Implementing GUI Package for Recognizing Muscle Disease Using EMG Signals

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Abstract— An artificial neural network gives a comprehensive and functional utility for the diagnosis and care of muscle diseases. Medical consultations are given at the neuromuscular clinics which are guided by neurologists with experts in muscle diseases. This work presents the design of muscle disease discovery and implementation of muscle disease discovery based on real electromyography signals .this paper consists of three main parts .the first part presents the quantification range of the signal of real human arm muscles (EMG SIGNAL).Data are reconstructed and reported using EMG lab software .surface electrodes are used to measure the real EMG signal. The suitable features are extracted for categorization. The second part applies signal concern such as filtering amplification and normalization using MatLab. Muscle disease are categorized using an ANN package based on features of EMG signals, Amplitude of signals of identify diseases. The third part explains the design of graphical user interface based on MatLab to implement the categories on real EMG signals. Sufficient results are acquired from numerous executions. With individual cases of human arm muscles thus guarantee the workability of this sketch of realistic implementation in hospitals or private clinics.

Keywords—Electromyography, adaptive neuro fuzzy inference systems, graphical user interface.

I. INTRODUCTION

Electromyography is the study of muscle function based on the examination and analysis of the electrical signals that emanate from the muscles. The electromyogram (EMG) is an electrical manifestation of the contracting muscle - this can be either a voluntary or involuntary muscle contraction. The EMG signal is a complicated signal which is affected by the anatomical and physiological properties of muscles, the control scheme of the peripheral nervous system, as well as the instrumentation used for detection of the EMG signal and the process used to record the EMG signals. Variations in any of these processes can affect the character of the signal and the analysis and conclusions drawn from the data. In order to minimize the cost and to reduce the complexity in neurological clinics graphical user interface is proposed to find muscle disorder.
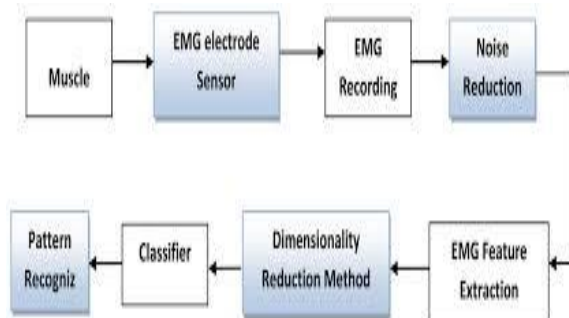

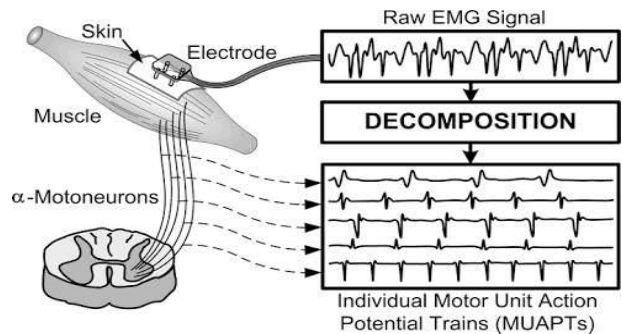**Fig 1. Block diagram**

Fig .2 electrical EMG Signal

II. DESCRIPTION OF EMG SIGNAL AND ACTIVITY CLASSIFICATION

A. The EMG Signal

This project aims to provide an overview of electromyography with an emphasis on its use in movement analysis. The following chapters cannot pretend to give all the knowledge needed to becoming a proficient electromyographer but rather they try to provide an overview of the processes involved and, when augmented with other readings and materials, it should be able to utilize either of the EMG Analysis and EMG Graphing software applications as tools in their research.

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The basic functional unit of the muscle contraction is a motor unit, which is comprised of a single alpha motor neuron and all the fibers it enervates. This muscle fiber contracts when the action potentials of the motor nerve which supplies it reaches a depolarization threshold. The depolarization generates an electromagnetic field which is measured as a very small voltage that is EMG.

