

Analysis and simulation of brain signal data by EEG signal processing technique using MATLAB

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Abstract— EEG is brain signal processing technique that allows gaining the understanding of the complex inner mechanisms of the brain and abnormal brain waves have shown to be associated with particular brain disorders. The analysis of brain waves plays an important role in diagnosis of different brain disorders. MATLAB provides an interactive graphic user interface (GUI) allowing users to flexibly and interactively process their high-density EEG dataset and other brain signal data different techniques such as independent component analysis (ICA) and/or time/frequency analysis (TFA), as well as standard averaging methods. We will be showing different brain signals by comparing, analysing and simulating datasets which is already loaded in the MATLAB software to process the EEG signals.

Keyword- EEG, Signal processing, MATLAB, Brainwaves, Diagnosis

I. INTRODUCTION

The human brain is one of the most complex systems in the universe. Nowadays various technologies exist to record brain waves and electroencephalography (EEG) is one of them. This is one of the brain signal processing technique that allows gaining the understanding of the complex inner mechanisms of the brain and abnormal brain waves have shown to be associated with particular brain disorders.

II. BRAIN SIGNAL PROCESSING

Signal processing is the enabling technology for the generation, transformation, and interpretation of information. At different stages of time our brain reacts differently. These brain signals used for various purposes so that it is possible to study the functionalities of brain properly by generating, transforming and interpreting the collected signal. This process is known as brain signal processing.

A. Brain Waves and EEG

The analysis of brain waves plays an important role in diagnosis of different brain disorders. Brain is made up of billions of brain cells called neurons, which use electricity to communicate with each other. The combination of millions of neurons sending signals at once produces an enormous amount of electrical activity in the brain, which can be detected using sensitive medical equipment such as an EEG which measures electrical levels over areas of the scalp.

The electroencephalogram (EEG) recording is a useful tool for studying the functional state of the brain and for diagnosing certain disorders. [5] The combination of electrical activity of the brain is commonly called a Brainwave pattern because of its wave-like nature.

III. OVERVIEW

EEG signals contain more relevant information about brain disorders and different types of artifacts. Signals in the form of dataset are already loaded to the tool so we will be using that signals to plot the data and visualization of the time-frequency domain plots which can be displayed all together.

Basically we will be monitoring the EEG signals according to the placement of electrodes which is called montages. After that we will observe the EEG signals to recognize and eliminate different disease related artifacts. Then unwanted signal will be subtracted by differential amplifier. Finally we will proceed for the signal filtering based on the different types of brainwave frequencies to diagnosis and simulate variety of brain disorders by using MATLAB.

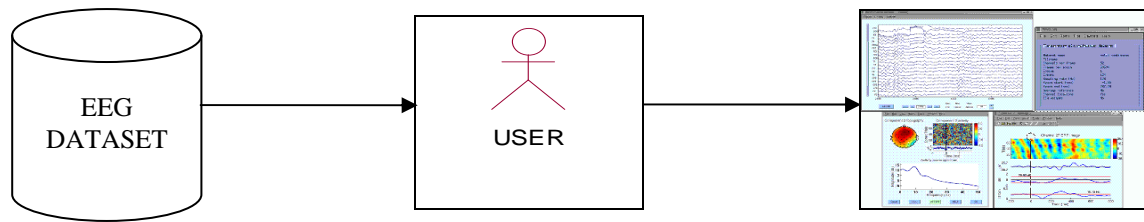


Fig. 1. Overview of the EEG Signal Processing Technique

IV. ANALYSIS AND DESIGN

A. Study of Existing EEG Hardware procedure techniques

Steps involved in the existing techniques are- The electrodes are placed to the brain by wires and electrical activity of the brain will get recorded to a computer .It will show the activity as a series of wavy lines drawn as an image on the computer screen.

Patients need to lie down and close their eyes during the recording. The recording may be stopped from time to time to allow the patient for stretching and repositioning.

Different things will be done by the patient during the test to record the brain activity at that time. Such as Taking breathe deeply and rapidly for few minutes and Looking at a bright, flashing light for checking the stimulation.

After recording the brain activities by the above mentioned process brain disorder symptoms will be detected.

V. SYSTEM DESCRIPTION

In our project we have included various features .Such as EEG montages - Montage means the placement of the electrodes. The EEG can be monitored with either a bipolar montage or a referential one. Bipolar means that just to use two electrodes on the scalp on all the sides and for reference electrode for one side of the brain. The referential montage means only having a common reference electrode in both the side of the brain. In this part we will be showing how brainwaves will vary according to the placement of electrodes.

