EEG Based Patient Emotion Monitoring System

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Abstract- *Emotions play an important role our life, the need and importance of emotion recognition has grown with an human computer interface applications and it is also helpful for the biomedical application. Emotion recognition could be done using different methods like text, speech, facial expression or gesture. In this paper emotions of patient can be detected directly from brain wave patterns using Discrete Wavelet Transform and feature extraction method. Feature extraction plays an important role in classification. Brain computer technique is widely used for recognition of emotions. In this project, we have taken samples of different emotions by identifying its brain wave states. In real time condition, EEG detection is very crucial because of fast changes in computations. Thus, we have used Neurosky mind wave brain sensor for capturing brain signals.*

Keywords- Human computer interface, discrete wavelet transform, Feature extraction.

I. INTRODUCTION

In medical field patient recovery from various diseases or health problems is not only depends on medicine.Non-medical factor such as patient psychology plays an important role in the healing process. Psychological factor, such as patient emotion can influence illness progress and its treatment. Emotional response of a patient to his/her illness may influence type and amount of medication prescribed by the doctor. The Patient's response to symptoms and medical advice can also effect to illness management by the patient [1]. Positive emotions such as happiness, smile causes better health and longevity in general. Thus, positive emotion in patients will results in better quality of life and better response for treatment. Therefore, observing patient emotion plays an important role in patient treatment. The main station for generating actions, reacting things and presenting emotions of our body is "Brain". So, by understanding brain signal we can identify the states of mind of patient.

Many researches in emotion recognition use various techniques like face image, voice or physiological signals. For expression, they observing one or a combination of human psychological signals, such as blood pressure, ECG, body temperature and brain waves. After that Electroencephalograph (EEG) is used for detecting various things.

Electroencephalography (EEG) detects the neural activity of Brain and this can help in detecting the emotion states or imagination like moving left hand or right hand, sleeping state, Drowsiness, Visual imagination etc. The detection of neural activity (such as disturbances occurs inside the brain) called as electrical movements of the brain can be used as a form of signal from which emotion can be easily detected and is very popular method because it does not require any physical effort from the user. This model can be used to build a system in which a human emotion can be easily feed and depending upon the application it can be used in a real-time situation as shown table 1 with different brain waves. Each activity is associated with a frequency range.

Table. 1. The types of EEG waveforms

Brain wave	Activity	Frequency Range
Beta	Alert/working	12-30Hz
Alpha	Relaxed/Reflecting	7.5-12Hz
Theta	Drowsy/Visual Imagery	4-7.5 Hz
Delta	Sleeping/Dreaming	Up to 4Hz

The implementation of emotion recognition in patient treatment can be seen in Fig. 1. First, patient's brain signal is captured using sensor device. The raw signal is then pre-processed to obtain matrix/vector data and then processed using artificial intelligence algorithm so that it could be translated to corresponding

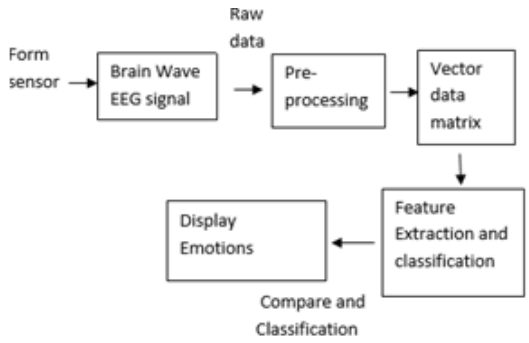

Figure.1. Basic block diagram of EEGpatient monitoring system

emotions. After the patient's emotion is known, doctor can adjust patient's treatments and get well response for the treatment. The problem in utilizing EEG for emotion recognition is because the complexity of brain signals. Human brain signals are unique between oneman to the other, and varied among time and condition. Moreover, brain signals are complex and susceptible to noise. Because of the complexity, emotion recognition research mainly aims at improving the accuracy or the recognition rate.

In this paper, we present brain signal processing method used for patient emotion recognition, namely feature extraction and SVM classifier. We are used Neurosky mind wave sensor to capture live brain wave signal as database. The efficiency of this method was measured by calculating its recognition rate. The paper structure gives as: Section II explains NeuroSky mind wave sensor in detail.Section III discusses the feature extraction method and discrete wavelet transform and SVM classifier. Section IV explains about the methodology to do automatic emotion recognition. Section V discusses the detail of the experiment methodology and result. Section VI concludes the paper.

II. EEG HEADSET

Mind wave headset is used for capturing EEG data and interfacing it with the PC with serial port. The main aim is to capture attention and meditation level of human. We may getsamples of alpha, theta, gamma, beta waves using database. To access this Think Gear Protocol is used for the data capturing. To access it we used MATLAB.

III. SECTION

A. Pre- Processing

After getting data from headset it needs to be processed and make it compatible for further processing.EEG signals are non-stationary and non-linear. EEG signals are easily acceptable to noise and interference caused by eye movement and muscle movement or any other action. The electronic devices can also cause interference due to EMI, EMC. The amount of raw data required for classification is not compatible for most machine learning algorithms. Thus, feature extraction is necessary for successful classification. Pre-processing includes transformation of EEG signals from time domain to frequency domain along with removal of noise and artifact. A various techniques of feature extraction methods available for BCI applications, such as Discrete Cosine Transform (DCT),Discrete Wavelet Transform (DWT), and Fast Fourier transform.

