of the skin change from perspiring or mugginess changes.

- **Preferred method of use** - Given the elite and little size of current hardware, it is conceivable to plan dynamic terminals that fulfill the above necessities without requiring any grating skin arrangement and evacuation of hair [9].

3.3.1 ELECTRODE GEOMETRY

Since the commencement of electromyography, the shape and the format of the recognition surface of the anode have not gotten much consideration. In all likelihood on the grounds that past clients of electromyography have been intrigued just in the subjective parts of the EMG signal. The coming of new handling systems for extricating quantitative data from the EMG signal requires more prominent spotlight on the arrangement of the terminal. The major (however not all) focuses to consider are:

- a. The signal to clamor proportion of the distinguished signal,
 - b. The data transfer capacity of the signal,
 - c. The muscle test measure, and
 - d. The vulnerability to crosstalk.
- **Signal-to-noise ratio** - The signal to-commotion proportion is an element of muddled collaborations between the electrolytes in the skin and the metal of the discovery surfaces of the anode. This is an included subject that is past the extent of this short treatise. Do the trick it to state that there are a few methodologies for lessening the commotion, for example, utilizing vast surface zones for the identification surfaces, utilizing conductive electrolytes to enhance the contact with the skin, and expelling dead (less conductive) dermis from the surface of the skin. Through experimentation we have discovered that discovery surfaces made of unadulterated (>99.5%) silver as bars 1 cm long and 1 mm in width give an adequately decent medium to the identification surface. The abundancy of the EMG signal is straightforwardly relative to the separation between the recognition surfaces. Consequently, this separation ought to be boosted. Be that as it may, expanding this separation acquaints bothersome qualities with the cathode plan. As the anode winds up bigger, it ends up cumbersome and can't be utilized to identify EMG signals from generally little (in width and also long) muscles, for example, those found in the hand, lower arm and the leg. Moreover, as the separation builds the sifting qualities of the differential enhancement

diminishes in data transmission. Thus, a trade off is fundamental. We have found by computations and by heuristics that a between discovery surface dispersing of 1 cm gives a worthy trade off [29].

- **Bandwidth** - The data transmission of the EMG signal is influenced by the between discovery surface dispersing and the conduction speed of the activity possibilities along the muscle strands. The differential arrangement has a spatial sifting highlight that can be communicates as a bandpass channel in the unearthly recurrence district of the EMG signal. Again observe *Muscles Alive* (1985) pp. 46-50 for subtleties. For a normal conduction speed of 4.0 m/s and a between recognition surface separation of 1.0 cm, the pass recurrence is 200 Hz and the invalid point is at 400 Hz. This data transfer capacity catches the full recurrence range of the EMG signal and stifles commotion at higher frequencies.
- **Muscle sample size** - The muscle test estimate requires not be extensive on the grounds that the muscle filaments of motor units are appropriated all through the majority of the muscle cross-area. Along these lines, it isn't important to cover a huge segment of the muscle with the recognition surface of the cathode to acquire an agent test of the EMG motion for a specific arrangement of dynamic motor units.

3.4 Cross-talk susceptibility - The weakness to cross-talk is a regularly neglected structure part of EMG cathodes. The more noteworthy the width and length of the location surfaces and the more noteworthy the interdetection surface separation the closer the terminal will be to nearby muscles. Consequently, bigger anodes are increasingly helpless to distinguishing signals from contiguous (horizontal and underneath) muscles. In circumstances where this issue is of concern, it is fitting to diminish the extent of the anode [29].

CHAPTER 4

EMG SIGNAL PROCESSING

General signal getting ready methods are used to process Electromyography signals. EMG signal examination encounters four stages as takes after Bi phantom Index (BIS), de-noising, include extraction, and arrangement. Figure 4.1 demonstrates the condensed type of the strategies, where each stage is discussed in detail. What's more, the utilization of the stages must be progressive, start from the accounting stage to game plan arrange. At each stage, a couple of exercises should be done before tossing the signal to the accompanying straightaway.

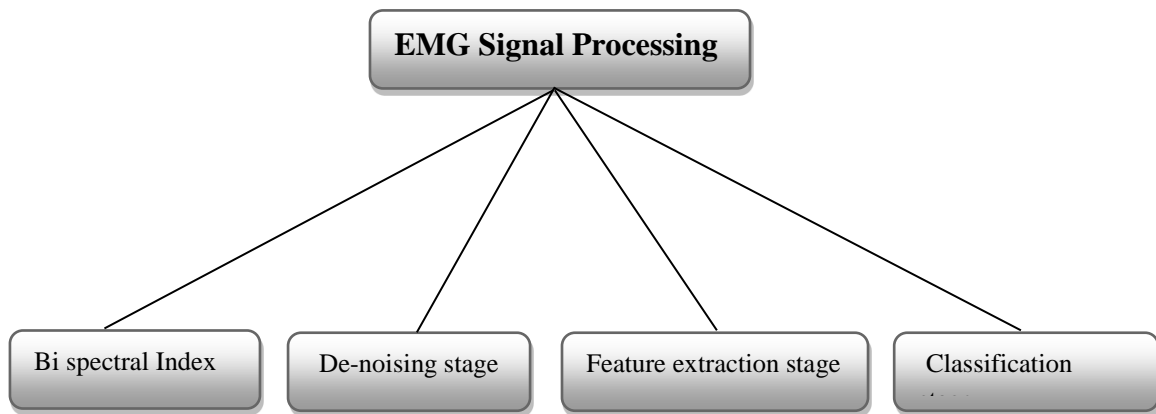


Figure 4.1: Basic stages of processing of Electromyography signal

4.1 Bi spectral Index (BIS)

BIS is a quantifiable record in light of a blend of the recurrence area, time, and high-orchestrate unearthly sub-parameters. Broad volumes of the clinical data are utilized to make the alone variable in perspective of the divergence of Electromyography signal; the uniqueness compares the direct of stupor and sedation. BIS fields from 100-00 (when understanding is cognizant). Generally, the bi extraordinary rundown is enlisted in two phases:

- Finding the First Fourier change (FFT) coefficients
- Computing the bi spectrum.

$$B(f_1, f_2) = X(f_1) \times X(f_2) \times X^*(f_1 + f_2) \quad (3)$$

In this point, $B(f_1, f_2)$ is an intricate bi range and $X(f)$ is the stunning Fourier change at recurrence f of the Electromyography signal $x(n)$. The bi soundness is utilized to find the association between power at f_1 and f_2 in the EMG signal; bi rationality can be enrolled autonomously for each anode.

Loss of perception occurs at qualities in the region of 70 and 80. What's more, the characteristics that reflect adequate hypnotizing sway are 40-60. BIS records under 30 address significant irregularities (calm in peril). Thusly, the anesthesiologist must change in like manner to extend this regard. BIS is useful for adjusting the portion of tranquilizers; this alteration keeps any aggravations in the patient's condition (care or smother EMG signal [21]).

4.2 De-noising Electromyography Signal Stage

The Electromyography signals are noted with a lot of clamors delivered from the earth or antiquated rarities. Propelled channels are utilized as a piece of the fundamental period of EMG data getting ready to empty control recurrence from the watched signal and decrease deplorable repeat portions. The electrical line racket was removed cleanly from the Electromyography movement by the chain of high-pass and low-pass channels duplicated and nitty gritty that the EMG signal resolved to have the mechanized divert in time region regularly incorporates cross-expanding each unfiltered data point and the neighbors with a course of action of weights. What's more, the relic is the second sort of clamor, which appears as sharp spike-waves, spikes, and waves in the Electromyography motion in perspective of advancements of anodes, and muscle. Each channel should be taken care of and de-noised freely from others, as showed up in Figure 4.2, which portrays the de-noising stage for each EMG channel.

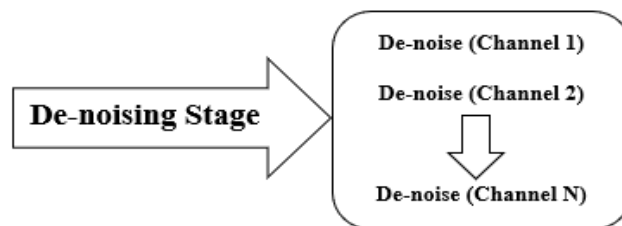


Figure 4.2: De-noising stage of Multi-channel to the noted EMG signal

The Wavelet Transform (WT) ousts diverse old rarities, for instance, visual ancient rarities, movement curios, and innate clamor, which are used to demonstrate the dimension of assortment in the EMG signal and mirror the effect of narcotic prescription

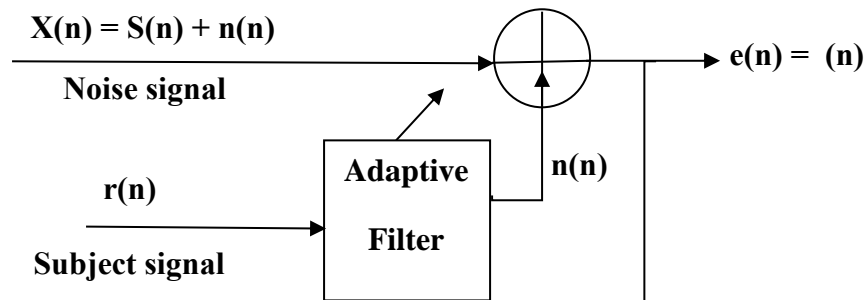


Figure 4.3: De-noising with Adaptive noise abolisher[24].

With the sensible choice of wavelet level smoothing procedure, antique clamor can be cleared to affirm and separate the EMG signal. Mother wavelet is particularly reasonable in depicting diverse sides of non-stationary signs, for instance, the discontinuities and repeated instances of the prominent EMG signal.

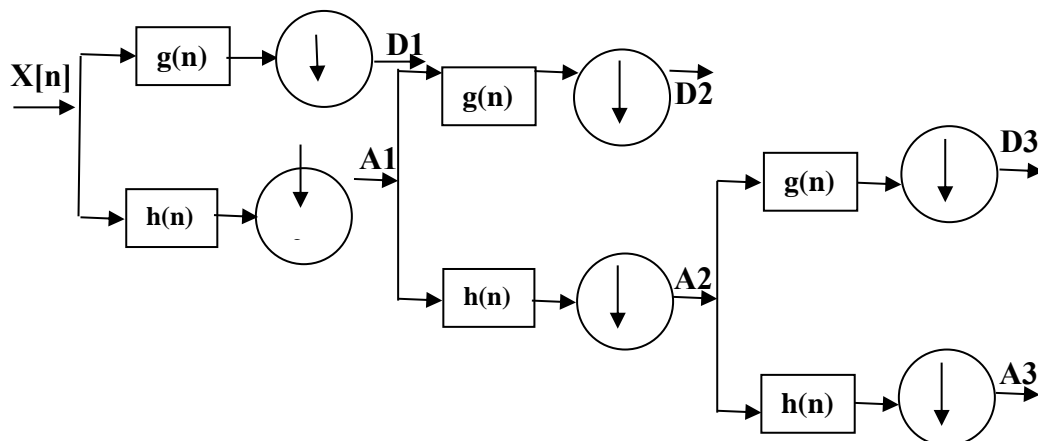


Figure 4.4: N-level Wavelet De-noising[23].

Wavelet Transform is practiced by a dynamic chain of high-take and low-pass a break space (adaptable channel). Figure 4.3 exhibits the rule adaptable channel used to isolate confusion from the EMG signal. The data signal $x[n]$ has adhered to the high-pass

procedure with drive response $h[n]$. A comparable data is gone in the meantime through the low-pass channel with the drive response $g[n]$. The ordered coefficients are browsed high-pass channel $y_{high}[n]$ and surmise coefficients are looked over low-pass channel $y_{low}[n]$, as showed up in Figure 4.4. The yield channels (convolution) are given picked in Equations (4) and furthermore from (5):

$$y_{low}[n] = \sum_{k=-\infty}^{\infty} x[k]g[2n-k] \quad (4)$$

$$y_{high}[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k] \quad (5)$$

Wavelet change has a central condition, which might be used as mother wavelet work. To use this change feasibly, exact focal points of the specific application should be seen as and the sensible mother wavelet limit should be picked completely. The last formula of the wavelet enunciation in regard to mother wavelet $\psi(t)$ and scaling limit $\phi(t)$ of the signal $x(t)$ [24].

$$x(t) = \sum_{k=0}^{\infty} c_k \phi_j(t) + \sum_{j=0}^{\infty} \sum_{k=0}^{\infty} d_{jk} \psi_k(t) \quad (6)$$

The underlying section in the Equation (6) addresses the estimation at the optional starting scale j_0 , all together that the second part depicts the intersection of the inconspicuous components. Thusly, the correct mother wavelet work is picked by its likeness with Electromyography signal, the ability to process the signs into biomedical applications. Furthermore, assurance of correct channels chooses the probability of generation and the condition of the wavelet. What's more, wavelet work is managed through the high-pass channel, which conveys the specific coefficients of wavelet rot. The scaling limit is in a general sense equivalent to the wavelet work, yet is directed through the low-pass channel, which is connected with the speculation coefficients of wavelet crumbling [21,23]. The results show that the methodology is sensible for wiping out knick-knacks caused through eye advancements and has upsides of straightforward use, quality, and little computational expense. Another methodology to remove the curio from Electromyography (EMG) signal; The proposed technique showed the best relic division execution for each kind of collectible and allowed inconsequential information hardship. Another procedure used to remove visual relics and muscle doodads (EMG) embedded with the prominent Electromyography signals

is modified old irregularity departure. SOBI was used to clear EOG trinkets, however standard relationship examination was used to remove muscle relics.

4.3 Feature Extraction of the Electromyography Signal Stage

To recognize and screen EMG assortments, various features of EMG signal were perceived to give a program structure that would support specialists in the midst of end. The game plan sort out can't recognize the recorded signal explicitly because of the enormous proportion of data that should be set up at one time, which backs off the request system. The component of each channel contrasts as demonstrated by the region of the anode on the human scalp. The bunch can be exposed to various abilities to create another display that addresses the possible destiny of each channel.

We use the workplace of wavelet methodology in examining the frequencies of mind hails and removing different features. The EMG signal is decayed into different sub-bunches as demonstrated by the breaking down dimension, and a short time later, the imperativeness of tests is figured by each dimension. The procedure was asked to remove the supportive features through the recorded Electromyography (EMG) signals. What's more, Wavelet change break down an EMG movement into various frequencies in gatherings, thusly, it is a ground-breaking instrument for depicting these signs. The intensity of EMG and the frequencies change ceaselessly at each dimension inside specific gatherings; the association between these assortments in repeat band can be used to depict the DOA. Two sorts of features are used to distinguish the assortment in Electromyography (EMG) signal: and first depends upon assortments run control range and second depends upon assortments in the signal at recurrence time space. Likewise, Isoflurane caused double pinnacles; where α go is the first and δ run is the second one. Extending the centralization of isoflurane is 0.3%-1.5% will move the α top repeat (10.6 Hz) to cut down frequencies (9.5 Hz) [30]. In a comparative setting, with respect to the basic α peak that was stage coupled in the moderate δ waves, greater groupings of isoflurane moved this apex (10.6 Hz) to cut down frequencies (7.6 Hz).

The extraordinary criteria for evaluating the diverse features are by figuring mean squared bumble (Equation (7) shows) and Equation (9) indicates motion to-commotion extent. These characteristics are registered from the main EMG (Electromyography) signal $x(n)$ and de-noised Electromyography (EMG) signal $\hat{x}(n)$:

$$\text{MSE} = \frac{1}{N} \sum_{n=1}^N [x(n) - \hat{x}(n)]^2 \quad (7)$$

$$\text{SNR} = 10 \log \left[\frac{\sum_{n=1}^N x^2(n)}{\sum_{n=1}^N [x(n) - \hat{x}(n)]^2} \right] \quad (8)$$

These characteristics can be found out at explicit frequencies and diverged from those in the midst of care with showing the assortments in qualities according to the DOA. We used institutionalized powerful entropy to depict the examination levels. This appalling entropy was found out for each EMG age inside the profitable repeat extent of mind signals. We used a short zone (only 1s) to screen correctly the alterations in Electromyography(EMG) signal [12]. AE (Approximate entropy) and PE (Permutation entropy) are asked to measure the effect of separating prescriptions using a flood of EMG data. These features reveal the effects of sevoflurane on cerebrum development.[10] AE relies upon the likeness of events in stage space and is an appropriate procedure for describing the mediation of the structure. AE depends upon three parameters: m, the embedding estimation, N, the number of tests; and r, as far as possible. PE relies upon the Shannon entropy (SE) and is determined using Equation (9):

$$H_p(m) = - \sum_j P_j \ln p_j \quad (9)$$

Now, P is probability scattering of the specific pictures, which are described as P_j, \dots, p_l ; and m is a phase, and J should be not as much as m. Both Approximate entropy and Permutation entropy see the two evaluations (anesthetized and alert) with a high association with one another. Furthermore, the desire probabilities exhibit that Permutation entropy has a more grounded capacity for isolating among the two evaluations. The results show that Permutation entropy checks the effects of sevoflurane higher reasonably than surmised entropy. This technique can be associated with plan another EMG watching system for assessing the effects of sevoflurane.

4.4 Signal Processing

This section is contracted the signal processing of the recorded EMG. EMG data loading, coding and plotting of the signals in various respected form to investigate the EMG for the detection purpose.

4.4.1 EMG data loading

For handling the EMG motion in MATLAB, above all else, we have to stack the EMG informational collection in the MATLAB instrument. For this reason, in this undertaking, spared the EMG informational collection in .content (Dot content) arrange

and spared the document in a similar organizer where the MATLAB programming is introduced. At that point run the MATLAB programming and at first opened the order window. In order window, the accompanying direction was composed: Load Data.txt.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.1232	0.1997	0.2762	0.0722	0.1487	0.1232	0.0212	0.1232	0.1742	0.1232	0.3272	0.2252	0.1997	0.1742	0.0467	0.0722
2	0.1232	0.2252	0.1997	0.1742	0.1997	0.0212	0.0977	0.1232	0.1742	0.1997	0.1487	0.1742	0.2252	0.1487	0.1487	0.1742
3	0.1742	0.2252	0.1232	0.1742	0.0212	0.2252	0.0977	0.0212	0.5312	0.3782	0.0467	0.0977	-0.0808	0.0722	-0.0043	0.2252
4	0.1487	0.1742	0.0212	0.1487	0.0722	0.0722	0.3527	0.2252	0.1997	-0.2848	0.4037	0.3527	0.0212	0.2252	-0.1318	-0.2593
5	0.2507	0.0722	0.1232	-0.3868	0.5057	0.4547	0.2252	-0.1318	-0.0043	-0.0808	0.2252	0.2252	0.1232	0.0212	0.3017	0.1997
6	0.1232	0.1997	0.1232	0.0722	0.2252	0.1487	0.6842	-0.4123	0.1232	0.5312	0.1742	0.1997	0.0977	0.0722	0.1742	0.1487
7	0.0722	0.0977	0.0212	0.1232	0.1742	0.1487	0.1997	0.2507	0.0977	0.1232	0.0977	0.0467	0.1742	0.1742	0.2252	0.2762
8	0.0212	0.1232	0.1742	0.1232	0.3017	0.1232	0.1997	0.1487	0.0977	0.0977	0.1232	0.1487	0.1487	0.1742	0.0722	0.2762
9	0.0722	-0.1318	0.2252	0.3527	0.1742	0.1232	0.1742	0.0722	0.1997	0.1232	0.1997	0.0212	0.1487	0.1232	0.2507	0.1742
10	0.1997	0.2252	0.0977	0.1232	0.1232	0.2252	0.0722	-0.1318	0.3272	0.2507	0.1487	0.1742	0.1487	0.0467	0.0722	0.1232
11	0.0977	0.1997	-0.0043	-0.4123	0.3017	0.5567	0.0977	0.4547	-0.8969	0.1742	0.5312	0.1997	0.2252	0.0977	0.2252	0.1232
12	0.1742	0.1232	0.1232	0.1232	0.0977	0.2507	0.1742	0.1232	0.1742	0.1742	0.0212	0.1742	0.0212	0.1232	0.1232	0.2252
13	0.1232	0.1997	0.0977	0.2507	0.1997	0.1232	0.1742	0.1232	0.0467	0.0722	0.0977	0.1232	0.1742	0.0977	0.2252	0.1997
14	0.1232	0.1997	0.1232	0.1487	0.2252	0.1487	0.1232	0.1487	0.1487	0.1997	0.2762	0.1232	-0.4123	0.1487	0.5567	0.1232
15	0.0977	0.0467	0.0722	0.6077	-0.4378	-0.0043	0.4292	0.3017	0.2252	0.0467	0.0722	0.2252	0.1232	0.0212	0.1742	0.1487
16	0.1997	0.5057	0.1742	0.2507	-0.8459	0.1232	1.8573	0.8883	0.4547	0.1742	-0.3868	-0.9224	-0.2593	0.0212	-0.0043	0.2252
17	0.2252	0.1232	0.1232	0.2252	0.1742	0.1997	0.1997	0.0722	-0.0298	0.3017	0.5567	0.1997	0.1487	0.0722	0.0977	0.0212
18	0.0722	0.0722	0.2252	0.1997	0.0722	0.1487	0.2252	0.1487	0.0467	0.0977	0.1997	0.1232	0.2252	0.1997	0.0722	0.0467
19	0.1997	0.3017	-0.1063	-0.4633	0.8883	-0.5908	0.8883	0.9138	-0.3358	-0.4123	0.6842	-0.0298	-0.1318	0.1487	-0.1063	0.3017
20	0.2762	0.0467	0.4292	-0.2593	-0.2593	0.3272	0.1997	0.1742	0.0722	0.0977	0.7097	0.2252	0.0212	0.0467	0.0467	0.0212