B. The Neuro muscular dis order

EMG contains two types of important information, timing of muscle activity and its relative intensity. Other information is also present (e.g. frequency spectrum and acoustic information) but most clinical diagnostic reports are based on the muscle activity and intensity components of the EMG signal. This information can be used within a wide variety of fields of study. Numerous neuromuscular disorders may

present aberrant EMG signals while performing functional tasks like posture and locomotion. This may be any combination of inappropriate muscle activation or errors in muscle activation intensity.

Biomedical engineers often use EMG signals to derive volitional control of an artificial limb or brace through the interpretation of the EMG signal. Biomechanists and other scientists can study the balance mechanism by which humans maintain postural stability in the presence of perturbations. Gait analysis laboratories study the precise control of the musculo-skeletal system during ambulation or other complex human movements. Clinical EMG – sometimes called "diagnostic EMG" or "Nerve Conduction EMG" is typically done by physiatrists and neurologists. This is the study of the characteristics of the motor unit action potential for duration and amplitude. These studies are typically done to help diagnostic neuromuscular pathology. They also evaluate the spontaneous discharges of relaxed muscles and are able to isolate single motor unit activity. Generally, these types of studies focus on a single muscle or group of muscles.

Kinesiological EMG – this is the type most often found in the literature regarding movement analysis. This type of EMG examines the relationship of muscular function to movement of the body segments and evaluates timing of muscle activity with regard to the movements. Additionally, many studies attempt to examine the strength and force production of the muscles themselves. Kinesiological EMG almost invariably looks at the actions, and interactions, of several muscles simultaneously. Both the EMG Analysis and EMG Graphing software applications focus almost exclusively on providing information from the viewpoint of Kinesiological EMG studies that involve multiple muscle contractions during physical activity.

C. The characteristics of EMG Signal

The wave shape of MU potentials is assessed based on the defined quantitative waveform features. Amplitude is determined by the presence of active fibers within the immediate vicinity of the electrode tip. Low-pass filtering by the volume conductor attenuates the high-frequency spikes of remote SFAPs. Thus, the MUP amplitude does not increase for a larger MU. However, MUP amplitude will increase if the tip of the electrode is located near a cluster of re-innervated fibers. Large MUP amplitudes are frequently observed in neurogenic diseases. Rise time is an increasing function of the distance between the electrode and the closest active muscle fiber.

Number of phases indicates the complexity of the MUP and the degree of misalignment between SFAPs. In neurogenic diseases, polyphasic MUPs arise because of slow conduction velocity in immature nerve sprouts or slow conduction velocity in re-innervated but still atrophied muscle fibers. Variation in muscle fiber size also causes polyphasic MUPs in myopathic diseases. To prevent noisy baseline fluctuations from affecting the count of MUP phases, a valid baseline crossing must exceed a minimum absolute amplitude criterion. Duration is the time interval

between the first and last occurrence of the waveform exceeding a predefined amplitude threshold, e.g., 5 µV. The MUP onset and end comprise the summation of low-frequency components of SFAPs scattered over the entire pickup range of the electrode. As a result, the MUP duration provides information on the number of active fibers within the pickup range. However, the MU territory can be larger than the pickup range of the electrode. Thus, MUP duration does not provide information on the total size of a large MU. Area indicates the number of fibers adjacent to the electrode. However, unlike MUP amplitude, MUP area depends on MUP duration and is therefore influenced by fibers in a larger region than that of MUP amplitude. Turns are a measure of the complexity of the MUP, much like the number of phases. However, a valid turn does not require a baseline crossing like a valid phase. Thus, the number of turns is more sensitive to changes in the MUP wave shape. To distinguish valid turns from signal noise, successive turns must be offset by minimum amplitude.
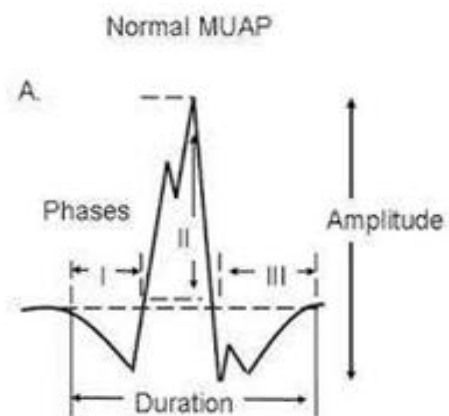