Discrete Cosine Transform

Discrete Cosine Transform is method used to convert time series signals into frequency components. In case of BCI, DCT is used to calculate maximum, minimum and mean value of EEG signal. The one-dimensional DCT for a list of N real numbers is expressed by the following formula:

$$Y(u) = \frac{\sqrt{2}}{N} a(u) \sum_{x=0}^{N-1} f(x) \cos \frac{\pi(2x+1).u}{2N}$$

$$where\ a(u) = 1$$
$$if\ u = 0\ a(u) = 1\ if\ u \neq 0$$

The input is a set of N data values (EEG samples). Output is a set of N DCT transform coefficients Y(u). The first coefficient Y (0) is called the DC coefficient and it holds average signal value. The rest coefficients are considering as the AC coefficients. DCT produces concentrated signals, where the energy is concentrated into few coefficients. Thus, DCT is effective for data compression which leads to reduced size of input vector for machine learning algorithms and reduces time required for learning.

B.Feature extraction

The artifacts free pre-processed data is used in feature extraction process. We had used following methods for feature extraction:

1. Fast Fourier Transform (FFT)
2. Classification

To analyse the brain signals correctly, Fast Fourier Transform (FFT) is the method which gives better result in frequency domain.

Fast Fourier Transform (FFT) Method:

We have used power spectral density (PSD) and the frequencies of respective waves to calculate features of EEG signal. PSD represents the EEG signals selectively and make it differ from another brain signals. There are five frequency bands which contains the major characteristics of EEG signal. The five frequency bands are: delta (δ: 1–3 Hz), theta (θ: 4–7 Hz),alpha (α: 8–13 Hz), beta (β: 14–30 Hz), and gamma (γ: 31–50 Hz).By applying the data sequence to the variables in program, we get modified discrete values and their plotting with respect to time. The information sequence is represented as xi (n).

Where, xi (n) is represented as follows:

xi(n)=x(n+iD),n=0,1,2,…,M−1while i=0,1,2,…,L−1;

The starting point of the ith sequence is iD. The datasegments that are formed are represented byL of length 2M.The result is given by:

P≈ (i) xx (f) =1MU||ΣM−1n=0xi (n) w(n)e−j2πfn/2
U: normalization factor of the power
U=1MΣM−1n=0w2 (n),
W (n): window function.
After calculating average value of signal
We get power spectrum as:
PWxx=1LΣL−1i=0P≈ (i) xx (f). [2]

Classification

Classification is done after extracting the features such as emotional state from happy, sad, under stress or neutral. We have used support vector machine (SVM) as a classifier.SVM is a statistical learning method. It uses a train data to separate the waves datasets. The datasets are separated out to classify them in their specified category. The incoming data is classified with the predefined EEG data which is stored as a sample data. Matching with trained data we will create it in matrix form and noted the different values.

IV. METHODOLOGY

In this system, NeuroSky sensor plays a most important role. The sensor is used to capture the raw brain waves, alpha,

Beta, theta, and gamma, and eye blink detection, attention and meditation signal. In older EEG sensor, they use conductive gel between sensor and head. Neurosky maintain the noise level. The collected data from sensor is directly got into an MATLAB using the serial port. Initializing serial port in MATLAB program and process the data. After that using classification method get difference between data and train SVM. Using serial port of computer calculated result is given to the controller. Controller displays the data on given screen.

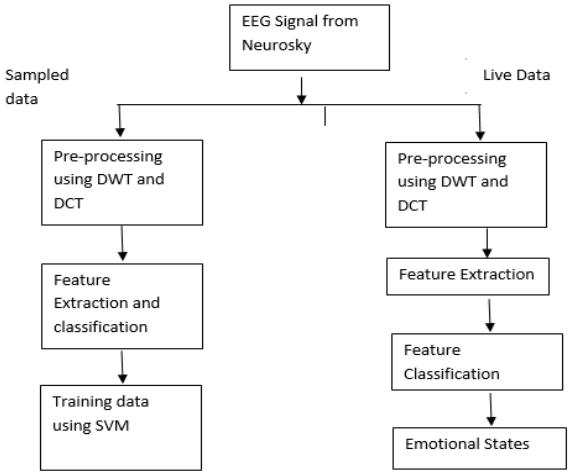

Figure.3. Methodology

V. RESULTS

Feature extraction with the help of SVM and FFT gives features more accurate and precise results from classification point of view. Linear SVM used for classification has provided good generalization and its performance is more as compared to other classifiers. SVM gives higher accuracy and reduces time for training datasets in emotion detection.

VI. CONCLUSION

Brain – computer interface is very efficient technique for a different human machine interface application. In this paper we detected human emotion which is very helpful for doctors to understand patient response. Feature extraction and SVM is a best combination to get desired result.

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