Cyrindrical Grasp

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.0977	0.1487	0.1997	0.2252	0.2507	0.1997	0.0722	0.0467	0.0722	0.1232	0.1487	0.1487	0.1742	0.1487	0.1997	0.2252
2	0.1232	0.1232	0.0977	0.1742	0.1487	0.0212	0.0722	0.1997	0.1232	0.1232	0.0977	0.0977	0.1232	0.1742	0.2252	0.1742
3	0.0722	0.0722	0.0977	0.1742	0.1742	0.1487	0.1487	0.1232	0.1232	0.1487	0.1742	0.1487	0.0977	0.0977	0.0977	0.0212
4	0.1742	0.1742	0.1997	0.1997	0.1742	0.2252	0.1232	0.1232	0.0977	0.0722	0.0467	0.1997	0.1997	0.1742	0.1232	0.1232
5	0.1232	0.1997	0.0977	0.0977	0.1742	0.1742	0.1487	0.1232	0.0977	0.0722	0.0722	0.0467	0.0977	0.0467	0.0977	0.1232
6	0.0212	0.1232	0.1742	0.1487	0.2252	0.2507	0.2252	0.1487	0.1487	0.1232	0.1232	0.1742	0.1487	0.1487	0.0722	0.0977
7	0.1232	0.1232	0.1232	0.1232	0.1997	0.1487	0.1742	0.1487	0.1232	0.1487	0.1232	0.0722	0.0722	0.0977	0.1232	0.1742
8	0.2507	0.2762	0.1997	0.1232	0.1487	0.1232	-0.0553	0.1997	0.3782	0.1997	0.1232	-0.0043	0.1232	0.1487	0.1232	0.1487
9	0.3782	0.6077	0.2507	-0.0808	-0.1828	-0.0043	-0.0043	0.5057	0.3782	-1.3814	0.6587	0.4037	0.4037	0.3272	0.2252	0.2252
10	0.1487	0.0977	0.0722	0.1232	0.1232	0.1487	0.1742	0.2252	0.1487	0.1232	0.0977	0.0977	0.1487	0.1742	0.2252	0.1487
11	0.0467	0.1742	0.3782	0.3272	-0.4378	-0.0298	0.4802	0.2762	-0.1063	0.2507	0.5822	0.1997	-0.1063	-0.0808	-0.0298	0.4037
12	0.0977	0.0977	0.1232	0.1742	0.1232	0.0722	-0.0043	0.2762	0.2252	0.1997	0.3782	0.1742	0.0977	0.0722	0.1232	0.1232
13	0.0977	0.1487	0.2252	0.1997	0.1742	0.1232	0.0722	0.0977	0.1997	0.1232	0.1232	0.1742	0.2252	0.2252	0.1487	0.1487
14	0.0977	0.1232	0.1997	0.2762	0.1997	0.1742	0.1487	0.1487	0.1232	0.0977	0.1232	0.0722	0.1232	0.1487	0.1232	0.0467
15	0.1232	-0.0043	0.1487	0.4547	0.2507	0.2252	0.2507	-0.9224	-0.1063	0.4037	0.4802	0.4037	0.3272	0.3782	0.2252	0.1232
16	0.2252	0.1997	0.1487	-0.1063	0.2252	0.2507	0.2762	0.2507	0.0977	0.0722	0.0212	-0.1063	0.1742	0.1742	0.2762	0.2762
17	-0.1063	-0.1063	0.0977	0.1232	0.6077	0.5312	-1.2539	0.2762	0.7607	-0.0553	0.6332	0.3527	0.1742	-0.0298	0.0467	0.0722
18	0.5057	0.0977	-0.0298	-0.1318	0.0977	0.0467	0.3527	-0.4633	0.3527	0.3017	0.2762	0.3017	0.2762	-0.0298	-0.0298	-0.1318
19	-0.4123	0.7607	0.5312	0.0212	-0.0553	-0.1318	0.1742	0.1232	0.1742	0.1232	0.2762	0.3527	0.0977	0.0467	-0.0043	0.2762
20	0.1232	0.0722	0.1232	0.1742	0.1742	0.2252	0.1742	0.1997	0.1232	0.1232	0.3272	-0.0808	0.4292	0.0212	0.0722	0.0212

Hook or Snap

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.1742	0.1232	0.1997	0.1997	0.1232	0.1232	0.0977	0.0977	0.1487	0.1997	0.1232	0.2252	0.1997	0.0977	0.1232	0.0977
2	0.1232	0.1997	0.2252	0.0977	0.1487	0.1487	0.0722	0.0977	0.1742	0.1997	0.1487	0.1232	0.1232	0.0722	0.1487	0.2252
3	0.2252	0.1487	0.1742	0.0722	0.1232	0.1997	0.1487	0.0977	0.1232	0.1997	0.1487	0.1487	0.0977	0.0977	0.1232	0.1997
4	0.1487	0.1232	0.0977	0.0722	0.0977	0.0977	0.0722	0.0722	0.0977	0.0977	0.0977	0.0467	0.0722	0.0722	0.1232	0.0977
5	0.1232	0.0722	0.1232	0.1487	0.1742	0.2252	0.0722	0.0977	0.1487	0.1742	0.1742	0.1742	0.1487	0.1232	0.1742	0.1487
6	0.1742	0.1742	0.1487	0.1232	0.1487	0.0977	0.0977	0.0467	0.1232	0.1232	0.1487	0.1742	0.1487	0.1232	0.1487	0.1487
7	0.2252	0.1232	0.1487	0.1742	0.2252	0.2252	0.1997	0.1487	0.1742	0.0722	0.1487	0.1232	0.1742	0.1997	0.0722	0.0977
8	0.0977	0.0722	0.0977	0.0722	0.0722	0.0722	0.1742	0.1742	0.1487	0.1487	0.1487	0.1742	0.2252	0.1232	0.1487	0.0467
9	0.2252	0.1232	0.1487	0.0977	0.0722	0.0722	0.1232	0.0467	0.1487	0.0977	0.0722	0.0722	0.0722	0.1232	0.0722	0.1232
10	0.1742	0.1487	0.1487	0.0977	0.0467	0.0722	0.0467	0.0977	0.0977	0.0977	0.0977	0.1487	0.1487	0.1487	0.1232	0.0977
11	0.1487	0.1997	0.1742	0.2252	0.2252	0.1232	0.1997	0.2252	0.1742	0.1487	0.1742	0.0977	0.0977	0.0977	0.0977	0.1487
12	0.1487	0.0977	0.1487	0.0977	0.0467	0.0722	0.1487	0.1742	0.1742	0.1997	0.2252	0.1487	0.1742	0.1232	0.1232	0.1487
13	0.1487	0.1232	0.0212	0.1232	0.1487	0.1997	0.1742	0.1232	0.1742	0.1997	0.1232	0.1232	0.0467	0.2252	0.2252	0.1742
14	0.2252	0.1487	0.1487	0.0977	0.0467	0.0977	0.1997	0.1997	0.2252	0.1997	0.1742	0.0977	0.0722	0.1232	0.0722	0.1232
15	0.1742	0.1742	0.0722	0.0977	0.0722	0.1487	0.1232	0.2252	0.2252	0.1997	0.1487	0.1742	0.0977	0.0722	0.0722	0.0977
16	0.0977	0.2252	0.1997	0.1742	0.1232	0.0977	0.0212	0.0722	0.1487	0.1742	0.2507	0.2507	0.2762	0.1742	0.0212	0.0467
17	0.1997	0.1232	0.1487	0.0977	0.0722	0.1232	0.2252	0.1487	0.0722	0.1487	0.1487	0.2252	0.1742	0.1232	0.0977	0.1232
18	0.1742	0.2252	0.2252	0.2252	0.2252	0.2252	0.1487	0.1487	0.1487	0.1232	0.1742	0.1487	0.1742	0.1487	0.1742	0.1742
19	0.1232	0.1232	0.1487	0.1742	0.1997	0.0977	0.0722	0.1487	0.1742	0.2507	0.1232	0.1487	0.1232	0.1487	0.1997	0.1232
20	0.0722	0.1232	0.1232	0.2252	0.1997	0.2252	0.1487	0.2252	0.1487	0.1487	0.0977	0.1997	0.1997	0.1997	0.1487	0.1232

Lateral

Figure 4.5: Recorded EMG Day 1(Cyrindrical Grasp, Hook or Snap, Lateral) data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10	0.1487	0.1997	0.0977	0.1487	0.1742	0.0722	0.1232	0.1232	-0.2848	0.7097	0.3017	0.0722	-0.0553	0.0722	0.1487	0.1487
11	-0.2593	0.3272	0.7352	0.1232	-0.0298	-0.0298	-0.0298	0.1742	0.1487	0.0722	0.2507	0.1487	0.1997	0.1997	0.0722	0.2252
12	0.0722	0.1487	0.1487	0.0977	0.1997	0.0467	0.1742	0.1487	0.1487	0.2252	0.1232	0.1232	0.1997	0.1487	0.0977	0.2252
13	0.1487	0.1487	0.1997	0.1997	0.0467	0.1742	0.1487	0.1487	0.2252	0.1232	0.1232	0.0722	0.1487	0.1487	0.2252	0.1232
14	0.0977	0.1232	0.1232	0.2252	0.1487	0.0722	0.2252	0.0977	0.0212	0.1232	0.1487	0.0722	0.2252	0.1487	0.1232	0.1742
15	0.2252	0.0722	0.1232	0.2252	0.0977	0.1487	0.1487	0.1487	0.0722	0.1232	0.1232	0.1232	0.0977	0.2252	0.0977	0.1487
16	0.1232	0.1742	0.2507	0.0977	0.2252	0.1487	0.1232	0.1487	0.1232	0.1487	0.0722	0.1487	0.1997	0.1232	0.1997	0.1742
17	0.1997	0.1232	0.1742	0.1997	0.1997	0.1742	0.2252	0.0722	0.1232	0.1997	0.1232	0.1742	0.1232	0.1487	0.1232	0.1487
18	0.1487	0.1997	0.0467	0.1232	0.1232	0.1742	0.1487	0.1232	0.1487	0.1742	0.1487	0.1742	0.2252	0.1232	0.1232	0.1487
19	0.0467	0.0212	-0.0808	0.0467	0.1487	0.0212	0.1997	0.3527	0.2252	0.1487	0.0722	0.1742	0.1997	0.0977	-0.0298	0.1232
20	0.2507	0.1232	0.0722	0.1232	0.1742	0.1742	0.0722	0.1742	0.1742	0.0722	0.1232	0.1232	0.1997	0.0977	0.0977	0.1742
21	0.0722	-0.1573	-0.0553	0.3272	0.0722	0.0467	0.1742	0.1997	0.3527	0.2252	0.2762	0.1487	0.2762	0.1742	0.1232	-0.1063
22	0.1232	0.0722	0.1997	0.1232	0.1997	0.2507	0.0722	0.1232	0.1997	0.1232	0.1232	0.1232	0.0977	0.2252	0.0722	0.1742
23	0.2507	0.1232	0.2507	0.0977	0.2252	0.0722	0.1997	0.0722	0.1487	0.1232	0.1487	0.0977	0.1487	0.1232	0.1742	0.1742
24	0.1487	0.1232	0.0977	0.1742	0.1997	0.1742	0.1487	0.1997	0.0722	0.2507	0.0467	0.0977	0.0467	0.1997	0.0722	0.1997
25	0.1232	0.1997	0.1742	0.1487	0.1997	0.0977	0.1232	0.1742	0.0977	0.1742	0.1232	0.1487	0.1997	0.0722	0.1487	0.1487
26	0.1232	0.1232	0.1487	0.1997	0.1742	0.1487	0.1232	0.1232	0.1487	0.1742	0.1232	0.1232	0.1487	0.1232	0.2252	0.0977
27	0.0467	0.1997	0.0722	0.1232	0.1487	0.1232	0.1487	0.1997	0.2252	0.0977	0.2252	0.0977	0.1997	0.1232	0.1487	0.1487
28	0.1487	0.1997	0.0977	0.1997	0.0977	0.1997	0.2252	0.1487	0.1997	0.0977	0.1997	0.1997	0.1487	0.1232	0.1997	0.1487
29	0.0977	0.1997	0.1487	0.1742	0.1232	0.1232	0.1487	0.1232	0.1997	0.1232	0.1997	0.1742	0.1487	0.0722	0.1742	0.1997

Cyrindrical Grasp

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	0.1742	0.2762	-0.0043	-0.0298	0.1232	0.2252	0.2507	0.1487	0.1742	0.1997	0.1232	0.0722	0.0467	0.2252	0.1742	0.0722
5	0.1232	0.0722	0.0977	0.1232	0.1487	0.0977	0.0722	0.1742	0.1997	0.1232	0.0722	0.0977	0.1487	0.1487	0.2252	0.1487
6	0.1997	0.1742	0.1997	0.0977	0.1487	0.1232	0.2252	0.1232	0.1742	0.1232	0.0977	0.1487	0.2252	0.0977	0.1487	0.1997
7	0.0722	0.1487	0.2252	0.2252	0.1487	0.1487	0.0467	0.1487	0.2252	0.2252	0.1997	0.0977	0.0722	0.1742	0.2252	0.1487
8	0.1997	0.0977	0.1487	0.1997	0.0467	0.1232	0.2252	0.2762	0.1742	0.0467	0.1487	0.2252	0.1742	0.0977	0.1487	0.2252
9	0.1487	0.0467	0.0722	0.1232	0.1487	0.2252	0.1997	0.1232	0.1232	0.1232	0.3017	0.0212	0.3272	0.2507	-0.0043	0.0722
10	0.1232	0.2252	0.1997	0.1742	0.1232	0.1232	0.0722	0.1487	0.1997	0.1487	0.1487	0.1742	0.2252	0.1997	0.1232	0.1487
11	0.1742	0.0722	0.1742	0.1997	0.1232	0.0977	0.1742	0.2252	0.1232	0.0977	0.1232	0.2252	0.1487	0.1232	0.1487	0.1997
12	0.1487	0.2252	0.2252	0.1487	0.1232	0.0722	0.1487	0.0722	0.1232	0.2252	0.1487	0.0977	0.0722	0.1742	0.2252	0.1487
13	0.0722	0.1232	0.1487	0.1487	0.2252	0.1487	0.0977	0.0722	0.1487	0.1232	0.1997	0.1487	0.0977	0.0722	0.1487	0.2252
14	0.1487	0.1997	0.1232	0.0722	0.1742	0.1997	0.1742	0.1487	0.1997	0.1487	0.1487	0.0977	0.1487	0.1997	0.1232	0.1232
15	0.1487	0.1997	0.1487	0.0977	0.1232	0.2252	0.1742	0.1487	0.0722	0.1232	0.2252	0.1487	0.0467	0.1487	0.1232	0.1997
16	0.1487	0.2507	0.1487	0.1232	0.0722	0.0977	0.1232	0.1742	0.1232	0.2762	0.1742	0.1232	0.1232	0.0212	0.1997	0.3272
17	0.1997	0.1997	0.1232	0.0722	0.1487	0.2252	0.1232	0.0977	0.1487	0.1487	0.2252	0.1232	0.0977	0.1232	0.1487	0.1487
18	0.0722	0.1742	0.2252	0.0977	0.1487	0.1487	0.2252	0.0977	0.1742	0.1997	0.1487	0.1232	0.0722	0.1232	0.2252	0.1742
19	0.1742	0.2252	0.1487	0.1487	0.1232	0.1997	0.1487	0.1487	0.0977	0.1232	0.1997	0.1997	0.1232	0.0977	0.1232	0.2252
20	0.1232	0.2252	0.1742	0.1742	0.0977	0.0722	0.1487	0.1997	0.1232	0.0722	0.0722	0.1487	0.2252	0.1742	0.0722	0.1487
21	0.1232	0.0722	0.1487	0.2252	0.1487	0.0722	0.1232	0.2252	0.2252	0.1742	0.1232	0.1232	0.0467	0.1487	0.1232	0.1742
22	0.3272	-0.1573	0.1232	0.2762	0.0212	0.2762	0.2252	0.1487	-0.0553	0.6587	0.2252	0.0977	-0.2083	0.0722	0.1487	-0.7184
23	0.1487	0.0722	0.0722	0.1487	0.1997	0.1232	0.1232	0.0977	0.0977	0.1232	0.1997	0.2252	0.1742	0.0722	0.1997	0.1742

Hook or Snap

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.0722	0.1487	0.1742	0.1232	0.0977	0.1232	0.1487	0.0977	0.0722	0.1487	0.1742	0.0977	0.1997	0.1232	0.1742	0.2507
2	0.0977	0.2252	0.0722	0.1742	0.0977	0.2252	0.0722	0.1742	0.1487	0.1742	0.1487	0.1487	0.1487	0.1487	0.0722	0.1997
3	0.0722	0.1487	0.1487	0.0977	0.1997	0.0467	0.1997	0.1487	0.1487	0.1487	0.1487	0.1487	0.1487	0.0977	0.1997	0.1742
4	0.0722	0.2252	0.1742	0.1487	0.1487	0.1487	0.1997	0.0467	0.1232	0.0722	0.1997	0.1742	0.1742	0.2507	0.0467	0.1997
5	0.1232	0.1742	0.1232	0.1742	0.1742	0.1487	0.0977	0.0977	0.1487	0.1232	0.1487	0.2252	0.0722	0.1742	0.0722	0.1997
6	0.0722	0.1487	0.1742	0.1232	0.1742	0.1232	0.2252	0.1232	0.1487	0.1742	0.0977	0.1997	0.1232	0.1997	0.0977	0.1997
7	0.1487	0.1232	0.1487	0.1997	0.0977	0.2252	0.0977	0.2252	0.1997	0.1232	0.1232	0.1232	0.1232	0.0467	0.2252	0.0977
8	0.0467	0.2252	0.0977	0.2252	0.1487	0.1742	0.1487	0.0722	0.1997	0.0977	0.1232	0.1232	0.1232	0.1487	0.0977	0.1997
9	0.1487	0.2252	0.1487	0.0977	0.0977	0.2252	0.1487	0.0722	0.1487	0.1997	0.1487	0.1487	0.1487	0.1487	0.2252	0.1487
10	0.1232	0.1487	0.1997	0.1487	0.1487	0.2252	0.0977	0.2252	0.1487	0.1232	0.1997	0.0722	0.2252	0.1742	0.0977	0.2252
11	0.2507	0.0722	0.1487	0.1232	0.1742	0.1742	0.0977	0.2252	0.1742	0.0977	0.1997	0.0722	0.1742	0.1742	0.0467	0.1742
12	0.1232	0.1742	0.0722	0.1997	0.1742	0.1487	0.1487	0.0977	0.1742	0.1487	0.1487	0.1997	0.1232	0.2252	0.1487	0.1232
13	0.1487	0.0977	0.1742	0.1232	0.0722	0.1487	0.2252	0.1232	0.0722	0.2252	0.1487	0.1742	0.1742	0.0467	0.1232	0.1742
14	0.0977	0.0977	0.1997	0.1487	0.1487	0.2252	0.0722	0.1742	0.2252	0.0977	0.1232	0.1997	0.0722	0.1232	0.1742	0.0977
15	0.1232	0.0977	0.1997	0.1232	0.1742	0.2252	0.0977	0.1232	0.1487	0.0977	0.2252	0.1742	0.0977	0.2252	0.0722	0.1487
16	0.1742	0.1487	0.2252	0.1742	0.1487	0.2252	0.0722	0.1487	0.2252	0.0722	0.2252	0.1232	0.1232	0.2252	0.0977	0.1232
17	0.1232	0.2252	0.0977	0.2252	-0.0043	0.0977	0.1997	0.2252	0.2507	0.0977	0.0212	0.2252	0.1997	0.1742	0.1232	0.2252
18	0.2252	0.1232	0.0722	0.2252	0.1232	0.0722	0.2252	0.1232	0.1232	0.1232	0.0722	0.1997	0.1742	0.0722	0.2252	0.1487
19	0.1487	0.1232	0.1487	0.1997	0.0722	0.1487	0.1232	0.2252	0.0722	0.1487	0.0722	0.1997	0.0467	0.1487	0.1742	0.0977
20	0.1742	0.1742	0.0722	0.1487	0.1742	0.0722	0.1997	0.0977	0.0977	0.1997	0.0722	0.1232	0.1487	0.0977	0.2252	0.0977