Fig 3 Characteristics of EMG Signal

D. The measurement of EMG

The EMG signal is obtained from the subject by either measuring non-invasively with surface electrodes, or invasively with wire or needle electrodes. The measured signal is then amplified, conditioned and recorded to yield a format that is most convenient for answering the clinical or scientific question of concern. The measurement and recording of a complex analog signal such as EMG is a complex subject as the signals of interest are invariably very small (in the order of 0.00001 to 0.005 of a Volt). In addition, the signals are usually found in combination with very large spurious signals from motion artifact, as well as induced voltages from nearby AC power lines, florescent lights, cell phones and other electrical equipment such as computers, monitors etc. – all of which are potent sources of interference. As a result, both a quality EMG system and a versatile analog signal recording system are essential if you are planning anything more than the most casual of analysis functions.

E. The Surface EMG Electrode

Surface electrodes used in EMG recordings can either be "active" or "passive" electrodes. In the passive electrode type, the electrode consists of a simple Silver/silver-chloride detection surface that senses a current on the skin through the skin-electrode interface. This type of electrode is normally used when the electromyography requires precise placement or if older EMG equipment in use. Active electrodes place a preamplifier either within the electrode or very close to the EMG data collection site. The advantages of surface electrodes are that there is minimal pain with application, they are more reproducible, they are easy to apply, and they are very good for movement applications. The disadvantages of surface electrodes are that they have a large pick-up area and therefore, have more potential for cross talk from
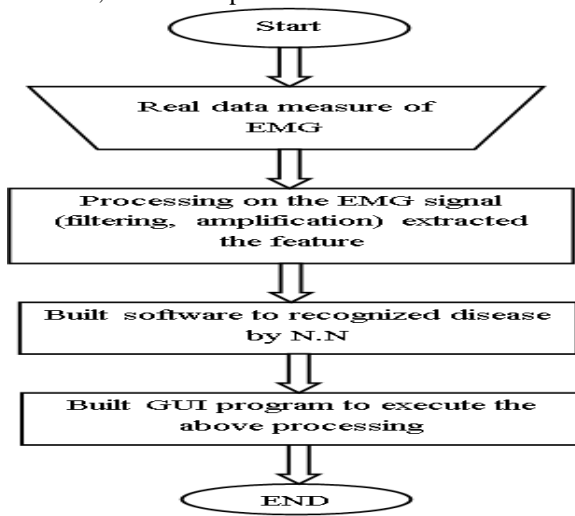

Fig 4 flow chart of measurement

F. The Noise Source

There are many sources of noise that can appear in an EMG study – almost any unwanted signal collected alongside the wanted signal is "noise" even though it may be a perfectly valid signal (e.g. pacemaker or EKG signals). Some of the more common noise sources are: electromagnetic fields (power lines), motion artifact due to lose electrodes at the skin interface or loose leads on the wires, involuntary reflex activity (clonus), and any other electrical device that might be either in the room, or close by, when the EMG studies are occurring. The majority of noise artifacts can be prevented by a few simple means. Proper cleaning of the skin is one such measure that is particularly critical if pre-amplified electrodes are not used. Using bipolar differentially amplified or double differentially amplified systems also help dramatically in the removal of artifacts from the system by eliminating signals that are common to both electrode inputs. Securing all loose electrode leads and making sure that there is some slack in these leads is important as well so that the electrodes on the recording site are not moved or stressed during the recording. Before the starting data collection, check that the electrodes are making proper contact, that there is no tension on the wires, and that all of the wires are plugged into all connectors correctly. Once the electrodes are