1) *Right Montages*: Patient data has collected according to electrodes are placed in the right side of the brain, so it will show the waves related to the right side of the brain based on time-frequency analysis.

2) *Left Montages*: Patient data has collected according to electrodes are placed in the left side of the brain, so it will show the waves related to the right side of the brain based on time-frequency analysis.

3) *Both Side Montages*: Patient data has collected according to electrodes are placed in the left and right side of the brain, so it will show the waves related to the right side of the brain based on time-frequency analysis.

A. EEG Channels

The electrical activity of the brain is conducted by wires from the scalp and electrodes are placed by using EEG machine. The inputs to the hardware EEG machine are then used to compose a montage, which is a specific arrangement or array of electrodes that display the EEG signal. In our project we are dealing with basically 20 channels of the brain because EEG hardware machine deals with only till 20 channels of the brain. Each channel basically compares input data taken based on placement of the two electrodes. Upward deflection of the wave is defined as negative and occurs when the first input data is negative with respect to the second input data or second input data is positive with respect to the first input data. A downward deflection of the brainwave is defined as positive, and occurs when first input data is positive with respect to second input data or when second input data is negative with respect to first input data.

B. Sensitivity

Amplitude is the magnitude of the EEG activity which is measured in microvolts (μV). It is determined by measuring the brainwave deflection in millimeters (mm) at specified machine sensitivity ($\mu\text{V}/\text{mm}$). We have analyzed the brainwaves according to the collected sensitivity values of the patients, EEG procedures are performed at a sensitivity rate of $7 \mu\text{V}/\text{mm}$, such that a 10 mm deflection of waves signifies amplitude of $70 \mu\text{V}$. We have measured with the sensitivity values $10 \mu\text{V}/\text{mm}$, $15 \mu\text{V}/\text{mm}$, $20 \mu\text{V}/\text{mm}$, $30 \mu\text{V}/\text{mm}$, $50 \mu\text{V}/\text{mm}$ because it is easier to determine the brainwave patters with these values.

C. Filtering

Low- pass filtering is used for smoothening the brainwaves and high-pass filtering is used for sharpening the brainwaves in order to make the signals more clearly to the viewer. According to the patients EEG hardware data collected we have shown in our project two types of filtering technique options such as – Low – pass frequency filters and High- pass frequency filters

For the low – pass frequency filters generally setting the maximum range till 1Hz and for high – pass frequency filters setting the maximum range till 70Hz because this the standard limit of filters.

D. Frequency Sweeping

Sweeping basically reduces the complexity towards analysing the brainwaves for EEG signal processing. At last we will sweep the signal to reduce the complexity for the visualization of the brainwaves. In this we will be using linear frequency sweeping and it has a fixed rate of frequency per time. Basically it is measured as Hz/sec.