Lateral

Figure 4.6: Recorded EMG Day 2 (Cyrindrical Grasp, Hook or Snap, Lateral) data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.0722	0.3272	0.0722	-0.0298	0.1487	0.2762	0.2252	-0.1063	-0.0298	0.2762	0.2252	0.1742	0.0977	0.0722	0.1487	0.2252
2	0.1742	0.1232	0.2252	0.1487	0.1742	0.0467	0.0212	0.0722	0.1232	0.0977	0.1232	0.1487	0.0977	0.0977	0.0722	0.0977
3	0.1742	0.1487	0.2252	0.1487	0.1487	0.0977	0.0977	0.1487	0.2252	0.2252	0.1742	0.1487	0.0977	0.0212	0.0722	0.0722
4	0.1232	0.1232	0.1232	0.1232	0.1742	0.1487	0.1742	0.1487	0.1997	0.2252	0.2252	0.1997	0.1997	0.0212	0.2252	0.1997
5	0.1742	0.1742	0.1997	0.2507	0.2252	0.1487	0.1742	0.1742	0.1997	0.1232	0.1742	0.1487	0.1232	0.1742	0.1232	0.1232
6	0.1997	0.1997	0.1232	0.2507	0.1487	0.1997	0.2507	0.2252	0.1487	0.1487	0.1487	0.1742	0.1997	0.2252	0.1232	0.0977
7	0.1487	0.1487	0.0467	0.0212	0.3527	0.0977	0.0722	0.0977	0.1232	0.1742	0.1232	0.1487	0.0977	0.0722	0.0722	0.1742
8	0.0467	0.0212	0.1232	0.0467	0.1487	0.1742	0.1487	0.1487	0.1742	0.2252	0.2252	0.0977	0.0722	0.1487	0.3017	0.1487
9	0.2252	0.1742	0.1742	0.2252	0.1487	0.0977	0.0467	0.0722	0.1487	0.1232	0.1997	0.2252	0.2252	0.1487	0.2507	0.1232
10	0.1232	0.1232	0.1232	0.1232	0.1742	0.2252	0.3782	0.3017	0.1487	-0.0043	0.0722	0.0977	0.1997	0.2252	0.1232	0.1232
11	0.2252	0.2252	0.2252	0.2252	0.1232	0.1997	0.2252	0.1997	0.0722	0.0977	0.1232	0.0977	0.1232	0.0722	0.0212	0.0977
12	0.1742	0.2507	0.2762	0.1997	0.1742	0.0977	-0.0043	0.0722	0.1232	0.0977	0.0722	0.0977	0.1487	0.1487	0.1742	0.0977
13	0.1487	0.0467	0.0722	0.1742	0.1487	0.2762	0.0467	0.0977	0.1742	0.1232	0.1232	0.1232	0.0722	0.1487	0.1487	0.2252
14	0.0977	0.1997	0.0722	0.1742	0.1487	0.0977	0.0977	0.1742	0.1742	0.2507	0.1487	0.1742	0.1742	0.1487	0.0977	0.0722
15	0.1232	0.1232	0.1232	0.1742	0.1487	0.1487	0.1997	0.0212	0.0467	0.1232	0.0977	0.0722	0.0722	0.1232	0.1232	0.1232
16	0.2762	0.1997	0.0722	0.0212	0.0467	0.1997	0.1487	0.1742	0.1232	0.1742	0.2252	0.1742	0.2252	0.1232	0.1487	0.1487
17	0.2507	0.1487	0.1742	0.1742	0.0467	0.0977	0.0977	0.0722	0.0467	0.0977	0.1232	0.1742	0.1232	0.1232	0.1232	0.1487
18	0.0722	0.1232	0.1487	0.1997	0.1997	0.0722	0.2762	0.1742	0.0977	0.1487	0.1232	0.1232	0.2252	0.2252	0.2252	0.1487
19	0.1742	0.1232	0.2252	0.1997	0.1487	0.1487	0.1232	0.1232	0.0977	0.1232	0.1232	0.1232	0.1742	0.1997	0.1997	0.1742
20	0.1997	0.1232	0.0977	0.1487	0.0977	0.1232	0.1232	0.1742	0.0977	0.1742	0.2252	0.2507	0.0212	0.1232	0.1232	0.1232

Cyrindrical Grasp

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.1487	0.2252	0.1232	0.1742	0.3017	0.1997	0.1232	0.2252	0.0722	0.0467	0.1232	0.1232	0.0722	0.1997	0.3017	0.0467
2	0.1997	0.0977	0.2252	0.1487	0.1742	0.2252	0.0977	0.2252	0.1487	0.1742	0.1487	0.0977	0.1742	0.1997	0.1742	0.1232
3	0.2507	0.1742	0.0977	0.0212	0.1487	0.2252	0.0977	0.1232	0.1742	0.2252	-0.3103	0.4802	0.5312	0.1997	-0.0553	0.1997
4	0.2252	0.1232	0.1487	0.2252	0.1487	0.1487	0.2252	0.1232	0.1232	0.2252	0.0722	0.1232	0.0722	0.1232	0.1487	0.1487
5	0.1487	0.0722	0.0722	0.1997	-0.0043	0.1232	-0.0043	0.1997	0.0977	0.0212	0.1487	0.3527	0.1232	0.1742	0.1487	0.2507
6	0.0722	0.2252	0.0722	0.1997	0.0722	0.1997	0.0722	0.2252	0.0722	0.1997	0.0977	0.1742	0.0722	0.2252	0.0722	0.2252
7	0.4037	-0.3103	-1.2284	0.7862	0.9138	0.5057	-2.0699	1.2198	0.6842	0.2762	0.0722	0.6587	0.7862	-1.3049	-0.5908	0.7097
8	0.1742	0.1232	0.1232	0.1487	0.1487	0.1487	0.0977	0.1997	0.0722	0.1997	0.0722	0.1997	0.0722	0.1487	0.0977	0.1742
9	0.1487	0.1232	0.0977	0.1487	0.1487	0.1487	0.1487	0.1487	0.2252	0.0722	0.2252	0.0977	0.1997	0.1232	0.1487	0.1742
10	0.1487	0.1232	0.1232	0.1742	0.0722	0.2252	0.0977	0.1487	0.1487	0.1487	0.1232	0.1232	0.2252	0.0977	0.1997	0.0977
11	0.1487	0.1232	0.1997	0.0977	0.1487	0.1232	0.0722	0.2252	0.1232	0.1232	0.1232	0.1487	0.1487	0.1232	0.1487	0.1487
12	0.1487	0.0722	0.2252	0.0467	0.2252	0.0722	0.1232	0.1487	0.1742	0.2252	0.0722	0.2252	0.0722	0.2252	0.0722	0.1742
13	0.0977	0.1997	0.1742	0.1487	0.2252	0.0977	0.1232	0.1487	0.0977	0.2252	0.1232	0.1487	0.1232	0.1487	0.1997	0.0977
14	0.1742	0.0977	0.0212	0.2507	0.0977	0.0722	0.1232	0.1742	0.1997	0.1997	0.0722	0.1997	0.2252	0.1742	0.1742	0.0722
15	0.1232	0.1232	0.0977	0.1742	0.0722	0.3017	0.1487	0.1997	0.0722	0.1997	0.0722	0.1742	0.0722	0.1997	0.0977	0.1997
16	0.1487	0.1232	0.1232	0.1487	0.1232	0.1487	0.1487	0.1232	0.1487	0.1232	0.1487	0.1487	0.1487	0.1742	0.1487	0.1487
17	0.1487	0.1232	0.2762	0.0722	-0.0298	0.1232	0.2507	0.1742	0.0977	0.1997	0.0977	0.1997	0.0977	0.1232	0.1487	0.0467
18	0.2252	0.0722	0.2252	0.0722	0.2507	0.0977	0.1997	0.1232	0.1487	0.1232	0.0977	0.1997	0.0722	0.1487	0.1232	0.0977
19	0.1232	0.1487	0.1232	0.2252	0.0722	0.2252	0.0977	0.1997	0.0722	0.1997	0.0722	0.1997	0.0977	0.2252	0.0977	0.1487
20	0.1742	0.1487	0.1232	0.2252	0.0977	0.1742	0.1487	0.0977	0.1997	0.1742	0.1232	0.1487	0.1742	0.2252	0.1487	0.0722

Hook or Snap

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.1232	0.1742	0.1232	0.1742	0.0722	0.1997	0.0722	0.2507	0.0977	0.1997	0.0722	0.1997	0.0977	0.2507	0.1487	0.1487
2	0.1232	0.1487	0.2252	0.1232	0.1487	0.1997	0.0977	0.1487	0.1487	0.1742	0.1487	0.0722	0.2252	0.1487	0.1487	0.2252
3	0.2252	0.0977	0.2252	0.0722	0.1487	0.0977	0.2252	0.0722	0.1997	0.0722	0.1997	0.0977	0.2252	0.0977	0.1997	0.0722
4	0.1232	0.1487	0.1487	0.0722	0.2252	0.0722	0.2252	0.1742	0.1232	0.1487	0.0722	0.1997	0.0722	0.2252	0.0977	0.2252
5	0.2252	0.0722	0.2252	0.0722	0.1997	0.0977	0.2252	0.0722	0.1997	0.0722	0.1997	0.2252	0.1742	0.1487	0.1487	0.1487
6	0.2252	0.0212	0.0977	0.1487	0.1232	0.2252	0.1742	0.1487	0.2507	0.1232	0.1742	0.1487	0.0722	0.2252	0.1997	0.1232
7	0.1487	0.1232	0.1742	0.1487	0.1742	0.1487	0.1232	0.1487	0.1997	0.0977	0.0977	0.2252	0.0467	0.2252	0.0977	0.1487
8	0.1742	0.1487	0.1487	0.1232	0.1487	0.1487	0.1232	0.1997	0.0722	0.2252	0.1232	0.1487	0.1742	0.1232	0.2252	0.0977
9	0.0977	0.2252	0.1487	0.1487	0.1742	0.1232	0.1232	0.1487	0.1487	0.0722	0.2252	0.0977	0.2252	0.0722	0.2252	0.1487
10	0.1487	0.1232	0.1232	0.1232	0.1232	0.0722	0.1487	0.1487	0.1232	0.1232	0.1742	0.1487	0.2252	0.1487	0.1487	0.1997
11	0.0977	0.1742	0.1487	0.1487	0.1232	0.1487	0.1487	0.1487	0.1232	0.1487	0.1232	0.1742	0.2507	0.0722	0.1997	0.0467
12	0.1487	0.1487	0.1487	0.1232	0.1487	0.1487	0.1487	0.1232	0.1487	0.2252	0.0467	0.2252	0.0977	0.2252	0.0722	0.2252
13	0.1997	0.0467	0.2252	0.0977	0.2252	0.0977	0.2252	0.0722	0.2252	0.0722	0.2507	0.0977	0.1997	0.1487	0.1487	0.1487
14	0.1487	0.1487	0.1487	0.2252	0.0977	0.1997	0.1742	0.1487	0.0722	0.2252	0.0977	0.1997	0.0722	0.1742	0.0722	0.1997
15	0.1487	0.1742	0.0722	0.1232	0.1487	0.0977	0.2252	0.1487	0.1487	0.1742	0.0722	0.2252	0.0722	0.1487	0.1742	0.1487
16	0.0977	0.2252	0.0977	0.0977	0.1487	0.1232	0.1997	0.1232	0.0977	0.2507	0.1742	0.0977	0.2252	0.1742	0.1232	0.1742
17	0.1997	0.0977	0.1487	0.1997	0.0977	0.1487	0.2252	0.1487	0.1742	0.2252	0.0977	0.1997	0.1742	0.1487	0.1232	0.0722
18	0.1232	0.1487	0.1997	0.1232	0.2252	0.1232	0.1487	0.0467	0.2252	0.0977	0.1232	0.0977	0.1997	0.1487	0.1742	0.1232
19	0.2252	0.0722	0.2252	0.0977	0.1742	0.1232	0.2252	0.1232	0.1997	0.0977	0.1487	0.1487	0.1997	0.1232	0.1997	0.1487
20	0.1487	0.0722	0.1997	0.1232	0.1997	0.1742	0.0977	0.2252	0.0977	0.1997	0.0722	0.1487	0.1232	0.1232	0.1487	0.1487

Lateral

Figure 4.7: Recorded EMG Day 3(Cyrindrical Grasp, Hook or Snap, Lateral) data

After stacked the information, we have been expected to run the information. In the workspace window, the information has been put away and by double tapping in the information name, the information will be run. That time the EMG information was in

unthinkable shape, and the framework of the information can without much of a stretch be noted. The principal phase of signal preparing is finished with the information stacking and running procedure. The following undertaking is that to compose a MATLAB code to plot the information and creating the EMG signal.

4.4.2 MATLAB coding

For our venture reason and to creating the EMG information, we fabricate a MATLAB code to run our information. In proofreader window, above all else, we decide x-level and y-level for unique and included boisterous signal, at that point we decide a commotion fluctuation and make a low pass FIR channel for the signal. In the wake of sifting we have plotted the first and uproarious signal with its capacity phantom thickness. In the wake of coding we spared it.

4.4.3 EMG Signal Plotting

Run the program and plot the information in graphical shape. Figure 4.8,4.9,4.10 is the EMG signal plotting of the regarded information stacked in the MATLAB.

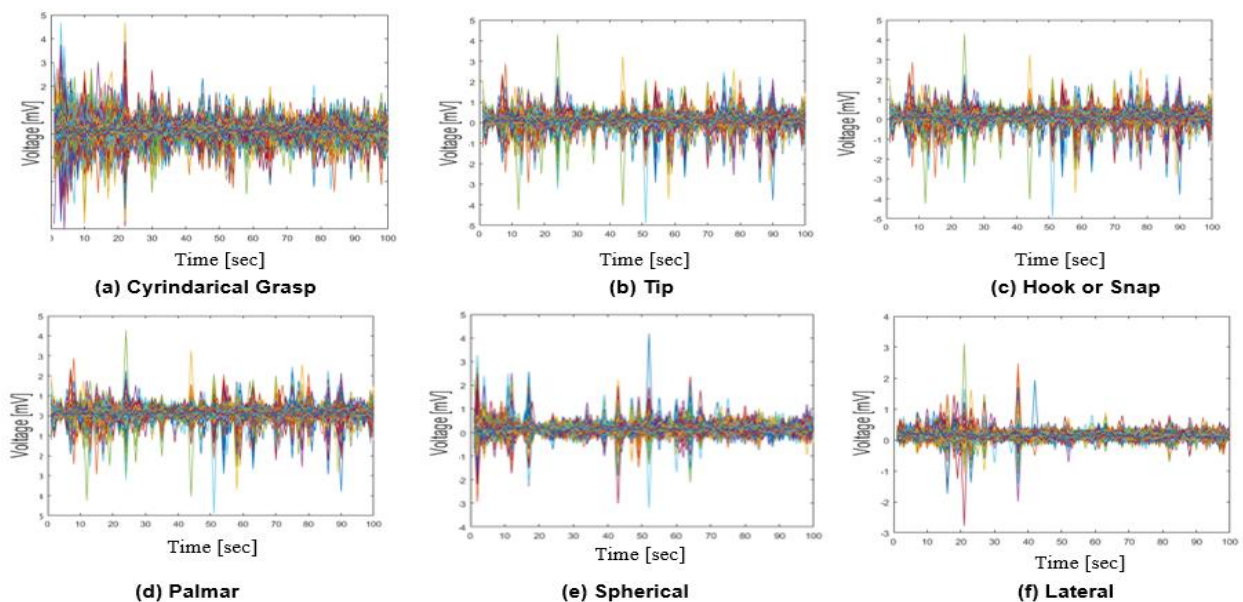


Figure 4.8: EMG Signal plotting for Day 1 data

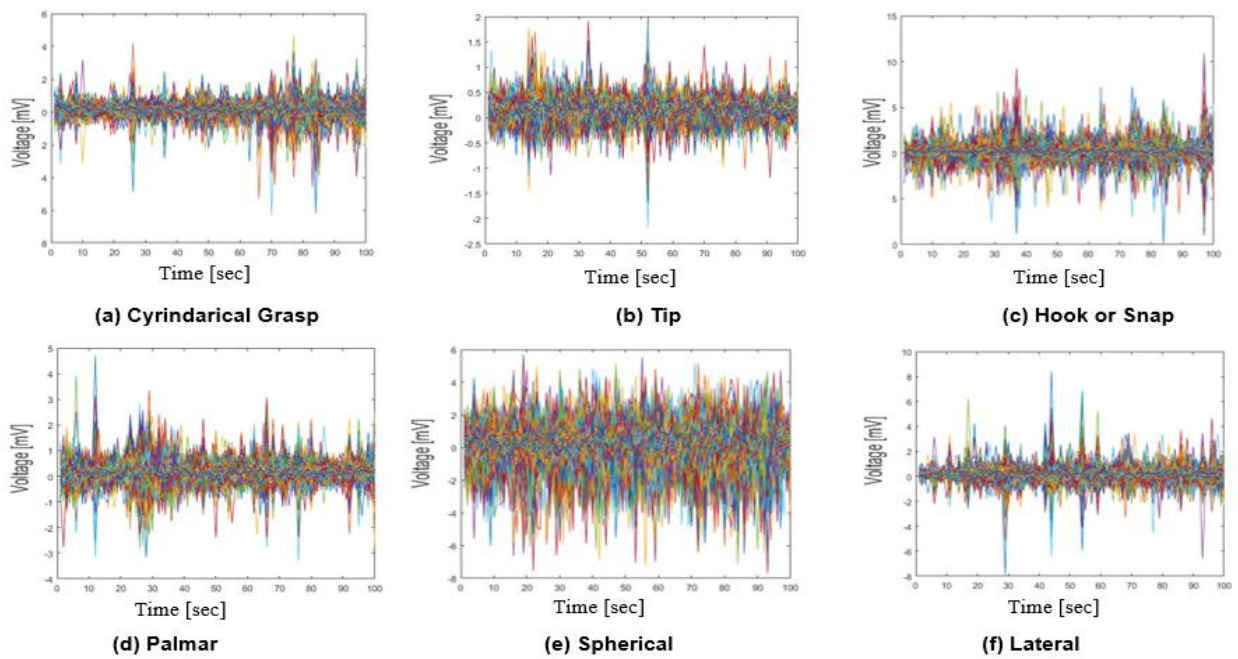


Figure 4.9: EMG Signal plotting for Day 2 data

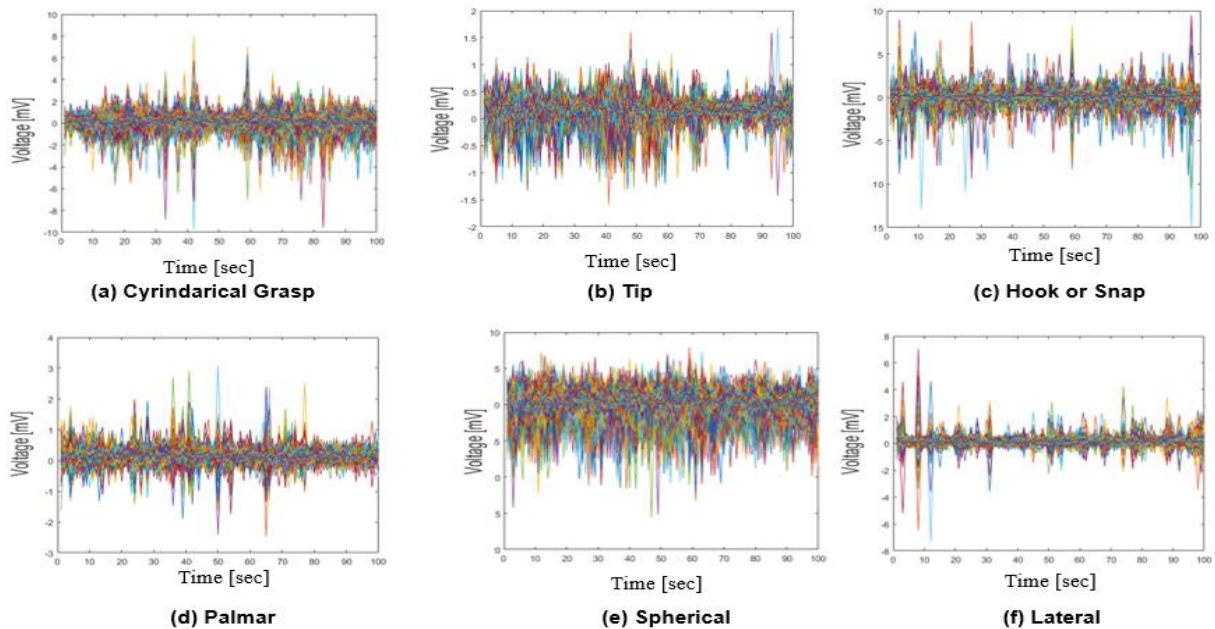
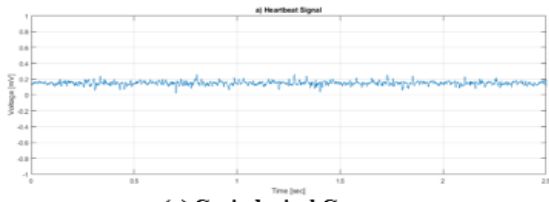


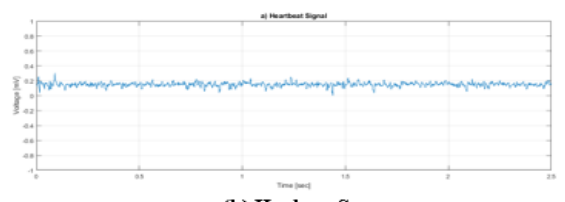
Figure 4.10: EMG Signal plotting for Day 3 data

In x pivot it speaks to time in second (sec) and y hub speaks to voltage in mv. Figure 4.8, 4.9, 4.10 is subject information motion for this task. With deference of this signal plotting, the irregularities can be recognized.

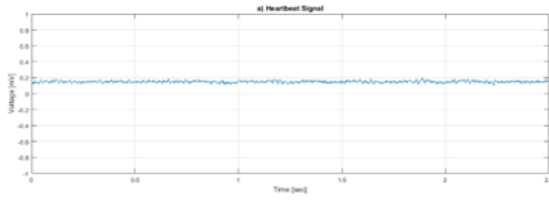
In EMG, Muscle signal example can likewise be observed. Figure 4.11, 4.12, 4.13 is the muscle signal occupied from the EMG information which was gathered from different subjects (understanding). This undertaking proposed a checking framework, by which the recognition of screen of the EMG might be increasingly proficient.