in position, the subject should have manual muscle tests applied for the specific muscles being tested to make sure that the EMG electrodes are picking up muscle activity appropriately. If certain electrodes seem to be working inappropriately, you can try switching the leads (if using discrete electrodes), or just switching electrode channels to see if this particular electrode works in another channel. If the signal is still bad after switching channels, then switch electrodes to see if the electrode itself is malfunctioning. When testing different subjects it is important to remember that there is an attenuation of the EMG signal as the amount of adipose tissue over the muscle being examined increases. Therefore, it may be difficult to pickup normal EMG signal levels when dealing with obese individuals when using surface electrodes.

Furthermore, do not fall into the trap of assuming that the measured EMG signal is proportional to muscle mass – EMG signal level is affected by many different factors but in the end, an active muscle will generate a larger signal than an inactive muscle.

III. FACTORS AFFECTING EMG SIGNAL

The amplitude range of EMG signal is 0-10 mV (+5 to -5) prior to amplification. EMG signals acquire noise while traveling through different tissue. It is important to understand the characteristics of the electrical noise. Electrical noise, which will affect EMG signals, can be categorized into the following types:

1. Inherent noise in electronics equipment: All electronics equipment generates noise. This noise cannot be eliminated; using high quality electronic components can only reduce it.
2. Ambient noise: Electromagnetic radiation is the source of this kind of noise. The surfaces of our bodies are constantly inundated with electric-magnetic radiation and it is virtually impossible to avoid exposure to it on the surface of earth. The ambient noise may have amplitude that is one to three orders of magnitude greater than the EMG signal.
3. Motion artifact: When motion artifact is introduced to the system, the information is skewed. Motion artifact causes irregularities in the data. There are two main sources for motion artifact: 1) electrode interface and 2) electrode cable. Motion artifact can be reduced by proper design of the electronic circuitry and set-up.
4. Inherent instability of signal: The amplitude of EMG is random in nature. EMG signal is affected by the firing rate of the motor units, which, in most conditions, fire in the frequency region of 0 to 20 Hz. This kind of noise is considered as unwanted and the removal of the noise is important.

The factors that mainly affect the EMG signal can also be classified. This kind of classification is set so that EMG signal analysis algorithms can be optimized and equipments

can be designed in a consistent manner. The maximization of the quality of EMG signal can be done by the following ways

1. The signal-to-noise ratio should contain the highest amount of information from EMG signal as possible and minimum amount of noise contamination.
2. The distortion of EMG signal must be as minimal as possible with no unnecessary filtering and distortion of signal peaks and notch filters are not recommended.
3. During the EMG signal processing; only positive values are analyzed. When half-wave rectification is performed, all negative data is discarded and positive data is kept. The absolute value of each data point is used during full-wave rectification. Usually for rectification, full-wave rectification, kalman filter is preferred.

A. The Activity Classification

There are more than 100 neuromuscular disorders that affect the brain, spinal cord, nerves and muscles. Many of these diseases are hereditary and life expectancy of many sufferers is considerably reduced. Early detection and diagnosis of these diseases by clinical examination and laboratory tests is essential for their management as well as their prevention through prenatal diagnosis and genetic counseling. Such information is also useful in research which may lead to the understanding of the nature and eventual treatment of these diseases. Laboratory investigations include neuro-physiological tests, nerve and muscle biopsies, biochemical analysis and more recently DNA analysis for the localization and identification of genes. Electromyographic examination studies the electrical activity of the muscle and forms a valuable neuro-physiological test for the assessment of neuromuscular disorders.

The shapes and firing rates of the motor unit action potentials (MUAPs) in an EMG signal provide an important source of information for the diagnosis of neuromuscular disorders. In order to extract this information from the EMG signals recorded at low to moderate force levels, it is required to identify and classify the MUAPs composing the EMG signal. The identification of possible MUAPs is done by segmentation of EMG signal using threshold technique. The identified MUAPs are clustered using a statistical pattern recognition technique.

