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Smart System to Recognize EEG Signal for Finding Brain Diseases Using K-Means Clustering

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Abstract

In this paper, we are providing a research ideology, in which analysis of the EEG signal is done using an intelligent system in order to detect the brain diseases such as Epilepsy, Alzheimer's disease etc. Here we are supposed to use clustering algorithm called k-means for distinguishing various diseases of human brain. Our main aim is to help the doctors by reducing the time complexity in analyzing EEG signal by our detection system which produces better results. We are proposing a technique of detecting epilepsy disorder and Alzheimer disease using k-means algorithm using MATLAB. The back propagation algorithm is also used in the classification network and discrete wavelet transform are used to process the EEG signal. Automated analyses of neurological disorders like Epilepsy, Alzheimer's disease are being discussed.

Keyword

Electroencephalogram (EEG), Epilepsy, Alzheimer's disease, Adaptive filtering, discrete wavelet transforms k-means clustering.

1. Introduction

We started this research track with the general goal of helping neurologists in their diagnosis of neurological disorders. Neurologists and epileptologists who are well trained currently *read* EEGs, that is, try to identify visual markers of EEGs. But EEGs can have markers that are invisible to the eyes of neurologists [2]. Our research also challenges the assumption that the EEG represents the dynamics of the entire brain as a unified system. On the contrary, an EEG represents the effect of the superimposition of diverse processes in the brain. The entire EEG is more representative of brain dynamics than the individual frequency sub-bands. In fact, the sub-bands may yield more accurate information about constituent neuronal activities underlying the EEG.

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Certain changes in the EEGs that are not evident in the original full-spectrum EEG and it may be amplified when each sub-band is analyzed separately. Over the years research people focused mostly on seizure detection and epilepsy diagnosis. In recent years the researchers had interest in other neurological issues and disorders [5]. Diseases like Alzheimer's affect many people in the world especially old age people. Because of working stress, it is expected that the people in the younger ages might get caught.

2. Importance of EEG

Normally, EEG is used to diagnosis brain diseases. As doctors a lot of time for diagnosis, we have developed detecting system. Computers have long been suggested to solve this problem and so automated systems to recognize electroencephalographic changes have been under study for several years. There is a strong demand for the development of such automated devices, due to the use of long-term video EEG recordings for proper evaluation and treatment of neurological diseases and prevention of the possibility of the analyst missing information. However, EEG signals include various artifacts, both from the subject and from equipment interferences. Initially, the artifacts present in the EEG signal are removed and then it is processed accordingly. Discrete wavelet analysis method is applied for extracting generic features embedded in an EEG signal[4]. Neuromuscular disorders have affected millions of people in the United States .An approximation of the overall occurrence is that 1 in 3500 of the world's population is found to suffer from a neuromuscular disorder. Either they are affected in earlier stages of life or in later age[3]. The EEG signal represents superposition of brain activities which traces out the variations as electrical potentials by placing electrodes at various places over the scalp.. The electrooculogram (EOG) signal is the chief and most widespread artifact in EEG analysis produced by eye movements and/or blinks repressing eye-blink over a continued recording course. Given the magnitude of the blinking artifacts and the high resistance of the skull and scalp tissues, EOG may affect greater part of the electrode [6]. The EEG signals provide lot of information about the function

of the brain. EEG which is obtained from scalp electrodes, is normally superposition of a huge amount of electrical potentials arising from a number of sources (including brain cells i.e. neurons). Direct measurements necessitate placement of electrodes inside the head, which in turn needs surgery. The existing method was not suitable as it created pain and risk for the subject. A solution to get rid of the existing stressful measurement is by placing the electrodes on the scalp of the subject. Signal processing is done in order to handle diverse issues in EEG signal analysis that includes data compression, detection and classification, noise reduction, signal separation, and feature extraction. The study of EEG signals is significant and useful for both research and medical diagnosis and treatment.