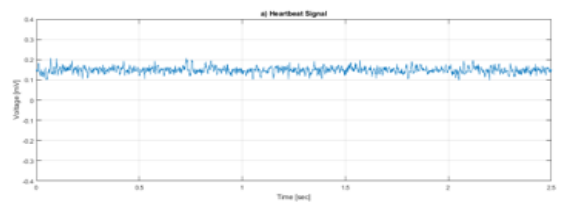
(a) Cylindrical Grasp



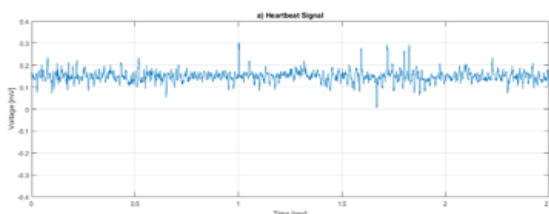
(b) Hook or Snap



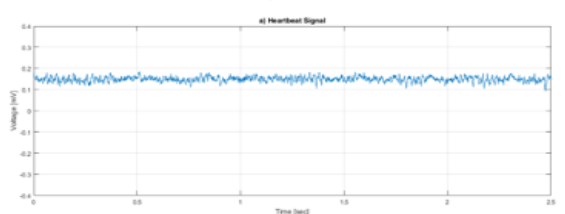
(c) Lateral



(d) Palmar

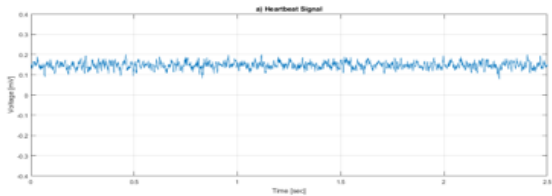


(e) Spherical

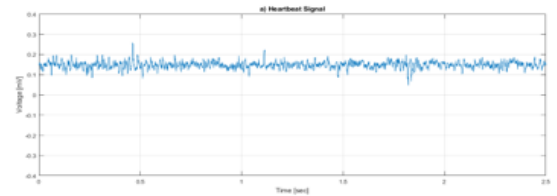


(f) Tip

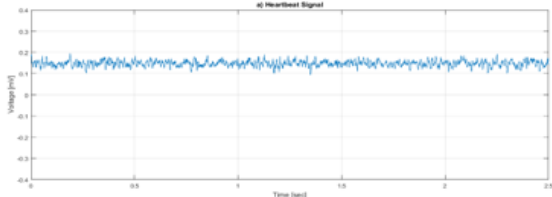
Figure 4.11: EMG Muscle Signal for Day 1 data



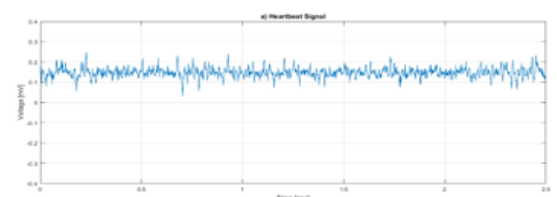
(a) Cylindrical Grasp



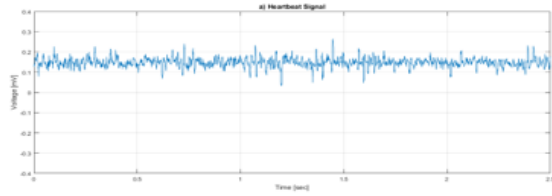
(b) Hook or Snap



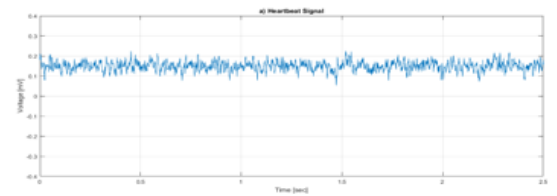
(c) Lateral



(d) Palmar

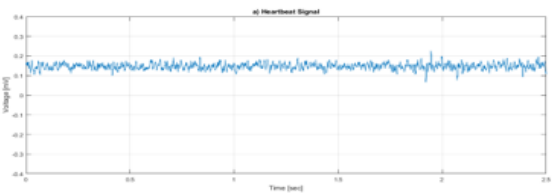


(e) Spherical

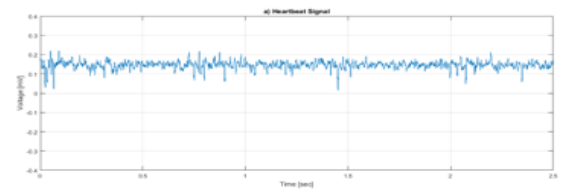


(f) Tip

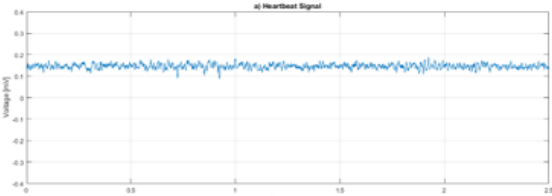
Figure 4.12: EMG Muscle Signal for Day 2 data



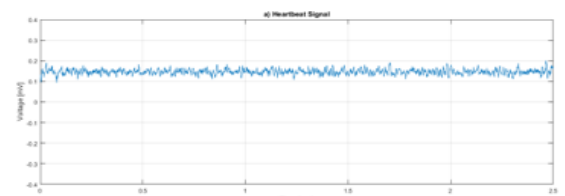
(a) Cylindrical Grasp



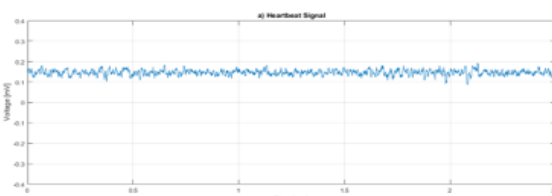
(b) Hook or Snap



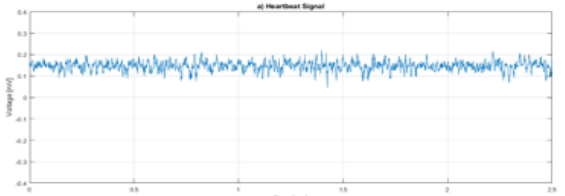
(c) Lateral



(d) Palmar



(e) Spherical



(f) Tip

Figure 4.13: EMG Muscle Signal for Day 3 data

There were foundation commotions, for example, control line clamor and high recurrence segments when the EMG hardware was interfaced to the sound port of the PC. The electrical cable clamor annihilated by the product executed of MATLAB code and the high recurrence parts additionally evacuated by applying a similar system. The yield of the EMG hardware is appeared in the figure 4.11 before separating:

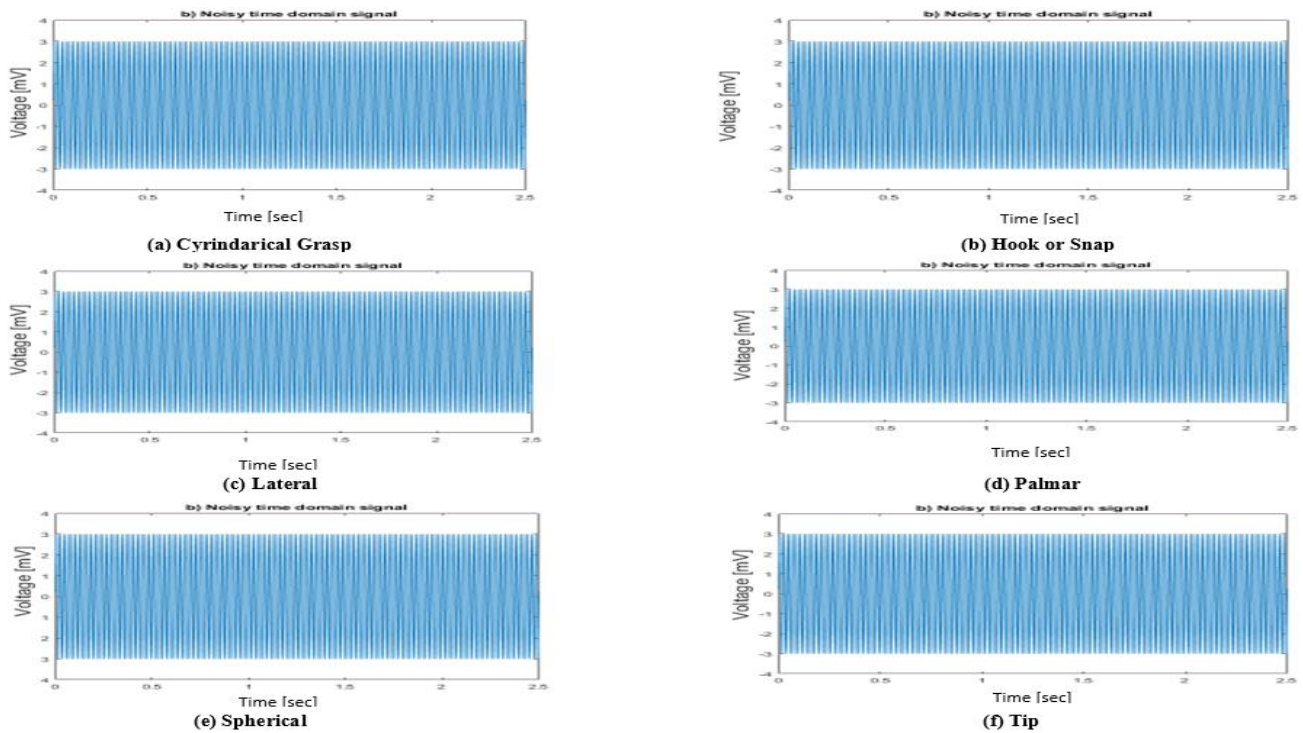


Figure 4.14: Noisy time domain signal for Day 1 data

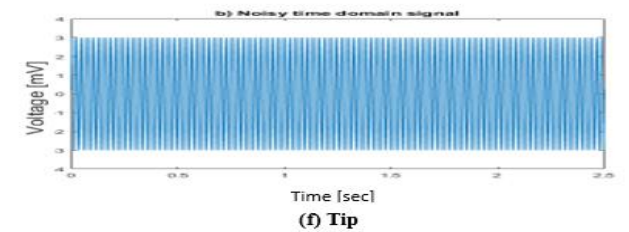
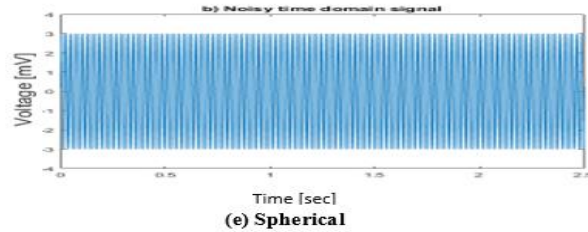
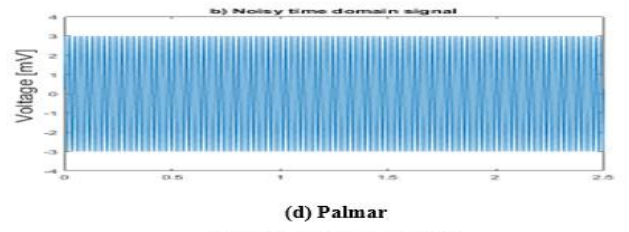
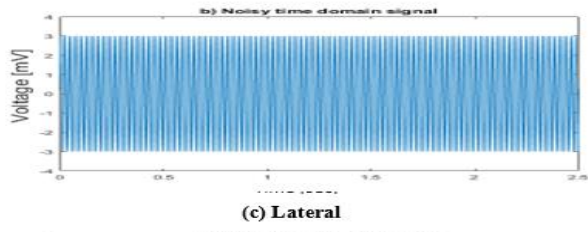
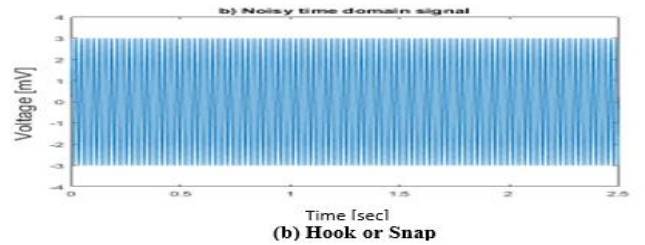
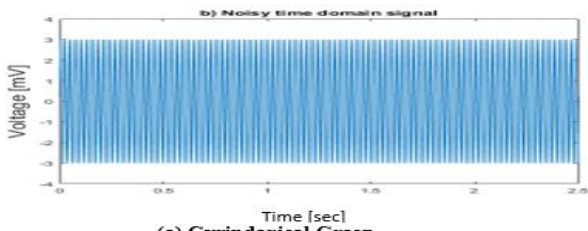


Figure 4.15: Noisy time domain signal for Day 2 data

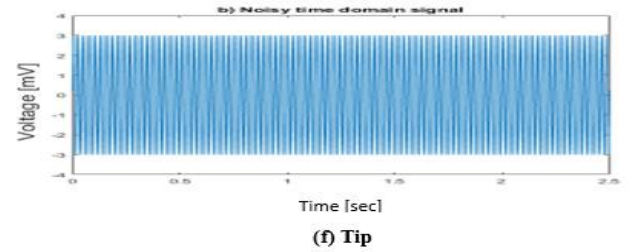
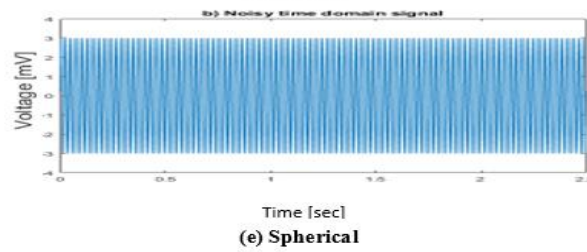
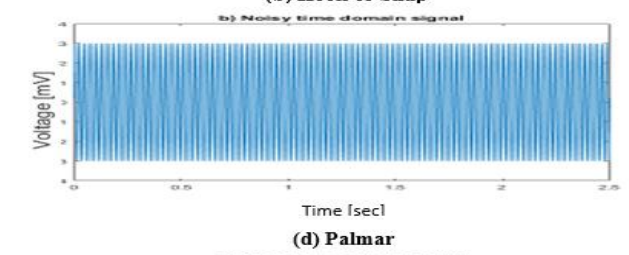
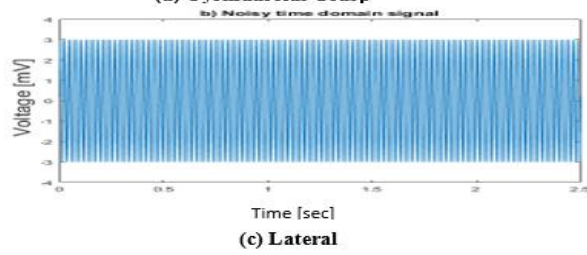
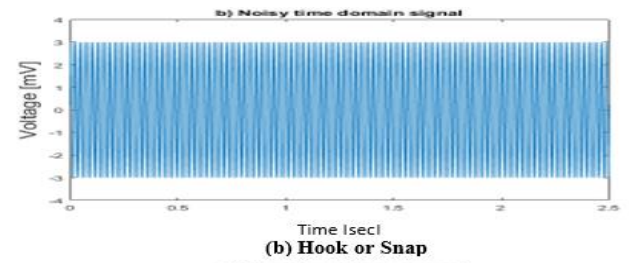
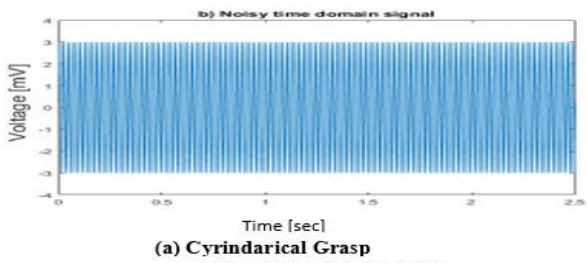


Figure 4.16: Noisy time domain signal for Day 3 data

After acknowledgment of the reality of back ground clamor, the EMG signal has additionally separated for expelling the electrical cable and high recurrence commotions. Figure 4.17,4.18,4.19 demonstrates the signal before separating.