Adaptive neuro fuzzy inference system is used as a classifier and thus 10 healthy and 10 muscular disorder subjects are taken.

IV. NEURO ADAPTIVE LEARNING

The basic structure of Mamdani fuzzy inference system is a model that maps input characteristics to input membership functions, input membership functions to rules, rules to a set of output characteristics, output characteristics to output membership functions, and the output membership functions to a single-valued output or a decision associated with the output. Such a system uses fixed membership functions that

are chosen arbitrarily and a rule structure that is essentially predetermined by the user's interpretation of the characteristics of the variables in the model.

ANFIS and the Neuro-Fuzzy Designer apply fuzzy inference techniques to data modeling. As inferred from the other fuzzy inference GUIs, the shape of the membership functions depends on parameters, and changing these parameters change the shape of the membership function. Instead of just looking at the data to choose the membership function parameters, choose membership function parameters automatically using these fuzzy logic toolbox applications.

To apply fuzzy inference to a system for already having a collection of input/output data that would be like to use for modeling, model-following, or some similar scenario. It is not necessary have a predetermined model structure based on characteristics of variables in your system.

In some modeling situations, it cannot discern what the membership functions should look like simply from looking at data. Rather than choosing the parameters associated with a given membership function arbitrarily, these parameters could be chosen so as to tailor the membership functions to the input/output data in order to account for these types of variations in the data values. In such cases, the use of fuzzy logic toolbox neuro-adaptive learning techniques incorporated in the anfis command.

A. Model Learning and Inference through Anfis

The neuro-adaptive learning method works similarly to that of neural networks. Neuro-adaptive learning techniques provide a method for the fuzzy modeling procedure to learn information about a data set. Fuzzy Logic Toolbox software computes the membership function parameters that best allow the associated fuzzy inference system to track the given input/output data. The fuzzy logic toolbox function that accomplishes this membership function parameter adjustment is called anfis. The anfis function can be accessed either from the command line or through the Neuro-Fuzzy Designer. Because the functionality of the command line function anfis and the Neuro-Fuzzy Designer is similar, they are except when specifically describing the GUI.

B. Algorithm for Finding Neuromuscular Disorders in Matlab GUI Using EMG

1) STEP 1
a) SET INPUT VALUES

- Threshold=Value of the Threshold signal Default value = 5.
- Time Pause= Time pause [s] between individual activities, Default=0.2.
- Channel Info =Info about the chosen channel (1-left, 2-right) Default=1.
- ActDur= Minimal duration [s] of the activity. Default = 0.01.
- MVC = Maximal voluntary contraction (isometric) Default value = 0.

- Start time = from what time [s] to start loading the file. Good for skiping the heading or Noise at the beginning of the file. Default value=0.2s
- Stop Time= Where to stop loading the file [s] Default value = 120 s
- RectDecision= Full-wav rectification. Yes-1 (default), no-0.

2) STEP 2

a) NOISE SIGNAL PROCESSING

Processing of the EMG noise signal (wav file) comprises of several steps. Insert constants for the computation

- Time pause between individual activities.
- Threshold from which the signal is taken into account.
- Minimal time of the activity.
  (Shorter activities are taken into account)

b) EMG SIGNAL PROCESSING

- Find values higher than the Threshold
- Find individual activities based on the time pause between the signals
- Omit activities shorter than the "minimal time of the activity"
- Find the maximal signal within individual activity and Corresponding time
- Compute the average value of individual activity
- Compute the energy of the activity
- Compute the biting frequency: $1/(Start(i+1)-Start(i))$

3) Step 3

- Open the command window and write a command dairy command window text.txt.to save the coding as a text file which is written in command window.

a) READ THE INPUT

- Threshold for the signal [s], what time divide the activities
- which channel should be chosen (1-left,2-right)
- minimal duration of the activity [s], [mV] for maximal voluntary contraction
- when to load the signal [s]
- when to stop reading the file [s]
- full-wave rectification (0-no, 1-yes)

4) STEP 4

- Pick the experimental noise file which is in the form of .WAV file

5) STEP 5

- Run the code. Display output message in the as 10 activities.