3. Description

3.1 EEG Recording

EEG (Electroencephalograph) is a technique for identifying neurological disorders[9],[1]. There are various neurological disorders like Epilepsy, Alzheimer's, brain cancer, etc. In this project a technique of detecting epilepsy disorder and Alzheimer's disease using K-Means clustering algorithm using MATLAB is proposed. This project also provides a technique of detecting disorder with great accuracy.

EEG is a medical imaging technique that reads scalp electrical activity generated by brain. Readings from EEG acts as a very powerful tool in neurology. The voltage range for EEG signal is 3-100 µ V which is 100 times weaker than ECG signal. Normally, EEG is used for diagnosis of Epilepsy. It takes lot of time for doctors to diagnosis the obtained readings. Computers have been proposed to solve out this issue thus, automated systems to recognize electroencephalographic changes have been under study for several years. Now a days, there is a demand for the development of such automated devices, due to the increased use of prolonged and long-term video[5].

EEG recordings are used for proper evaluation & treatment of neurological disorders and for prevention of the possibility of the analyst missing (or misreading) information. EEG signal from the patient is taken through electrode and given to the intelligent systems and necessary preprocessing is done to strengthen the signal and then it is Converted into digital values and all the necessary details are extracted from the EEG signal and then classification of signal is done with the help of K-Means algorithm where it plays a major role of clustering which is a necessary thing in classification and then as per the result ,the disease is being identified after diagnosis.

The block diagram of our smart system is as shown in the Figure 1.It shows the how the EEG signal is taken through EEG electrode and how it is processed inside ARM Processor. The input signal is digitized and then compared with the database. Another input from the patient is also compared with the incoming results. All these process takes place inside the ARM Processor and finally the disease is detected.

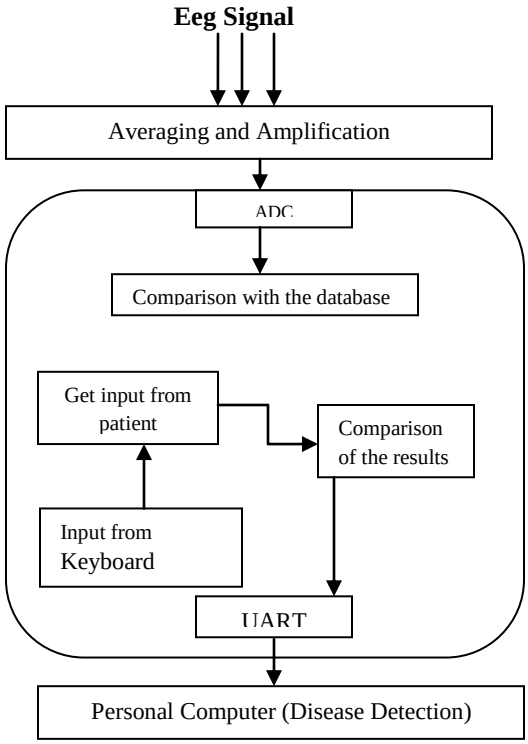

Figure 1: Our Smart System

3.2 EEG Electrode

Silver-Silver Chloride electrodes are known for their low offset voltage, low noise and stability. These electrodes can be used indefinitely with minimal care.

The EEG Waveform generated from each of the electrode placed is shown below.