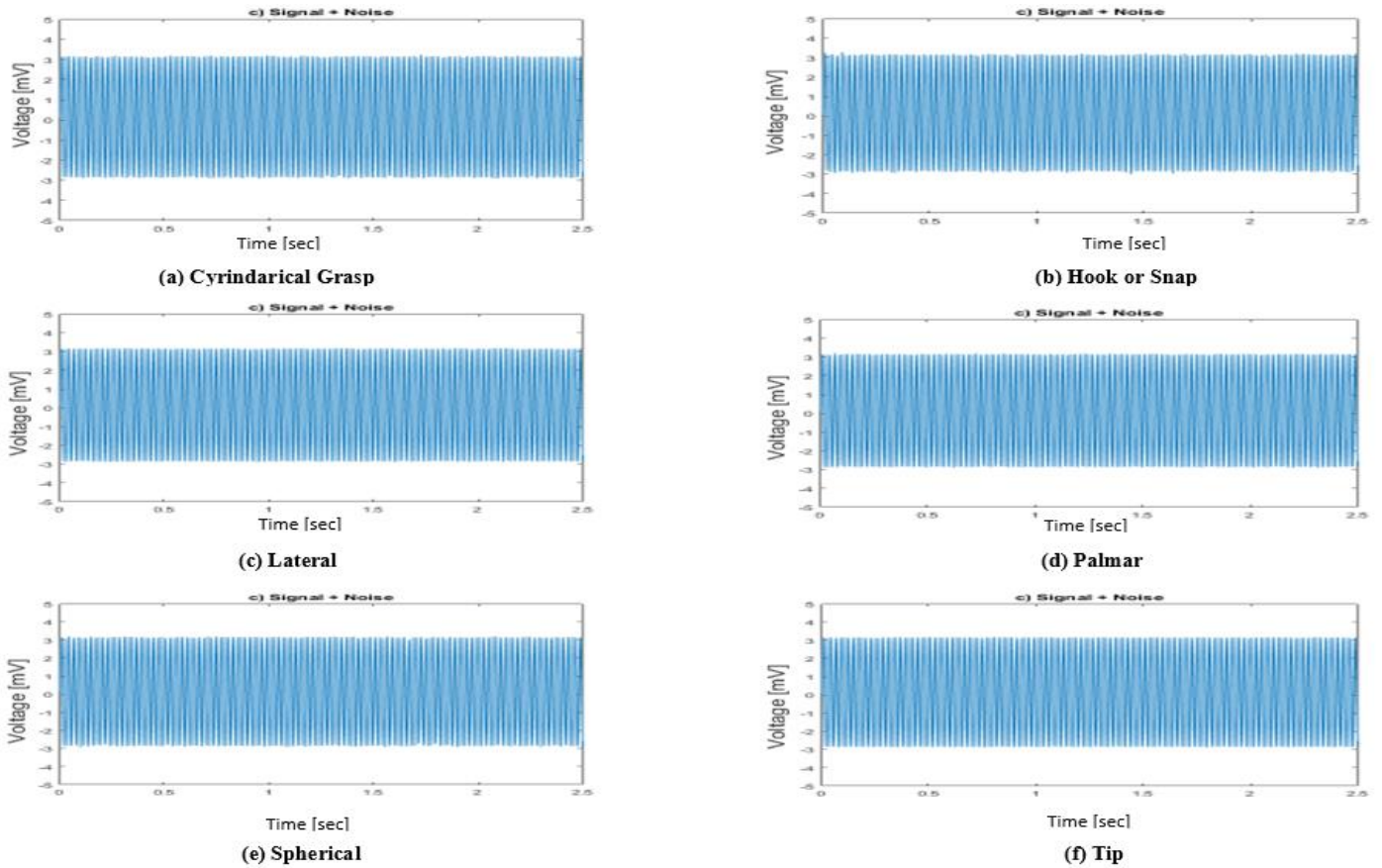


Figure 4.17: Signal with Noise for Day 1 data

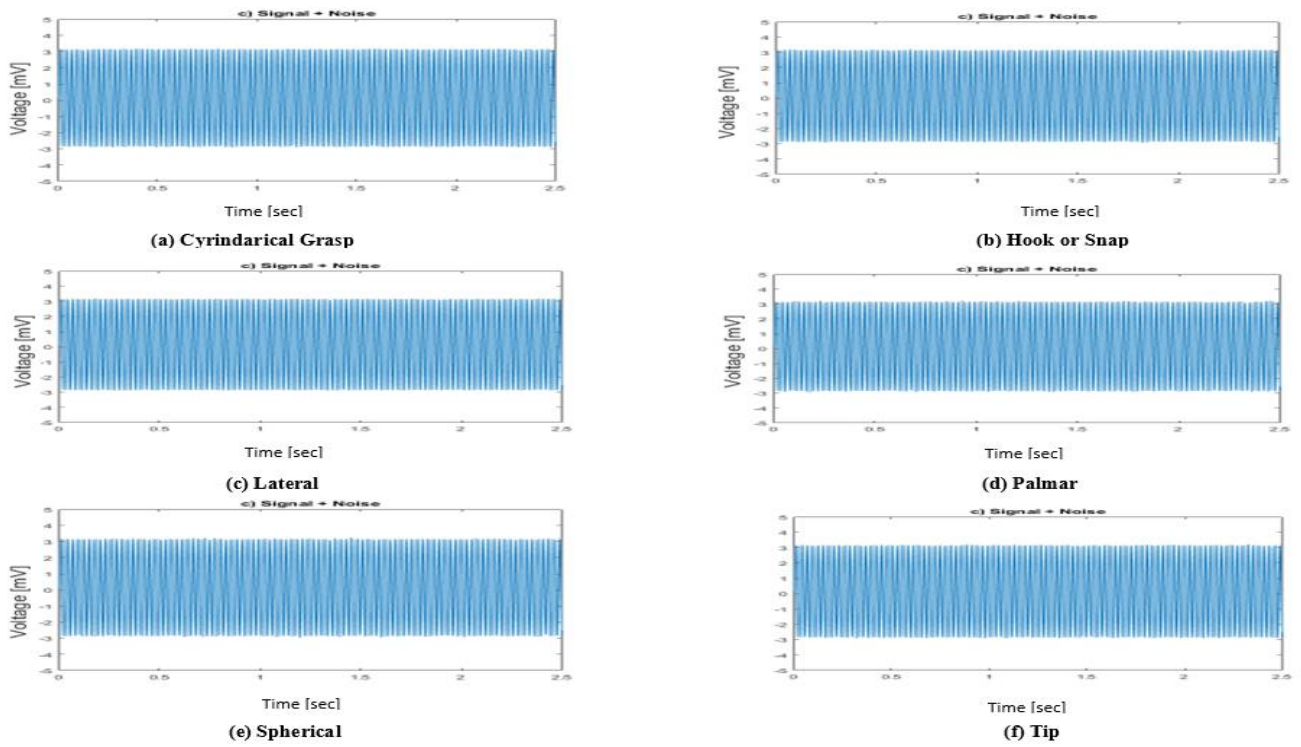


Figure 4.18: Signal with Noise for Day 2 data

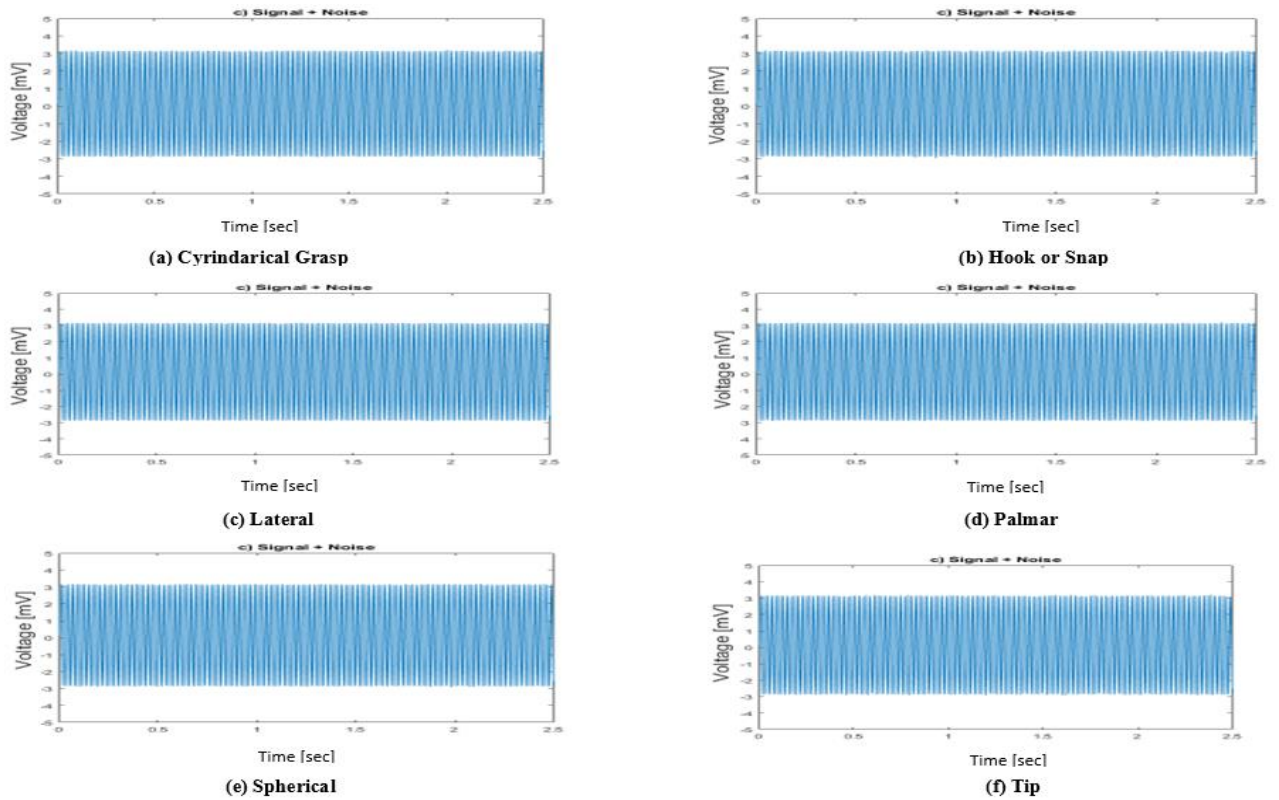


Figure 4.19: Signal with Noise for Day 3 data

The point of this undertaking is to distinguish the commotion or little changes or little anomalies conveying with the first cerebrum signal (EMG). Figure 4.20,4.21,4.22 demonstrates the first data conveying signal and furthermore the mistake signal.

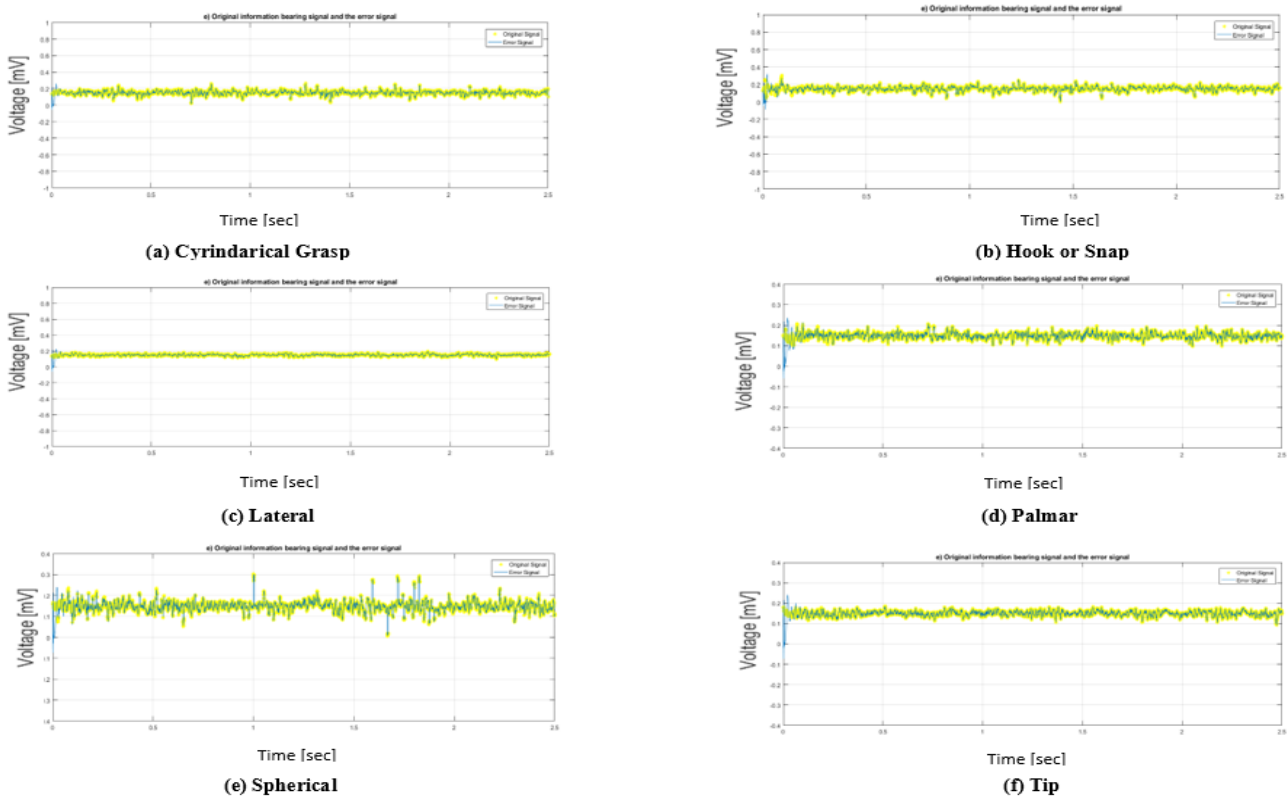
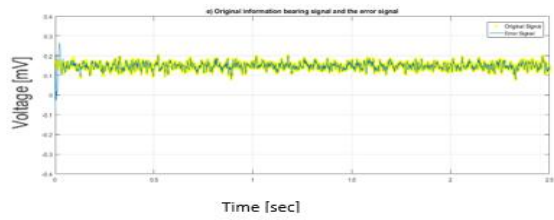
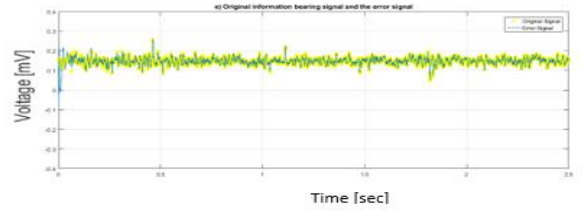


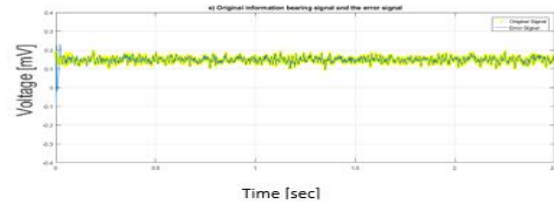
Figure 4.20: Original information carrying signal and also the error signal for Day 1 data



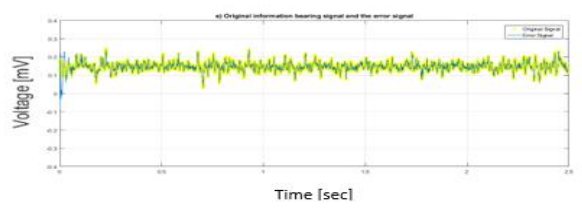
(a) Cylindrical Grasp



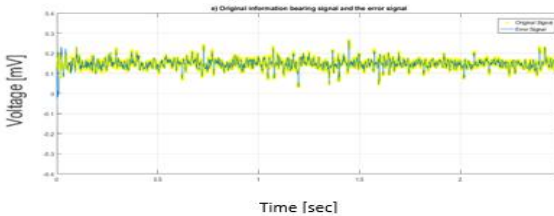
(b) Hook or Snap



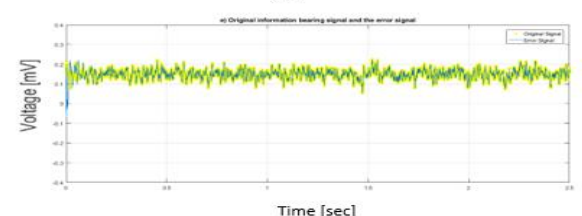
(c) Lateral



(d) Palmar



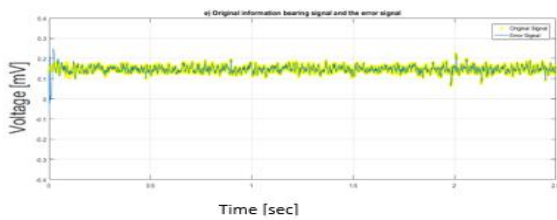
(e) Spherical



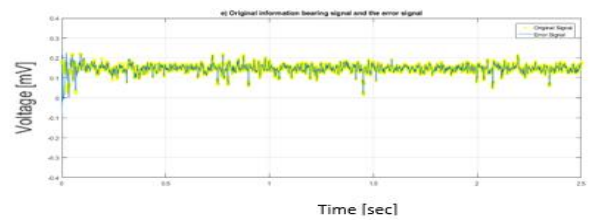
(f) Tip

Figure 4.21: Original information carrying signal and also the error signal for Day 2

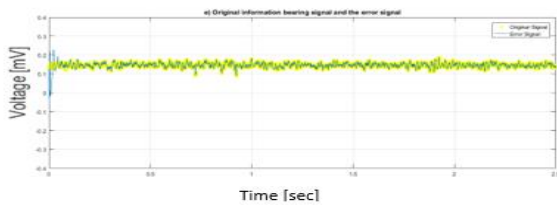
data



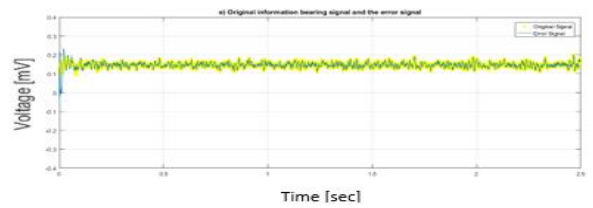
(a) Cylindrical Grasp



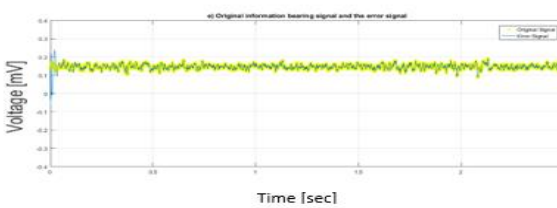
(b) Hook or Snap



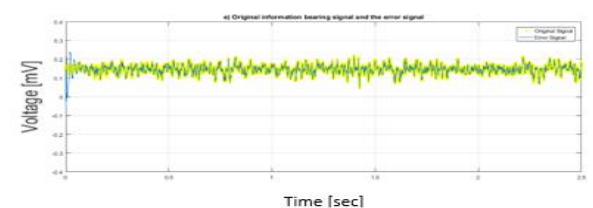
(c) Lateral



(d) Palmar



(e) Spherical



(f) Tip

Figure 4.22: Original information carrying signal and also the error signal for Day 3

data

Also, removing different factual parameters alongside the other preparing procedures including separating, the proposed technique for wavelet-based EMG signal investigation can screen the cerebrum and in addition recognize any kind of irregularities in a progressively exact and successful way.

CHAPTER 5

RESULTS AND ANALYSIS

The outcomes and examining the results of this undertaking is talked about in this section. The two most mainstream strategies for the signal dissecting or checking systems with genuine trials are depicted in this area to clear up that the proposed technique in wavelet-based EMG signal investigation of this venture decides the littlest changes or variations from the norm in the cerebrum signals (EMG) that helps for crisis medication.

5.1 Calculation of Power Spectral Density (PSD)

Power Spectral Density (PSD) is one of the possible part extraction methods to perceive differentiates in the cerebrum electrophysiological dealing with in youths with dyslexia. Known to be a neurological issue, dyslexia causes learning deficiencies generally related to scrutinizing, in spite of the way that examination has shown that composed work issues furthermore acts imperative test and is a not too bad marker to perceive a youth to be dyslexic.

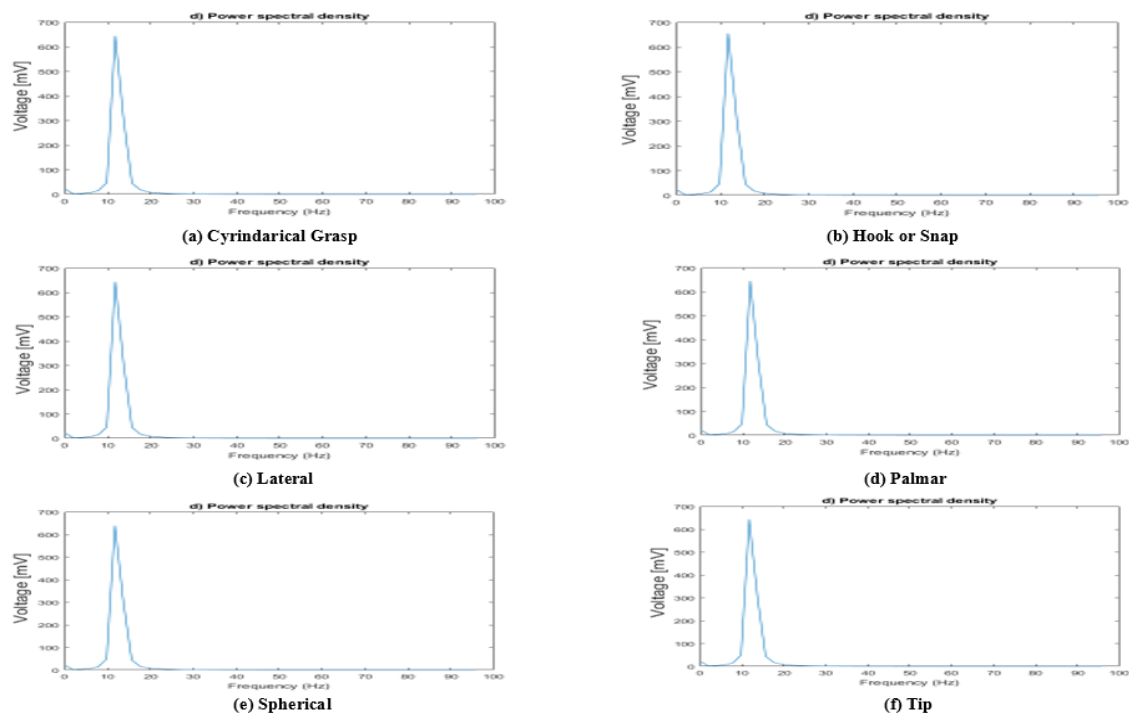
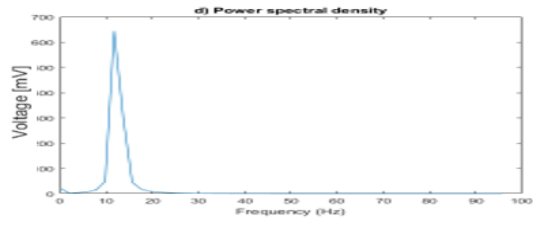
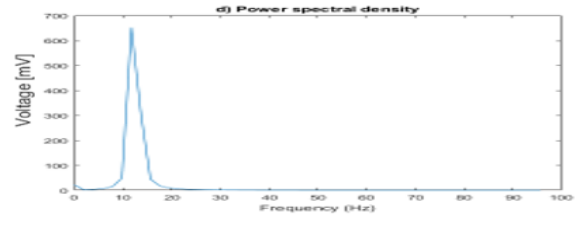


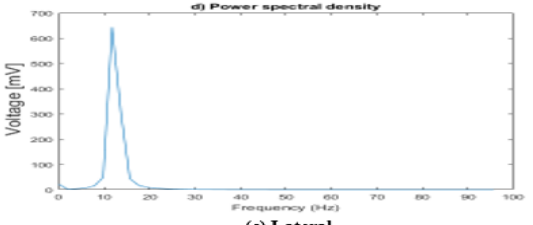
Figure 5.1: Power Spectral Density for Day 1 (a)



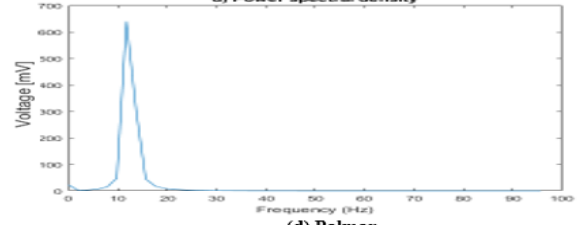
(a) Cylindrical Grasp



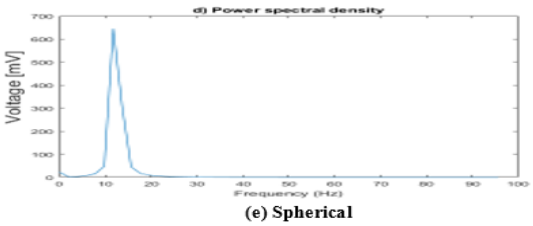
(b) Hook or Snap



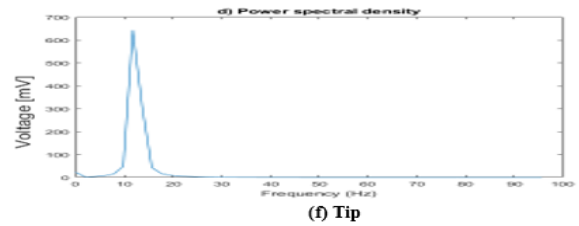
(c) Lateral



(d) Palmar

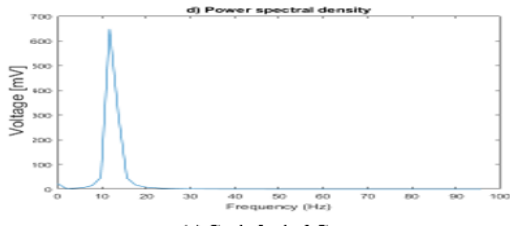


(e) Spherical

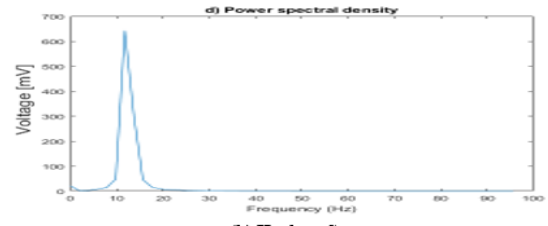


(f) Tip

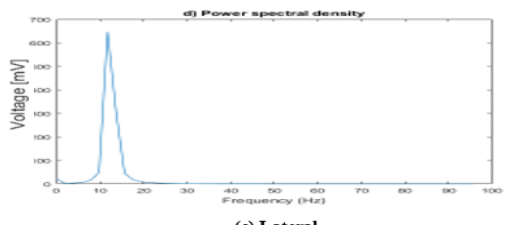
Figure 5.2: Power Spectral Density for Day 2 (a)



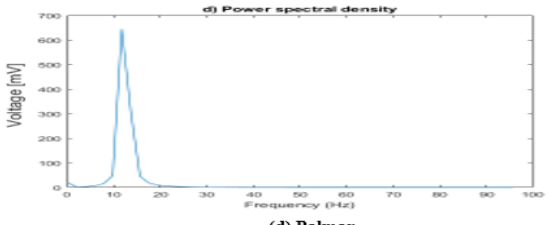
(a) Cylindrical Grasp



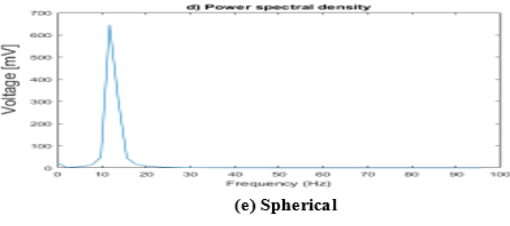
(b) Hook or Snap



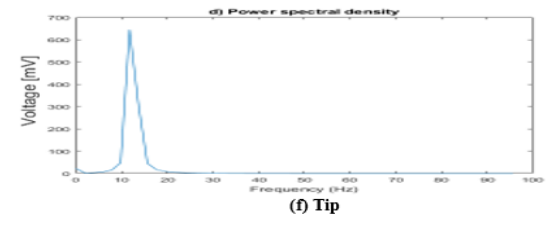
(c) Lateral



(d) Palmar



(e) Spherical



(f) Tip

Figure 5.3: Power Spectral Density for Day 3 (a)

Electromyography (EMG) signal control range thickness (PSD) has appeared in figure 4.17,4.18,4.19. It speaks to the power dispersion of EMG in recurrence space to assess the variations from the norm of the cerebrum. In x hub it speaks to recurrence in hertz and y hub speaks to voltage in mv.