6) STEP 6

- Check the name of the file if it contains the date and time. Save the info in the xls file.

7) STEP 7

a) CONDITIONS FOR CREATING RESULTS FOLDER

- If the name of the input wav file is longer than 256 characters,
- which is the limit for windows folder name's length,
- The directory will be composed of the first 200 characters of the file + the "Counter Number" will be added to see,
- How many files has too long name
- However, because of the excel file names restriction; the file name cannot be 256, but only 218. Therefore, the folder name length is restricted to 150.

8) STEP 8

a) CHECKING CONSTRAINT FOR INDIVIDUAL PARAMETERS.

- The input from the user is check if is fulfill the conditions for individual parameters.
- Input and output can be the same.
- If the condition for the particular variable is not fulfilled, the value is changed to default value and user is informed via a warning message.

9) STEP 9

a) PLOT FOR 10 INDIVIDUAL ACTIVITIES

- Time vector on x-axis.
- The first component is "time" -it is a time vector in which each element corresponds to the time of each sample.
- Therefore we can plot "y" (left) against "t" to show the waveform directly in the form of MVC (muscle voluntary contraction).

10) STEP 10

a) ANALYSIS

- Computes the dime difference between two adjacent steps in "Peaks"
- Info about the length (duration) of all the cycles.
- Duration of the cycle [s].
- Mean value of the previous cycle (1).
- Max value of the previous cycle (1).
- Energy value of the previous cycle.
- For the frequency computation we need info of start 1 and start 2.

11) STEP 11

a) DISPLAY THE ACTIVITIES

- Displaying individual activities as a saved file with all the individual parameters. Compute and display the frequency analysis of the biting frequency.
- Eliminate the noise using kalman filter matlab code.

12) STEP 12

a) DISPLAY 10 ACTIVITIES IN SINGLE PLOT

- Plot the parameters with respect to X and Yaxis.

- grid on
- xlabel('Time [s]')
- ylabel('Magnitude of the signal')
- xlim([0, length(Channel)/fs]).
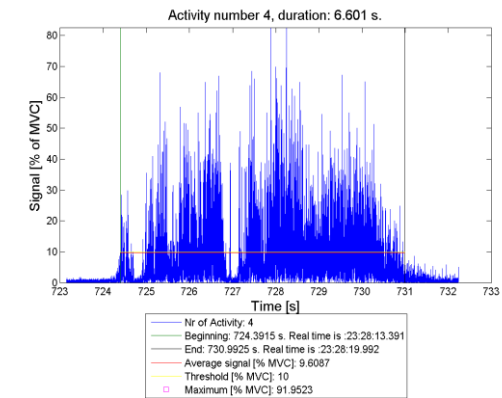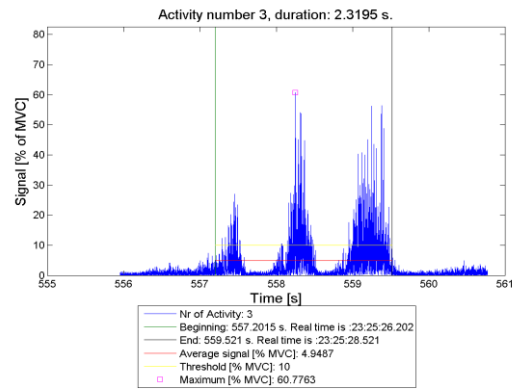
13) STEP 13