VI. ARCHITECTURAL DESIGN

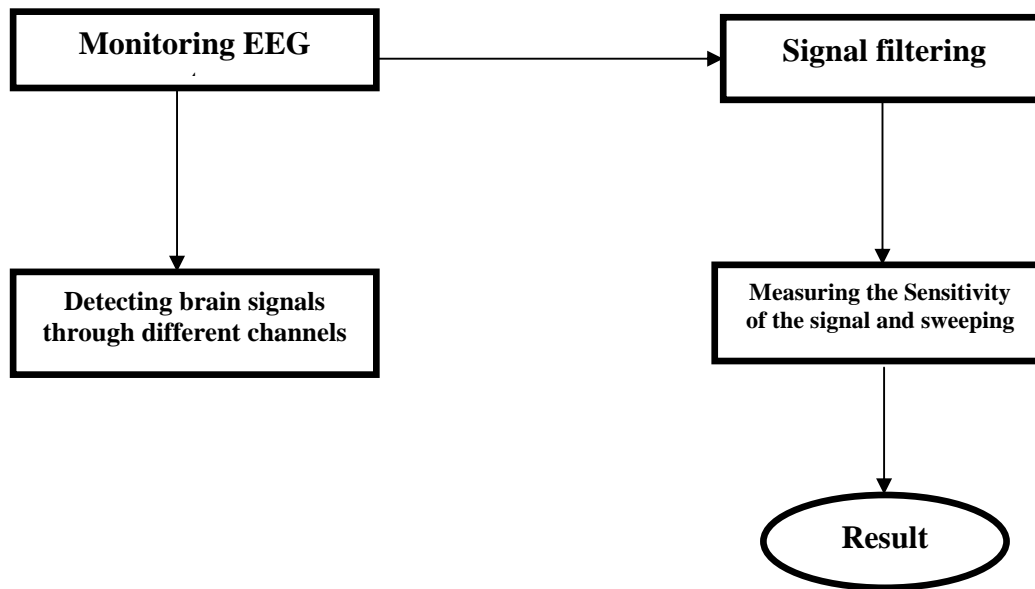


Figure 2: System architectural design

VII. METHODOLOGY

A. Procedures

- 1) Different EEG signals are collected as a form of dataset in the MATLAB;
- 2) Load the data into the software for brain signal processing;
- 3) Process the datasets;
- 4) Extract and select the specific features for different EEG datasets;
- 5) Classify the datasets according to the product features such as- montages, channels, sensitivity, filtering and sweeping
- 6) Check the variation of different brain waves based on their characteristics,
- 7) Select the specific montages such as – left side montage, right side montage or both side montages to check change in different brainwaves.
- 8) Then select the channels out of 20 channels for viewing more detailed waveforms.
- 9) By fixing the sensitivity values of the collected EEG data we will be setting filtering range of the signals for high frequency (50 - 70 Hz) or for low frequency (0.1 - 1 Hz); we will change the values of sweeping also according to the data.
- 10) At last we will get the final EEG signal in waveform.

B. Flow Chart

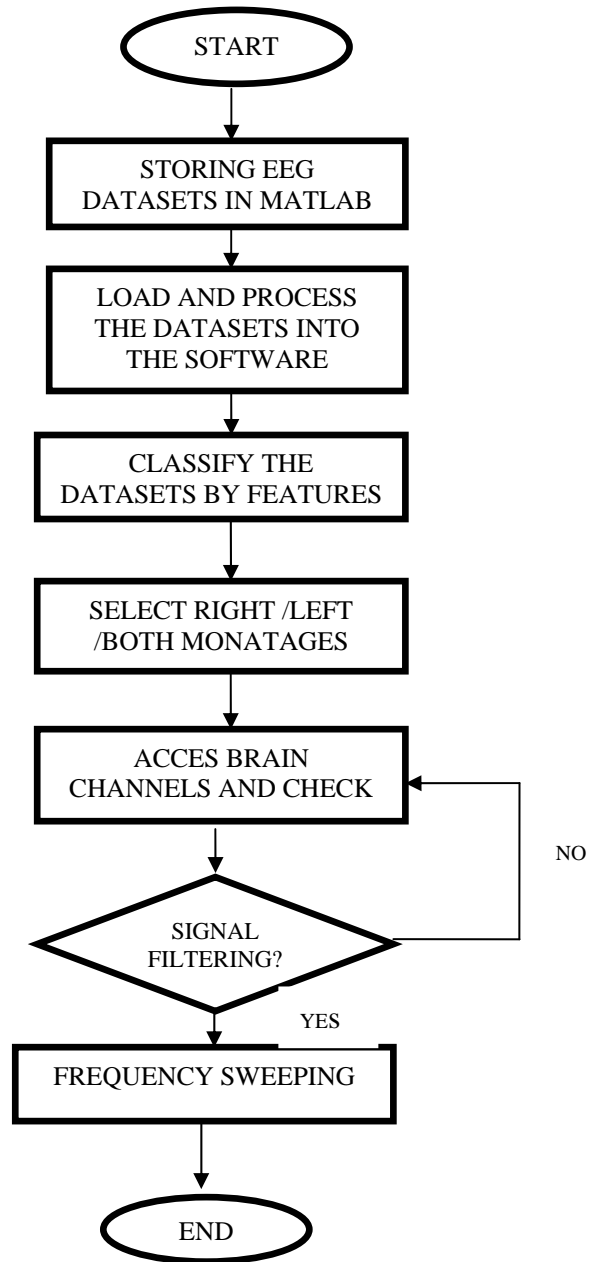


Figure 3: Flowchart

C. Implementation



Figure 4: Welcome page

This is the welcome page of our GUI which leads to the kind of selection of the next section by selecting the 'click here' button.