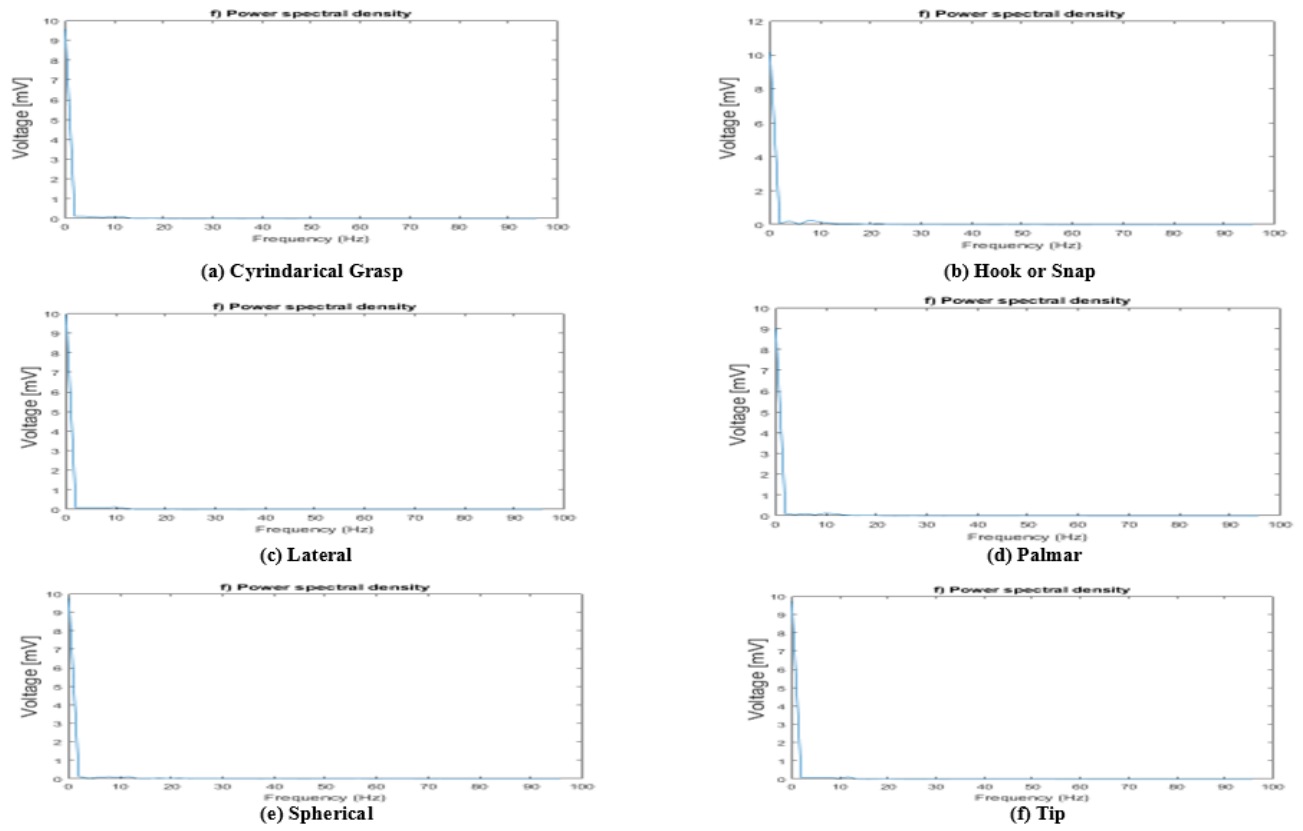
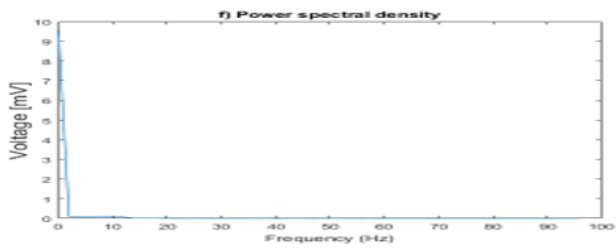
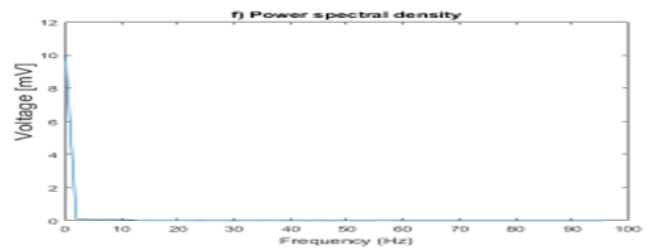


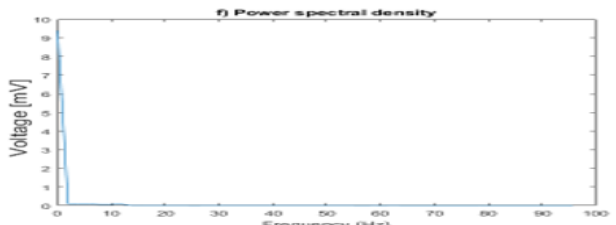
Figure 5.4: Power Spectral Density Day 1 (b)



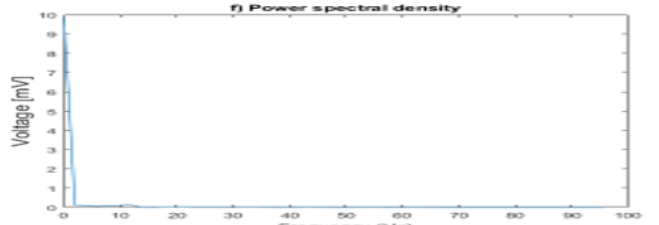
(a) Cylindrical Grasp



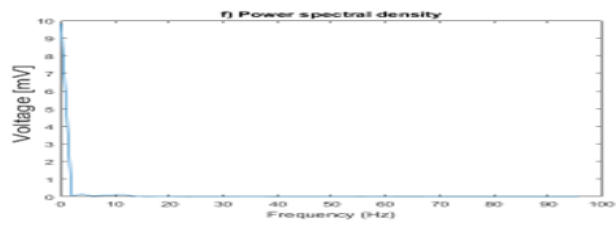
(b) Hook or Snap



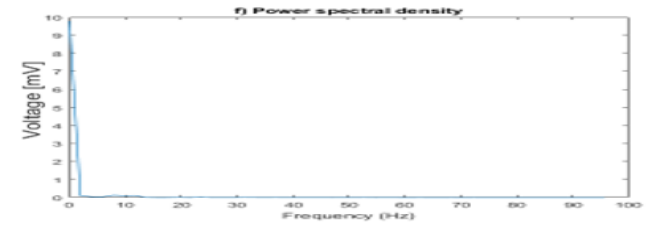
(c) Lateral



(d) Palmar

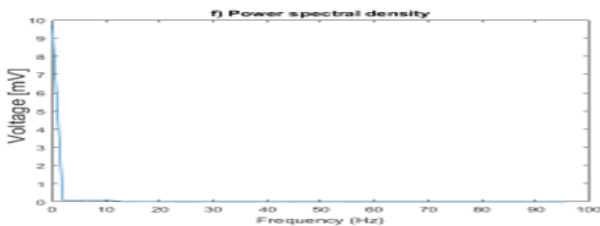


(e) Spherical

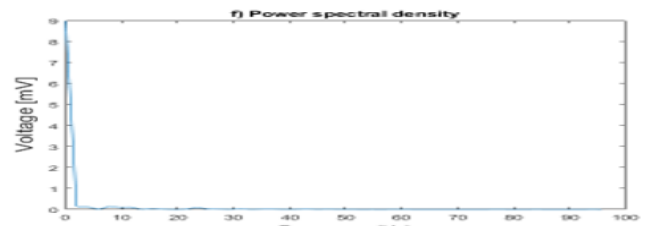


(f) Tip

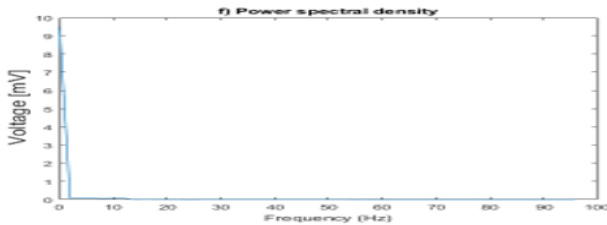
Figure 5.5: Power Spectral Density Day 2 (b)



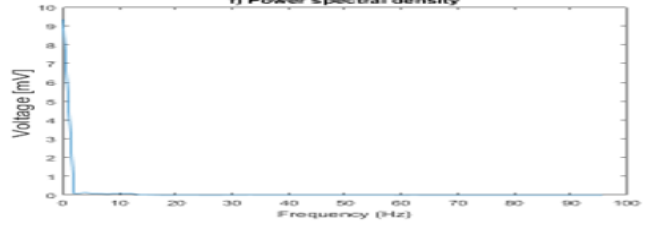
(a) Cylindrical Grasp



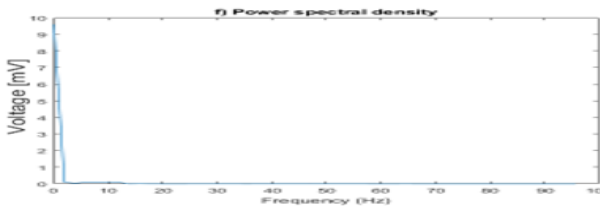
(b) Hook or Snap



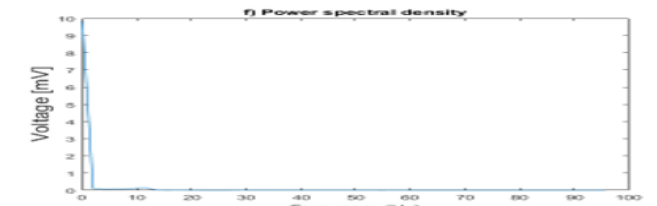
(c) Lateral



(d) Palmar



(e) Spherical



(f) Tip

Figure 5.6: Power Spectral Density Day 3 (b)

Power Spectral Density (PSD) is the recurrence reaction of an arbitrary or intermittent signal. It reveals to us where the normal power is disseminated as an element of recurrence.

- The PSD is deterministic, and for specific sorts of arbitrary signs is free of time. This is valuable in light of the fact that the Fourier change of an irregular time signal is itself arbitrary, and thusly of little utilize computing exchange connections (i.e., finding the yield of a channel when the info is irregular).
- The PSD of an irregular time signal $x(t)$ can be communicated in one of two different ways that are proportionate to one another.

- a. The PSD is the normal of the Fourier change size squared, over a substantial time interim

$$S_x(f) = \lim_{T \rightarrow \infty} E \left\{ \frac{1}{2T} \left| \int_{-T}^T x(t) e^{-j2\pi ft} dt \right|^2 \right\}$$

- b. The PSD is the Fourier change of the auto-relationship work.

$$S_x(f) = \int_{-\infty}^{\infty} R_x(\tau) e^{-j2\pi f\tau} d\tau$$

$$R_x(\tau) = E \{ x(t) x^*(t + \tau) \}$$

- The power can be determined from an arbitrary signal over a given band of frequencies as pursues:

- a) Total Power in $x(t)$:
$$P = \int_{-\infty}^{\infty} S_x(f) df = R_x(0)$$

- b) Power in $x(t)$ in range $f_1 - f_2$:
$$P_{12} = \int_{f_1}^{f_2} S_x(f) df = R_x(0)$$

This signal must be stationary, which implies that measurements don't change as an element of time.

- If an irregular signal $x(t)$ is hung loose invariant channel with recurrence reaction $H(f)$, the subsequent signal $y(t)$ has a PSD as pursues:

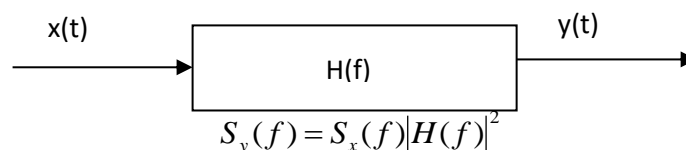


Figure 5.7: Random Gaussian noise signal

5.2 Wavelet Transform (WT)

Wavelet change is starting late transformed into a to a great degree conspicuous concerning examination, de-noising, and weight of signs and pictures. This territory portrays limits used to perform staggered Wavelet Transforms and single.

5.2.1 Original EMG (Electromyography) Signal analysis by Wavelet Transform (WT)

Wavelet change gives an entire three-dimensional data about any Muscle signal i.e. what diverse recurrence segments are available in any signal and what are their individual amplitudes and at time pivot where the distinctive recurrence segment exits. For this task examination, we utilizing the wavelet instrument in MATLAB and creating the signal.

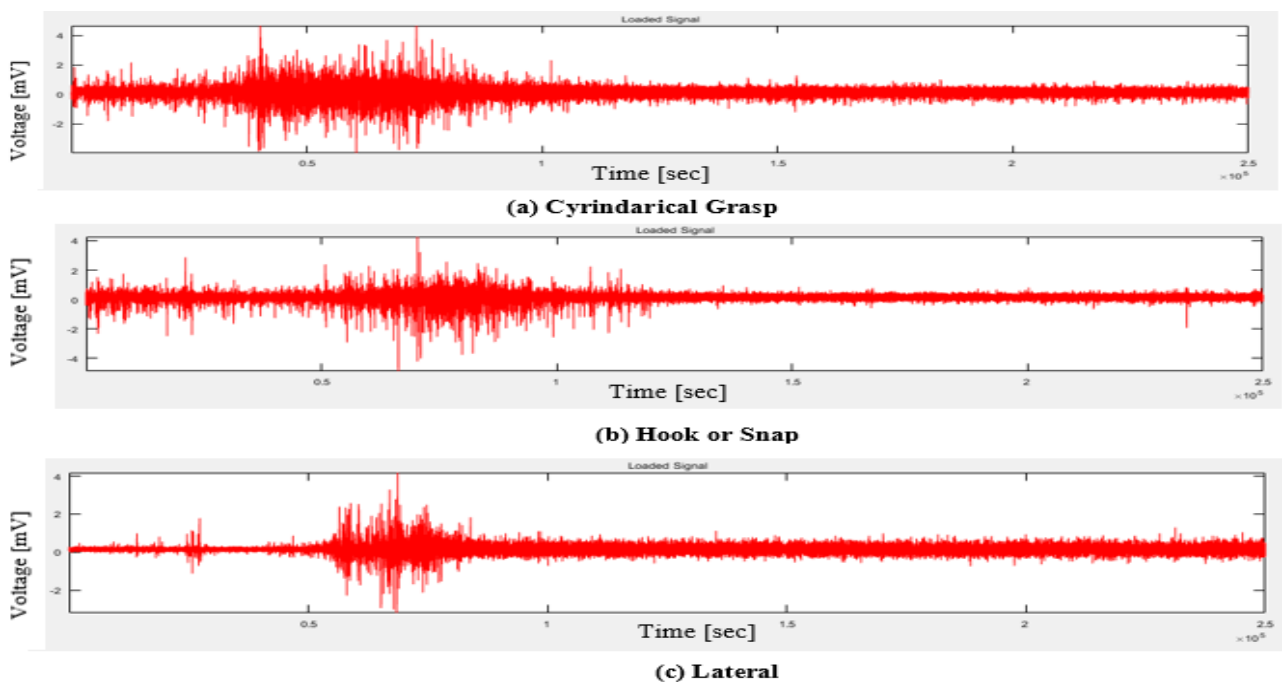


Figure 5.8: Raw EMG signal Using Wavelet Transform For Day 1

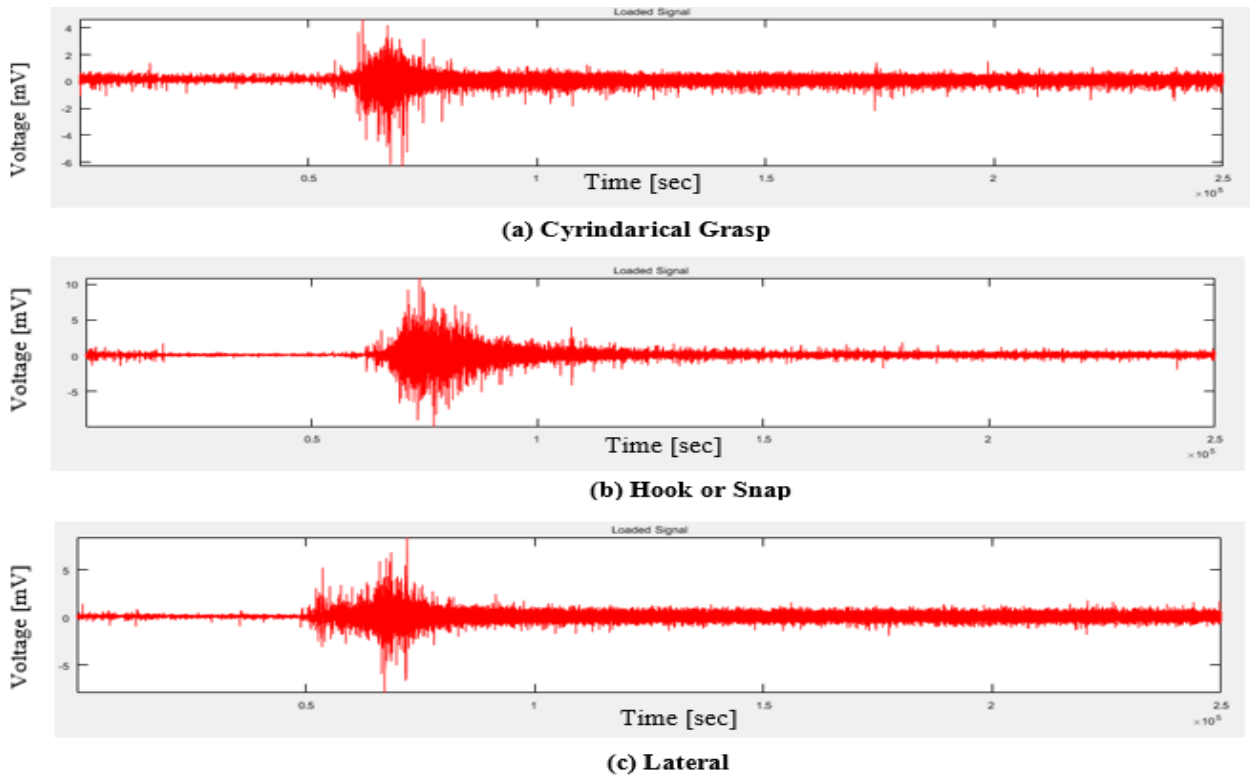


Figure 5.9: Raw EMG signal Using Wavelet Transform For Day 2

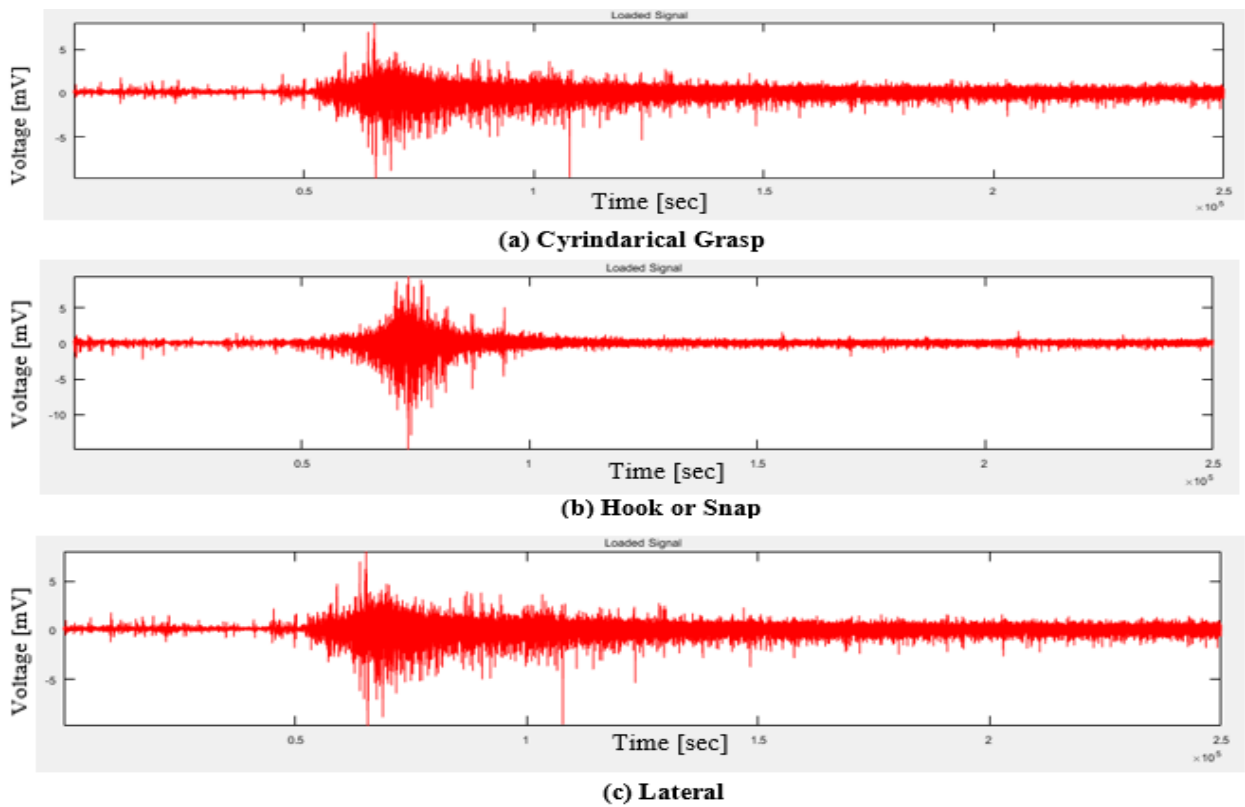


Figure 5.10: Raw EMG signal Using Wavelet Transform For Day 3

Wavelet Transform has high time assurance and furthermore high recurrence assurance and in addition time and recurrence goals can likewise be changed. The decay of Electromyography (EMG) motion in wavelet device appears in figure 5.11,5.12,5.13.