a)   TRAINING SETS OF SIGNAL TO BE FEED IN AN ANFIS

- Train the values for neuromuscular disorder and feed a value for each parameter and compare with the original signal.
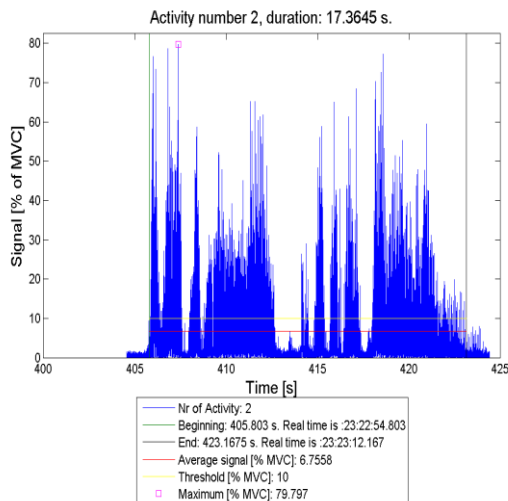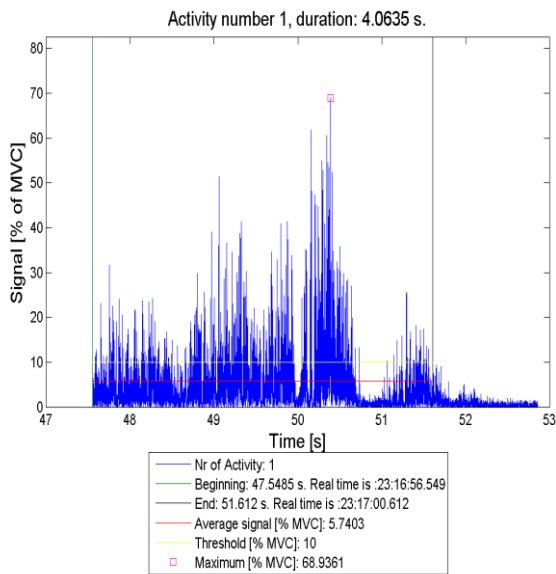
14) STEP 14

a)   GUI WINDOW DISPLAY

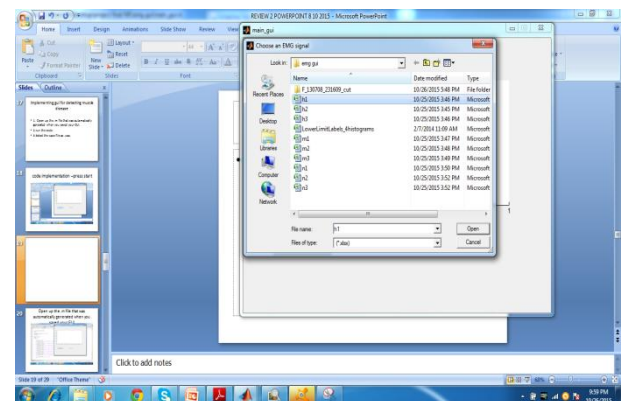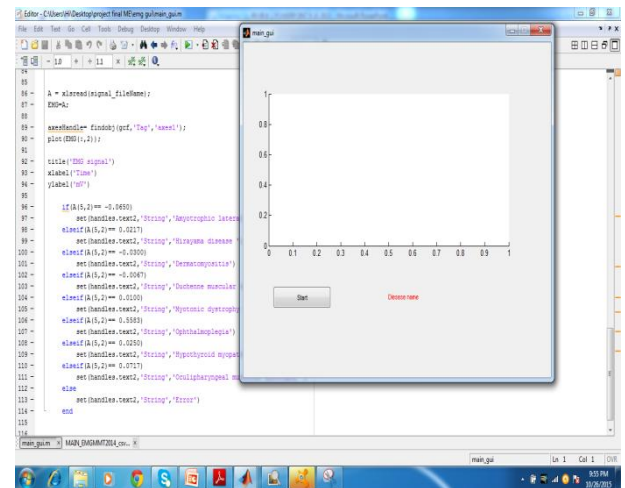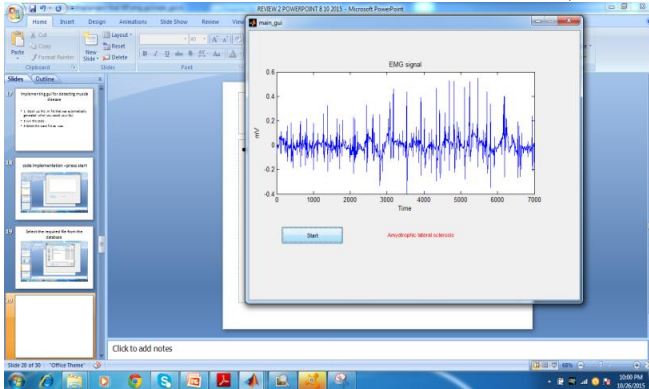- Run the program to find neuromuscular disorder in human