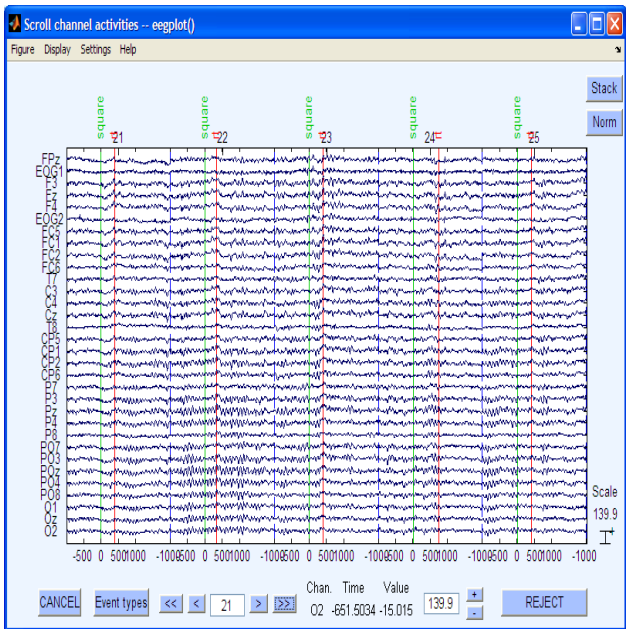

Figure 2: EEG Waveform

3.3 Filtering

Once the EEG signals have been acquired, they were converted by ADC circuit into digital form and then pre-filtered by the digital filter built-in. The EEG signals taken from EEG electrodes will be having artifacts. The recording process is liable to contaminate the EEG data at many points. So if such artifacts are present during further processing then it won't be producing better results at the output. The artifacts that are created due to the various factors must be removed. Pre-processing of signal helps to remove the outliers and make subsequent signal clustering task easier and better [10]. EEG signals that are collected from various hospitals are in .eeg format. The obtained signal data is first converted to excel format which is supported by MATLAB. Out of four frequency bands, delta band is selected for detection of epileptic disorder [11]. Delta wave is trained using Back Propagation Algorithm to compare the normal and epileptic delta waves. Finally depending on the output epileptic disorder is detected. EEG signal Cn be recorded up to 100Hz by doctors using RMS software. But the signal up to frequency range of 60Hz is only useful for diagnosis of Epilepsy. So by using band pass filter we are band limiting the signal up to 60Hz. During recording, EEG signal is influenced by various artifacts like 50 Hz line noise, eye blink, eye movement, muscle activity, etc. These artifacts must be removed before processing the EEG signal. 50 Hz line noise is removed by using a notch filter [6]. Our next step to be carried out is to decompose the signal into various frequency bands i.e. alpha (9-13 Hz), delta (1-3 Hz), theta (4-8 Hz), beta (14-30 Hz) using DWT.

3.4 EEG Amplifiers

A minimum of 25 electrode inputs are recommended and 32 electrode inputs are preferred when recording process takes place. Normally, the system should provide two reference inputs in order to prevent the loss of data should one reference electrode become dislodged during recording. The input impedance should be greater than 10 mega-ohms. The common mode rejection ratio should be at least 100 dB for each input. Here we are using only 3 electrodes for demo purpose of the project.

3.5 Filters

Ideally, the EEG data is acquired and stored to disk with a wide band pass of 0.1-100 Hz. This broad band pass will allow the data to be re-filtered for viewing at a later time using any filter setting within this band pass. Routine filter settings can be selected to set the "display" band pass for display during acquisition. All filter settings should be indicated and stored automatically in the file and available for display on playback. Filter settings should offer a range of 0.1-100 Hz for display on the monitor. The value of sensitivities between 1 and 200 m V/mm for display on the screen are desirable. The noise present in the EEG Signal is removed with help of low pass filters and averaging is carried out in order to carry out the noise reduction process. The noise free signal is fed to the ARM Processor.

3.6 Input from keyboard

In order to make trusted output in the project, we are making the patient to answer via keyboard. There will be a set of questions which we will be asked to the patient. The patient is able to answer whether Yes or No by pressing Y or N respectively. This Y or N combinations produce certain digital value & it is carried to the next stage. The proper digital value generation deals with programming.

3.7 Comparison of results:

The digital value obtained from the comparison made with the database and the digital value obtained from the patient through keyboard is compared with the help of the K Means clustering algorithm. Even though the patient gives wrong combinations of Y or N, the intelligent system works intelligently to detect the brain disease irrespective of the fault digital value. It obtains its data from patient's EEG Signal which tends it to provide an intelligent output.

3.8 Disease detection display:

The result will be transmitted to the computer screen from ARM processor through UART. Some symptoms of the disease will be displayed. Depending upon the answer and the age group of the patient the state of the patient will be displayed, whether the patient is normal or not and specifies whether treatment is necessary or not.