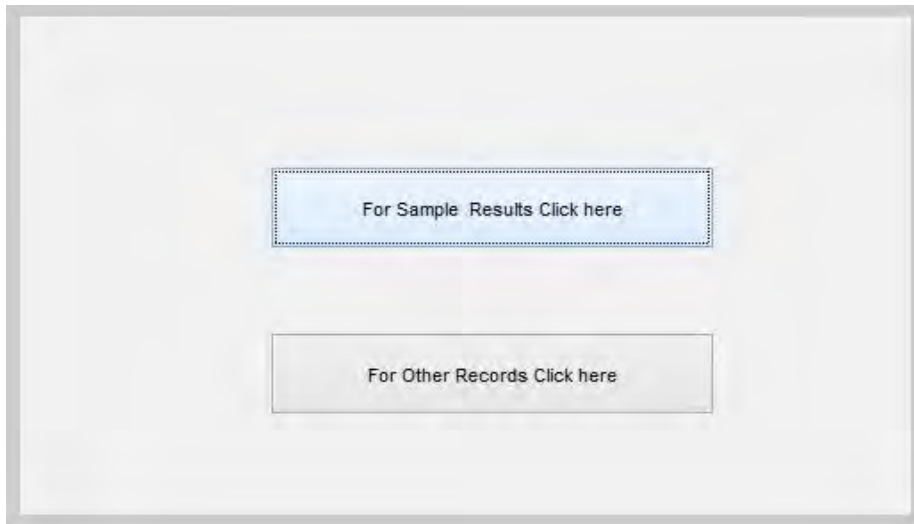


Figure 5: Sample results and other records page

This page is loaded after selecting the 'click here' button of the first page. In this page two options are mentioned. For checking the exiting patients records select the first option and for diagnosis of different brainwaves forms select the second option.

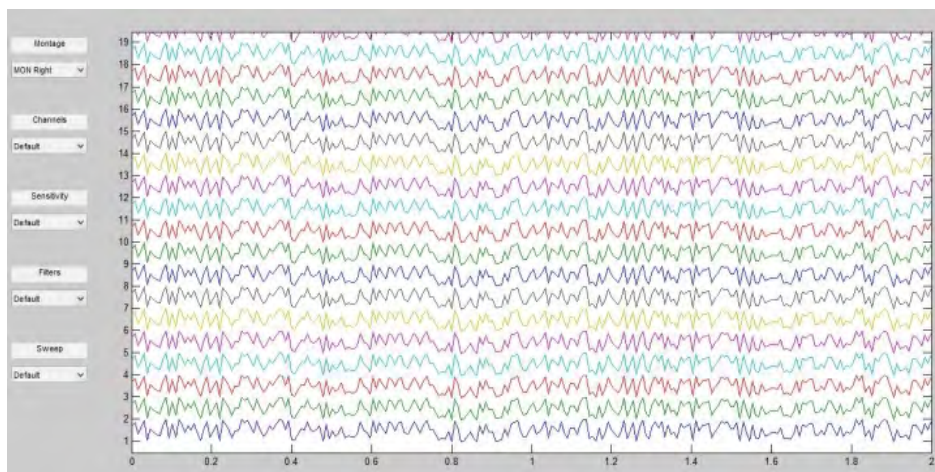


Figure 6: Brainwaves pattern

The above is the result obtained by the changes made in montage module just by selecting right montage of the brain and different frequencies of brainwaves can be easily determined.

VIII. ANALYSIS AND RESULT

TABLE I
Different patient data montage

5.6014109e-001	6.9510397e-004	2.5127513e-001
8.8967125e-001	2.3849760e-002	1.2872483e-001

TABLE II
Different patient data of brain montage

4.8976380e-001	1.9324533e-001	8.9589157e-001
3.4878481e-001	4.5134058e-001	2.4090500e-001

TABLE III
Different patient data of brain sensitivity

5.7083843e-001	9.9685021e-001	5.5354157e-001
5.7161573e-001	1.2218915e-001	6.7116623e-001

TABLE IV
Different patient data of Signal Filtering

1.5194708e-001	3.9710884e-001	3.7472247e-001
8.8665840e-002	8.3825559e-001	5.8471862e-001

TABLE V
Different patient data of Signal Sweeping

4.3390472e-002	6.9162515e-001	9.7898547e-001
2.6296403e-001	6.8056620e-001	2.3365315e-001

IX. CONCLUSION

The above mentioned project has clearly demonstrated the concepts about open source plug-ins, running under the platform MATLAB environment and its ability to process biophysical data by different way such as - using simplicity of its command line language or using the many MATLAB functions and the methodology related to the analysis of the brain signal processing through MATLAB software toolbox. It has been described in detail the procedure in the modeling of EEG signals and insight brain signals recorded during surgical procedure.

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