V.   RESULT ANALYSIS

A.   HUMAN ARM MOVEMENT FOR 10 ACTIVITY-EMG

Activity number 1, duration: 4.0635 s.

Nr of Activity: 1
Beginning: 47.5485 s. Real time is :23:16:56.549
End: 51.612 s. Real time is :23:17:00.612
Average signal [% MVC]: 5.7403
Threshold [% MVC]: 10
Maximum [% MVC]: 68.9361

Activity number 2, duration: 17.3645 s.

Nr of Activity: 2
Beginning: 405.803 s. Real time is :23:22:54.803
End: 423.1675 s. Real time is :23:23:12.167
Average signal [% MVC]: 6.7558
Threshold [% MVC]: 10
Maximum [% MVC]: 79.797

Activity number 3, duration: 2.3195 s.

Nr of Activity: 3
Beginning: 557.2015 s. Real time is :23:25:26.202
End: 559.521 s. Real time is :23:25:28.521
Average signal [% MVC]: 4.9487
Threshold [% MVC]: 10
Maximum [% MVC]: 60.7763

Activity number 4, duration: 6.601 s.

Nr of Activity: 4
Beginning: 724.3915 s. Real time is :23:28:13.391
End: 730.9925 s. Real time is :23:28:19.992
Average signal [% MVC]: 9.6087
Threshold [% MVC]: 10
Maximum [% MVC]: 91.9523

B.   Muscle diseases detected in MATLab GUI

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VI. CONCLUSION

High-accuracy NN detection was used to distinguish human muscle EMG signals. Muscle diseases were detected based on EMG signals using ANFIS-NN, which is an efficient method because of its simplicity and accuracy. This method can be implemented in many medical applications, such as the use of artificial limbs and high-accuracy robot applications.

The design of the proposed package is based on the GUI technique, which gives the capability to connect all three parts under consideration, simulate individual parts by transportation among them, and finally present the three parts simultaneously as one animation system. Moreover, this package includes instructions with explanations presented in notes and graphs, thus enabling this package to be used as an educational tool for human muscle diseases detection.

Real-time monitoring and analysis of EMG signals, extraction of all important features from captured EMG required for correct diagnosis of different neuromuscular diseases, and patient data management enable remote clinicians to follow patient progress. The developed GUI can be easily modified to suit clinician needs.

REFERENCES

[1] An Intelligent Recovery Progress Evaluation System for ACL Reconstructed Subjects Using Integrated 3-D Kinematics and EMG Features, Owais A. Malik, S. M. N. Arosha Senanayake, Senior Member, IEEE, and Dansih Zaheer.

[2] A. K. G. Murphy, "Effective Information Display and Interface Design for Decomposition-based Quantitative Electromyography", M.Sc thesis, University of Waterloo, Canada, 2002.

[3] N. BU, "EMG-Based Motion Discrimination Using a Novel Recurrent Neural Network", Journal of Intelligent Information Systems, 21:2, 113–126, 2003.

[4] Toshio Tsuji1 "Pattern classification of time-series EMG signals using neural networks", international journal of adaptive control and signal processing, 2000.

[5] Clinical neurophysiology,"U K misra, Jkalita.3E.