4. Software description

EEGLAB is found to be an interactive MATLAB toolbox that is used for processing the continuous and event-related EEG, MEG and other electrophysiological data using independent component analysis (ICA), time/frequency analysis, and other methods including artifact rejection. EEGLAB provides an interactive graphic user interface (GUI) allowing users to flexibly and interactively process their high-density EEG and other dynamic brain data using independent component analysis and/or time/frequency analysis (TFA), as well as standard averaging methods. EEG (Electroencephalograph) is only one recording technique for identifying neurological disorders. There are numerous neurological disorders like Epilepsy, Brain cancer, Alzheimer etc. It is found that epilepsy is one of the common neurological disorders [11]. Our research track also provides a technique of detecting epilepsy disorder with great accuracy. EEG is a medical imaging technique that reads scalp electrical activity generated by brain. The voltage range for EEG signal is 3-100 μ V which is 100 times weaker than ECG signal. [7]

5. Simulation Results

All neuroscience is based on the brain activity where each component is responsible for certain functions, without explanation of how they cooperate in coordinated responses [8]. The detection of Epilepsy disease and detection of Alzheimer's disease is shown in the figure 3 & 4. The results are simulated using EEG LAB. The EEG lab is very helpful in generation the EEG signals as like it is generated from normal human brain. The Waveforms get differentiated in both the cases which give clear perception of the difference of two disease signals.

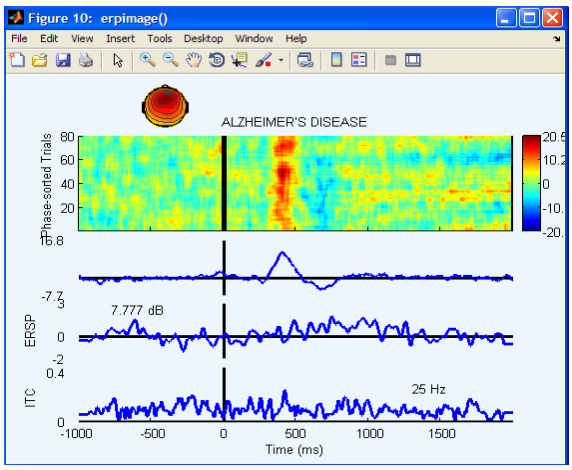

Figure 3: Detection of Epilepsy

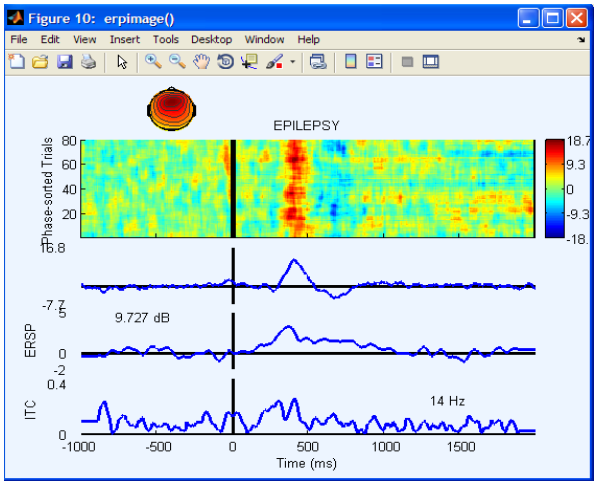

Figure 4: Detection of Alzheimer's

6. Conclusion

The traditional way of analyzing EEG signal is by normal visual inspection of signals. This method of evaluation is tedious and also time consuming. Thus it is the reason for introducing computer assisted processing which simplifies the work of medical doctors and makes the evaluation more objective. Visual evaluation prone to mistakes as neurologists have subjective point of view. They are making this evaluation according to their experience obtained in clinical practice. Here the K means clustering algorithm is the representative of unsupervised learning methods. This paper provides a technique of detecting epilepsy disorder and Alzheimer disease. The above results indicate that the use of this tool can be used for detection of epilepsy within few seconds. The results of several studies have demonstrated that

the Wavelet Transform is the most promising method to extract features from the EEG. Our Smart system provides stress less analysis of brain diseases which avoids many misreading. This system if implemented in medical field then it would a great boon for neurologists to make an easy analysis of diseases.

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