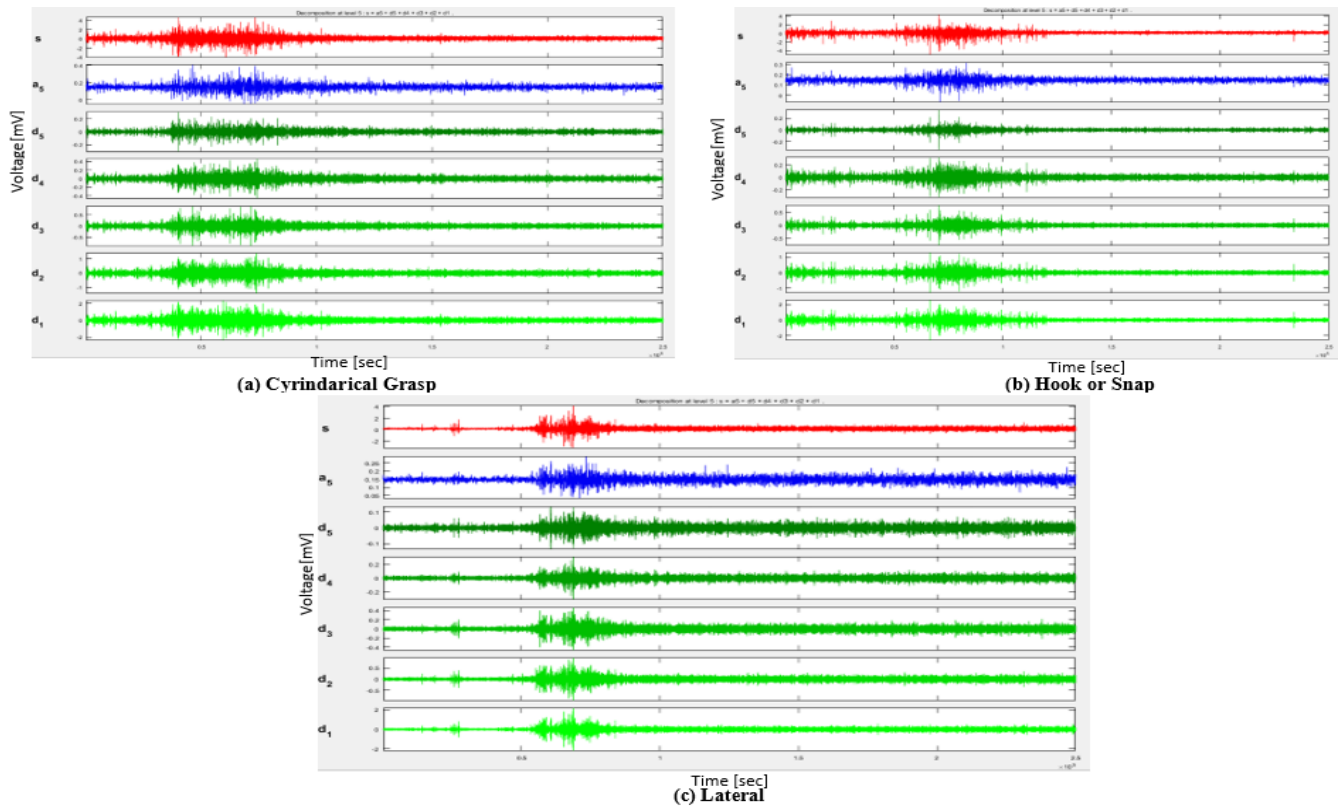


Figure 5.11: Decomposition of the Electromyography signal in wavelet tool For Day 1

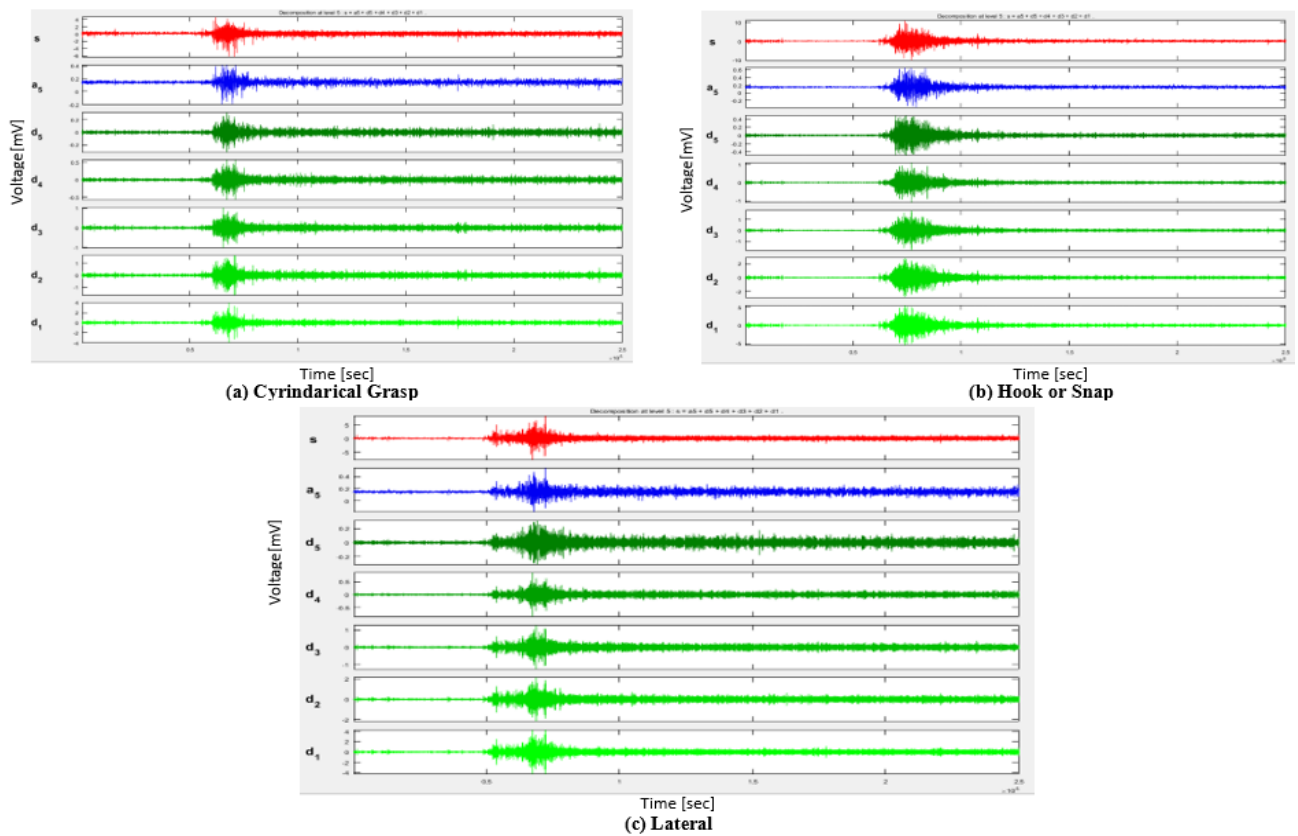


Figure 5.12: Decomposition of the Electromyography signal in wavelet tool For Day 2

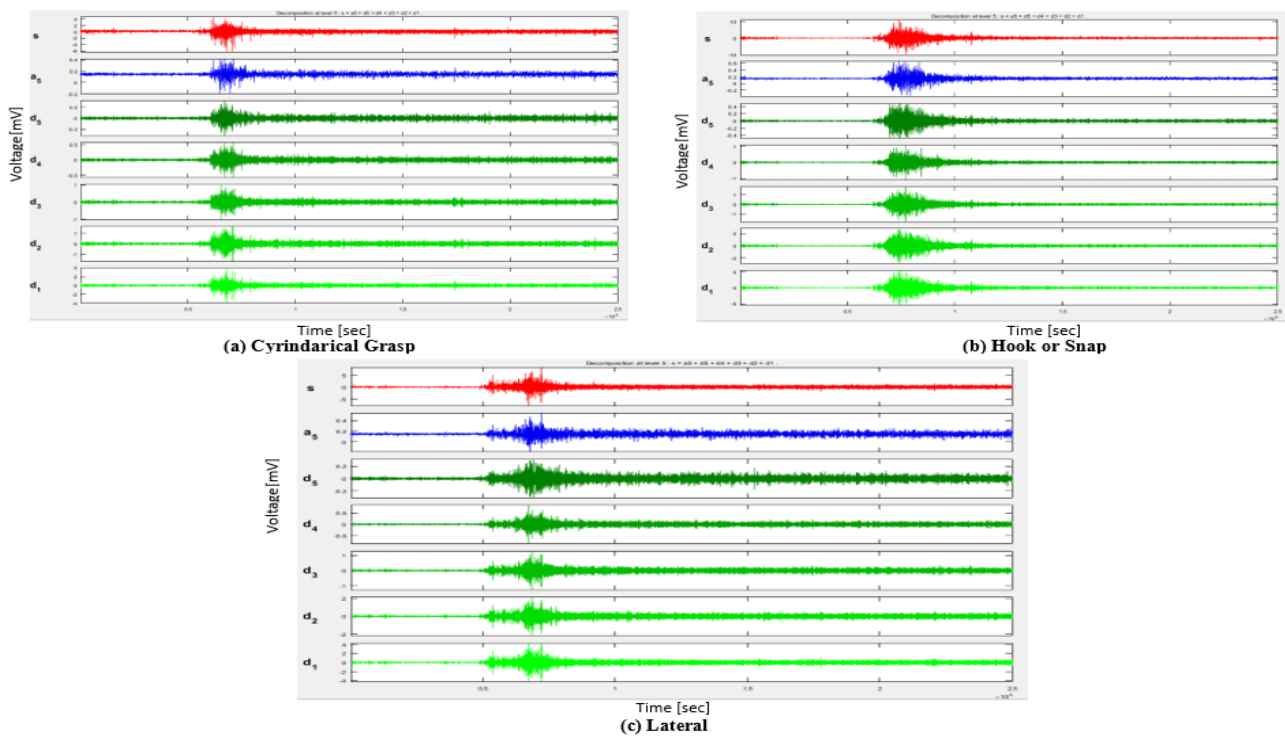


Figure 5.13: Decomposition of the Electromyography signal in wavelet tool For Day 3

The 2D portrayal of the wavelet change (WT) of signs has an incredible element to speak to the signs as abundancy, recurrence and time area frame. The 2D portrayal of the signs is increasingly advantageous for neurotic cases. The examination of this undertaking elucidate that the 2D portrayal of the signs in wavelet-based investigation, the measurable portrayal of the parameters and ghastry investigation satisfies the point of this work.

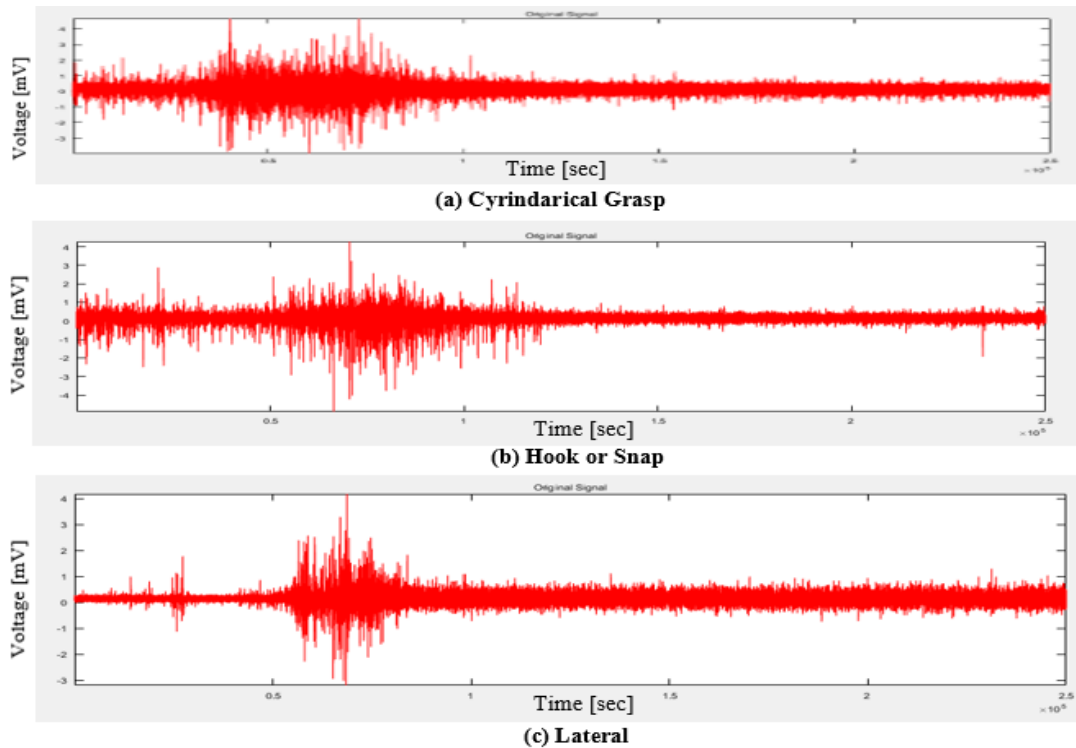


Figure 5.14: Statistical EMG signal analysis in wavelet For Day 1

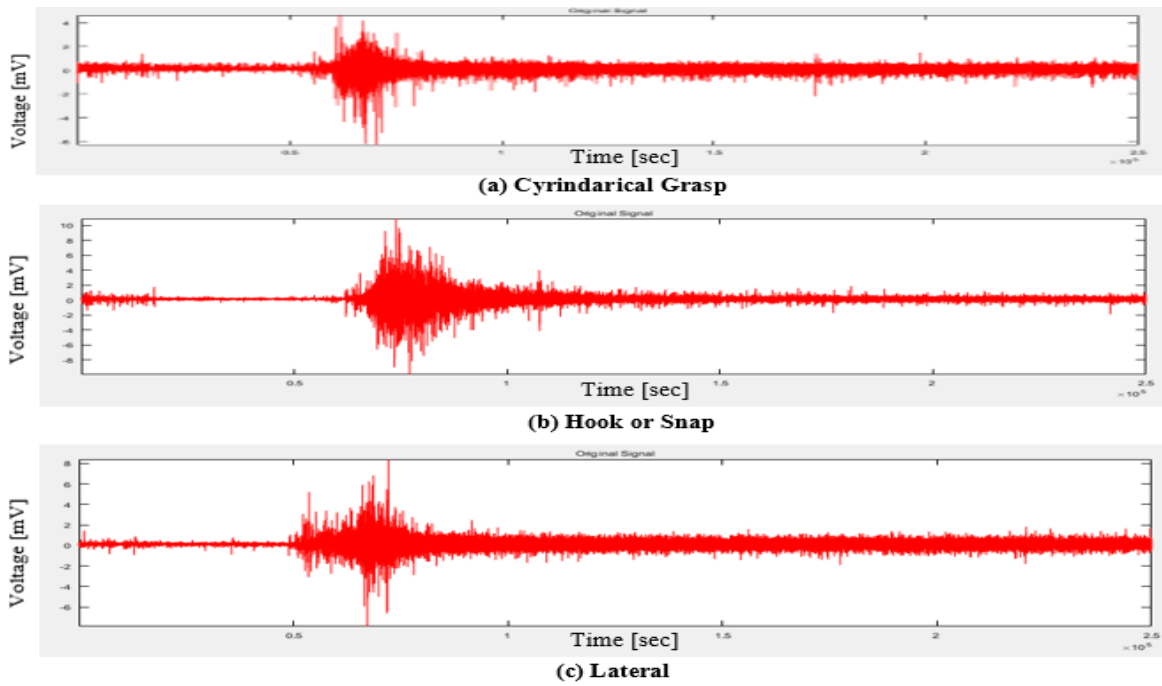


Figure 5.15: Statistical EMG signal analysis in wavelet For Day 2

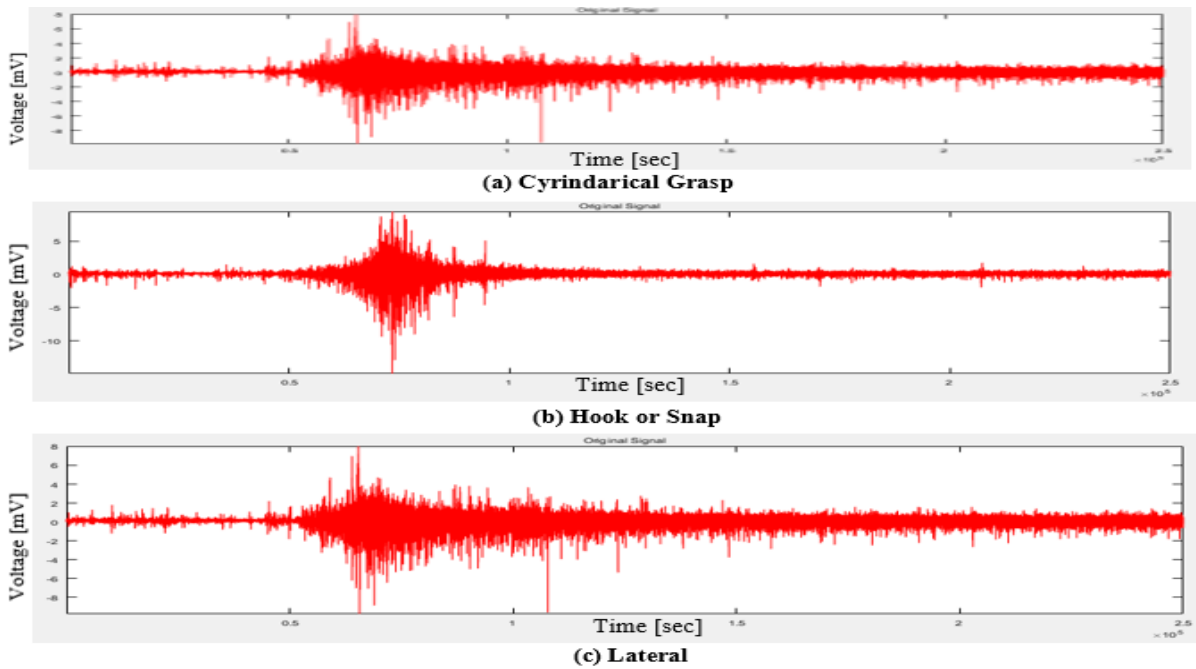


Figure 5.16: Statistical EMG signal analysis in wavelet For Day 3

Wavelet change is appropriate for a stationary and non-stationary signal. It ponders the nearby conduct of the signal, for instance, intermittence or spikes. The measurable investigation through the wavelet instrument identifies the changes. It demonstrates the littlest estimations of every parameter [30].

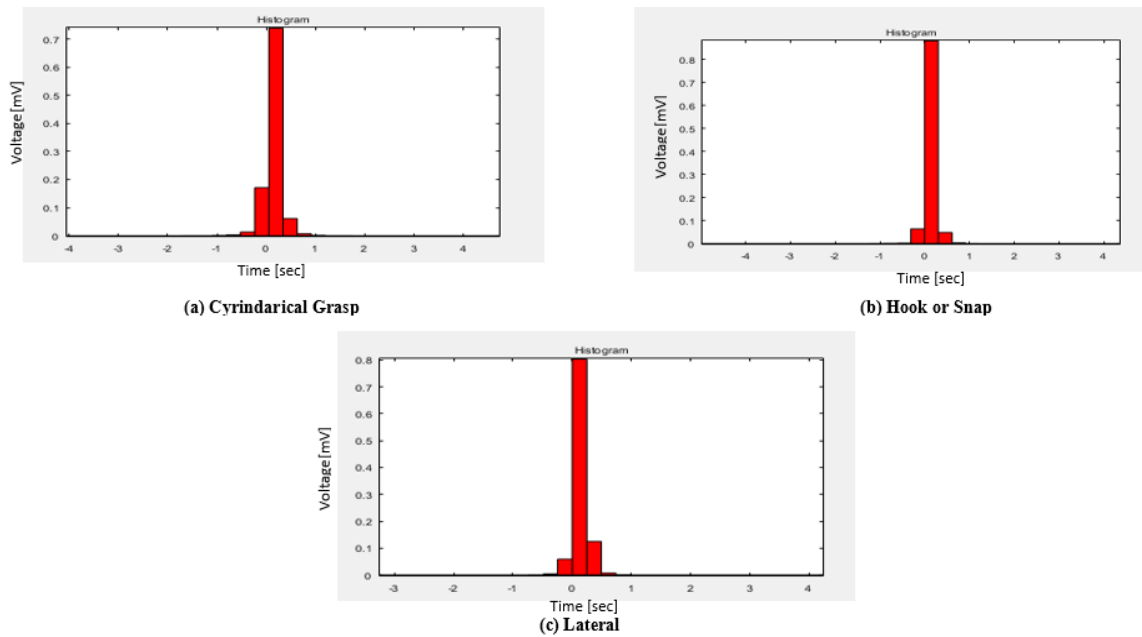


Figure 5.17: Statistical EMG signal analysis in wavelet (Histogram) For Day 1

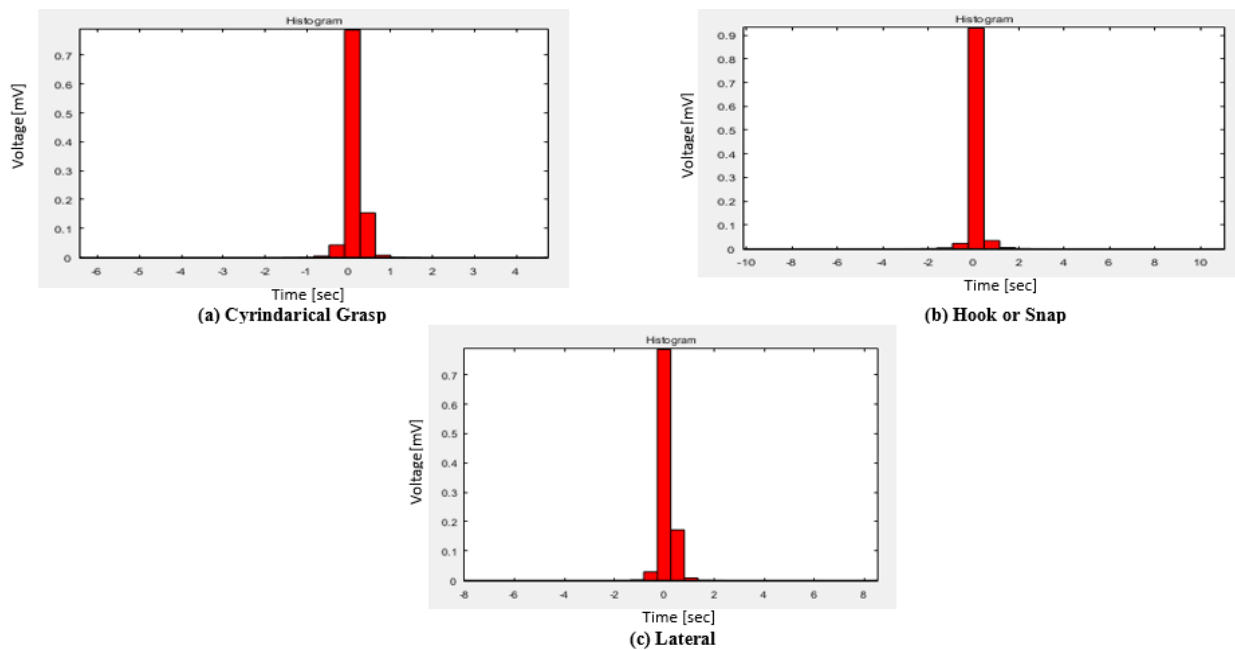


Figure 5.18: Statistical EMG signal analysis in wavelet (Histogram) For Day 2

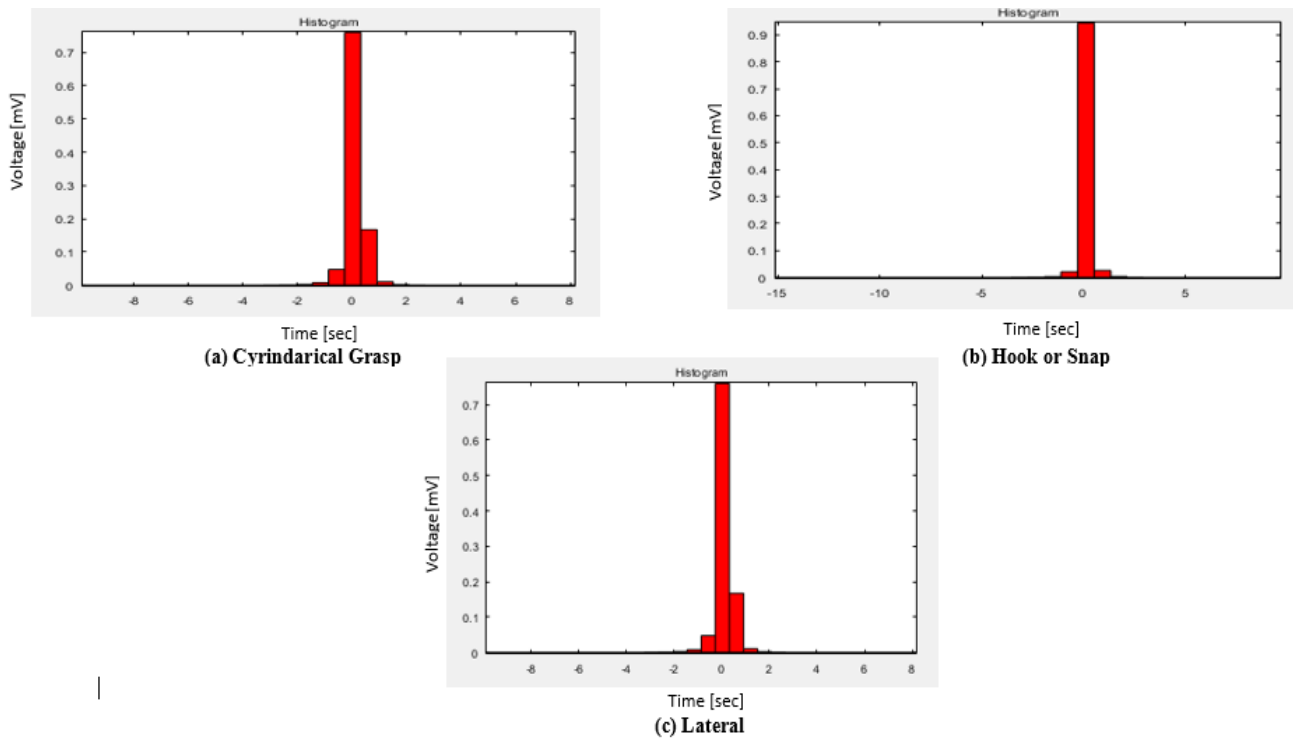


Figure 5.19: Statistical EMG signal analysis in wavelet (Histogram) For Day 3

The factual parameters alongside the other preparing procedures including sifting, makes the wavelet otherworldly breaking down strategies progressively compelling and nearly blunder free checking framework and identification of the littlest variations from the norm in the cerebrum motions in sudden conditions. This venture clear up that the little anomalies can be identified through the aides of those measurable parameters in observing the EMG signals and make the best possible strides in customary or crisis conditions [31,32] .

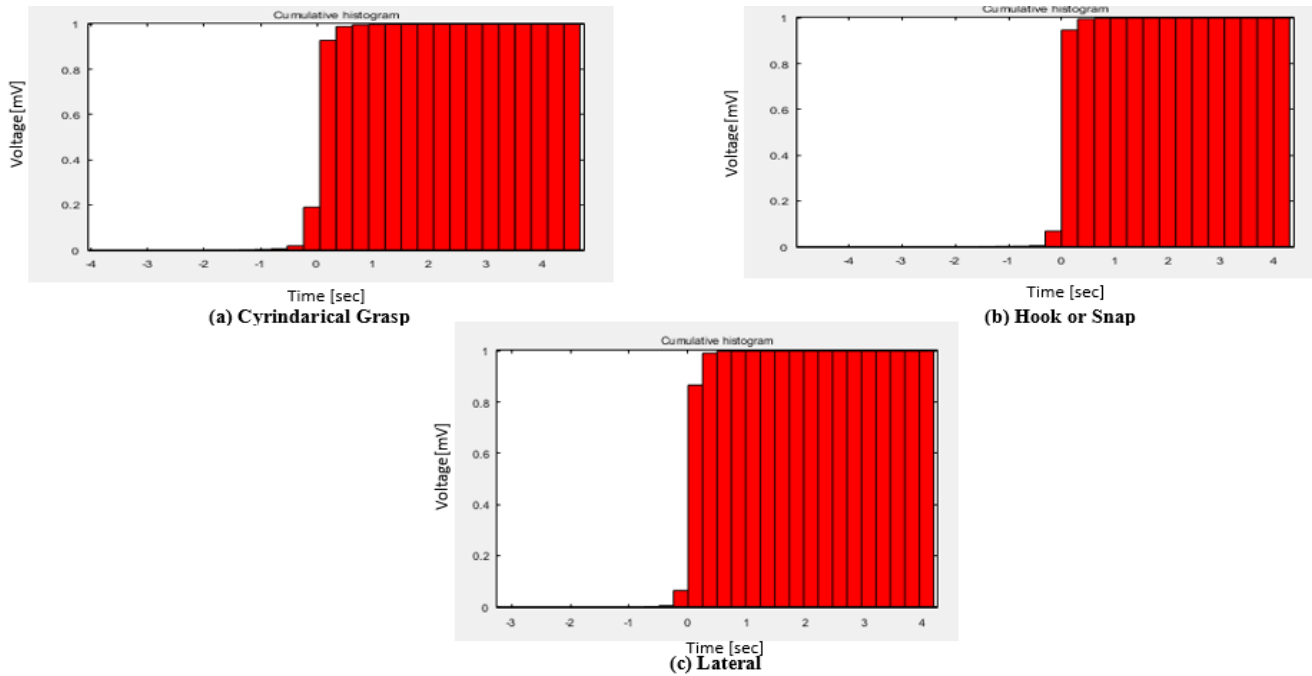


Figure 5.20: Statistical EMG signal analysis in wavelet (Cumulative) For Day 1

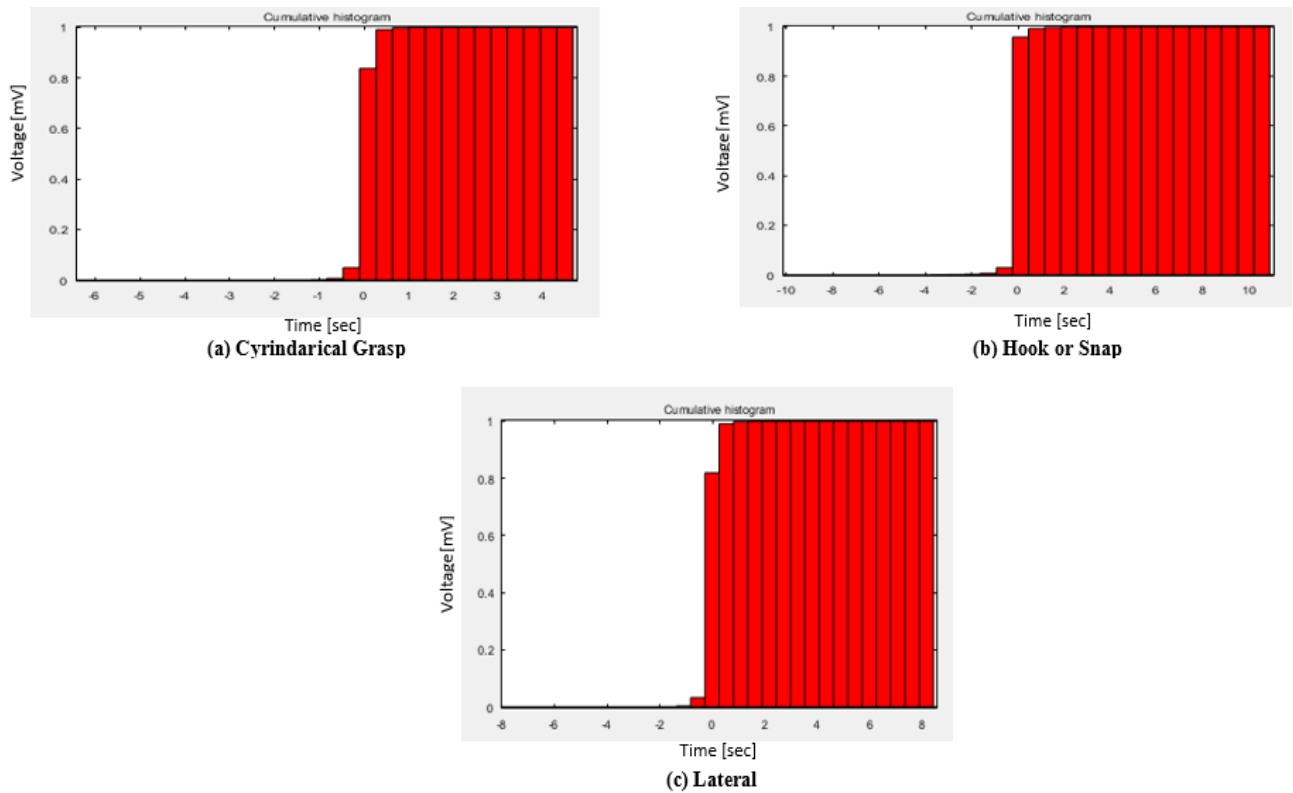


Figure 5.21: Statistical EMG signal analysis in wavelet (Cumulative) For Day 2

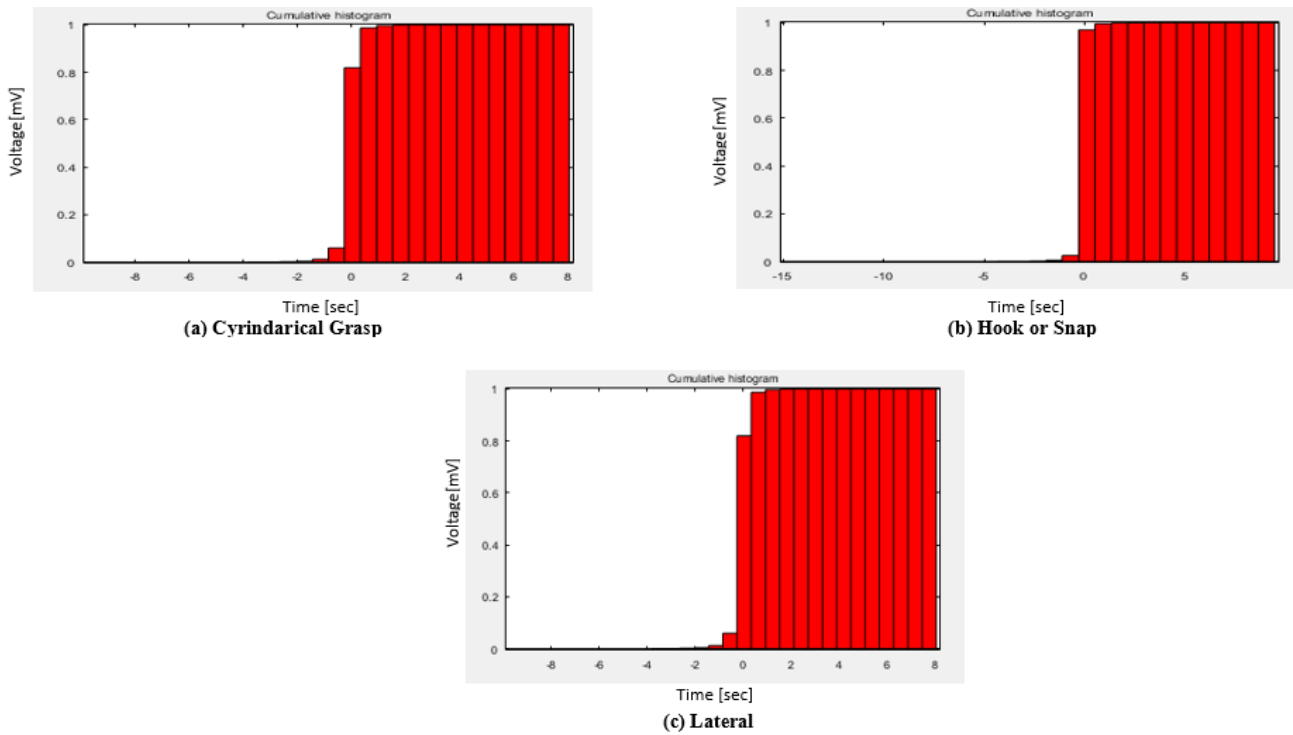


Figure 5.22: Statistical EMG signal analysis in wavelet (Cumulative) For Day 3

In wavelet investigation, the signal is changed over into a scaled and deciphered variant of mother wavelet which is extremely unpredictable and distinguishes littlest changes. The mother wavelets are progressively reasonable for foreseeing the neighborhood conduct of the signal, for example, abnormalities and spikes. This is another element of the wavelet phantom examination procedure of this venture.

Table 5-1: Statistical analysis of the original EMG signal in wavelet tool

Parameter	Day 1 Value			Day 2 Value			Day 3 Value		
	Cyrindrical Grasp	Hook	Lateral	Cyrindrical Grasp	Hook	Lateral	Cyrindrical Grasp	Hook	Lateral
Mean voltage	0.1483	0.1489	0.1485	0.1473	0.1482	0.1478	0.1467	0.1469	0.1467
Median frequency	0.1487	0.1487	0.1487	0.1487	0.1487	0.1487	0.1487	0.1487	0.1487
Mean frequency	0.1959	0.1487	0.1245	0.08282	0.1071	-0.008132	0.03012	0.1113	0.03012
Maximum	4.662	4.28	4.178	4.662	10.88	8.411	8.029	9.457	8.029
Minimum	-3.983	-4.901	-3.192	-6.329	-9.975	-7.884	-9.746	-14.92	-9.746
Range	8.645	9.181	7.37	10.99	20.86	16.3	17.77	24.38	17.77
Standard Dev.	0.1828	0.1346	0.1145	0.1815	0.301	0.2325	0.3311	0.2977	0.3311
Median Abs. Dev.	0.0765	0.051	0.051	0.0765	0.0765	0.07651	0.102	0.0765	0.102
Mean Abs. Dev.	0.1085	0.0812	0.07512	0.11	0.1312	0.1354	0.1853	0.1276	0.1853
L1 norm	4.528e+04	4.097e+04	3.986e+04	4.528e+04	5.122e+04	5.061e+04	6.188e+04	5.095e+04	6.188e+04
L2 norm	117.7	100.4	93.77	116.9	167.7	137.7	181.1	166	181.1
Max norm	4.662	4.901	4.178	6.329	10.88	8.411	9.746	14.92	9.746

Table 5- 1 is a summary of the measurable estimations of mind (EMG) signal dependent on the wavelet ghasly investigation. From this table, it appears to be obvious to all that the littlest changes or any sort of variation from the norm in the cerebrum can without much of a stretch be recognized and with the assistance of this checking, any crisis prescription of the subject (Patient) may be given.

CHAPTER 6

CONCLUSION

Electromyogram signal extraction plays an important role to detect most of the neuropathy muscle disease. Neuromuscular disease patients will be benefited most when EMG signals are offered with the best analyzing report. First Fourier Transform (FFT) has an incredible element in frequency division signal analysis but it can't guarantee the identification of little abnormalities in the EMG signal information. In this project, a strategy is proposed to screen and distinguish the littlest changes or irregularities in the muscle signals with the assistance of wavelet-based EMG signal investigation. This project is justify that wavelet-based EMG signal analysis is one of the best methods for muscle signal monitoring and detection and determines smallest changes or abnormalities of muscle signal that helps for medication.

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APPENDIX

MATLAB Code:

```
x1 = 3.5*emg(2700).';
y1 = sgolayfilt(kron(ones(1,13),x1),0,21);
n = 1:30000;
del = round(2700*rand(1));
signal= y1(n + del);
t = 0.00025:0.00025:7.5;
%subplot(3,2,1);
figure ;
plot(t,signal);
axis([0 2.5 -5 5]);
grid;
xlabel('Time [sec]');
ylabel('Voltage [mV]');
title('a) Muscle Signal');
nvar = 0.5;          % Noise variance
%noise = randn(size(signal))*nvar;
noise=3*sin(2*pi*50*t);
%subplot(3,2,2)
figure
plot(t,noise);
axis([0 2.5 -4 4]);
title('b) Noisy time domain signal')

nfilt = fir1(31,0.5);          % 31st order Low pass FIR filter
```

```

fnoise = filter(nfilt,1,noise); % Filtering the noise
d = signal+fnoise;
%subplot(3,2,3)
figure
plot(t,d);
axis([0 2.5 -5 5]);
title('c) Signal + Noise')

D = fft(d,512);
Pyy = D.* conj(D) / 512;
f = 1000*(0:256)/512;
%subplot(3,2,4);
figure
plot(f(1:50),Pyy(1:50))
title('d) Power spectral density')
xlabel('Frequency (Hz)')

M = 32; % Filter order
lam = 1; % Exponential weighting factor
delta = 0.1; % Initial input covariance estimate
w0 = zeros(M,1); % Initial tap weight vector
P0 = (1/delta)*eye(M,M); % Initial setting for the P matrix
Zi = zeros(M-1,1); % FIR filter initial states

% Running the RLS adaptive filter for 1000 iterations. The plot shows the
% convergence of the adaptive filter response to the response of the FIR filter.
Hadapt = adaptfilt.rls(M,lam,P0,w0,Zi);
Hadapt.ResetBeforeFiltering = 'off';
[y,e] = filter(Hadapt,noise,d);
H = abs(freqz(Hadapt,1,64));
H1 = abs(freqz(nfilt,1,64));

```

```

%subplot(3,2,5);
figure
plot(t,signal,'* Y',t,e); grid;
title('e) Original information bearing signal and the error signal');
legend('Original Signal','Error Signal');
axis([0 2.5 -5 5]);

E = fft(e,512);
PYY = E.* conj(E) / 512;
F = 1000*(0:256)/512;
figure
%subplot(3,2,6);
plot(F(1:50),PYY(1:50))
title('f) Power spectral density')
xlabel('Frequency (Hz)')

```