Electro-encephalographic Study and Survey of Feature Extraction for Emotion Detection using Wavelets

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Abstract— Emotions play a very important role in finding the state of mind of others, have role in non verbal communication and different emotions have got influence on the voluntary and non-voluntary actions of the human body. So by finding the emotions of a person we can predict in which state the person is and what the person wants to say. Emotion detection is one of the applications of Brain Computer Interface; it mainly helps the people with motor disabilities, neuronal disorders and other disorders by developing tool for them in real time. We mainly concentrating on extracting the features from the EEG and we have discussed about best wavelet for feature extraction and classifying the emotions using neural network. By considering the some of the intrinsic aspects of emotions this can also help in the treatment of Autism Spectrum Disorder (ASD), Attention deficit Hyperactivity Disorder (ADHD) and anxiety disorder. By developing a real time tool for detecting the emotions automatically can help these people. In this we are mainly classifying five emotions happy, excited, angry, fear and neutral emotions.

Index terms— Emotions, BCI, Emotion detection, motor disabilities, Wavelets, Feature extraction

I. INTRODUCTION

With the recent innovations and discoveries in the human machine interface or human computer interface has lead to the recognition of emotions; as emotions play a very important role in the human–human interactions and decision making too. Since the emotions have got these many significances that can relate to various other things that happens in our body like even the heart rate, thought, breath rate vary with the different emotions. So we can find out in which state the person is and what the person wants to say. Various experiments have been conducted and study has been done on finding and analyzing the emotions from speech, text, facial expressions but failed to detect or predict the exact emotions of a person because sometimes emotions remain internal and cannot be known by external expressions. To overcome these disadvantages and find out the emotions exactly people started analyzing the electroencephalograms (EEG). The brain controls most of the activities of the body. So processing of those signals yield efficient results compared to other this has led to the study and analysis of EEG. Basically electroencephalography (EEG) is a technique of collecting the signals from the brain. It is one of the useful techniques to distinguish different mental states and brain diseases. It is widely used in different medical applications as it contains rich information about the human tasks. This EEG has got lot of interest with various applications from medicine to entertainment like games and for controlling various other things

The limbic system of the brain is mainly responsible for the interpretation of the emotions. The limbic system mainly includes amygdala, thalamus, hypothalamus and hippocampus. The hypothalamus is responsible for processing the stimulus signals and providing the responses correspondingly. For ex: heart rate or galvanic skin response. Whenever hypothalamus gets the information it is passed on to the amygdala; this mainly helps with learning the things and evaluating new stimuli by comparing them with the previous experiences accordingly emotions will be generated. Hence amygdale is vital for processing the emotions

Emotion recognition is one of the applications of brain computer interface and the analysis of EEG for bci deals with neuronal membrane potentials. EEG is obtained or collected by using the electrode cap by placing it on the scalp. EEG measures change in the electrical potential produced by the brain. Neuron is the basic and structural unit of the nervous system. So when a stimulus is provided to the body there will be change in the voltage of inside cell; when this voltage reaches certain threshold level a response will be provided to the stimulus. The voltage range is from -60mv to +20mv. Frequency and amplitude are the characteristics of EEG.
Database collection
10-20 system

EEG is collected by placing electrodes on the scalp by applying gel. So this 10-20 system is an international standard for determining suitable placement of an electrode on the scalp. The name of the system is because of the method of finding the exact position of the electrode. The number 10 in system name represents the electrodes are placed 10% above the nasion and inion and the number 20 indicates the inter-electrode distance.

![Figure 1: the 10-20 system - standardized placement of electrodes on scalp for EEG measurements](image)

There are 16, 32 and 64 electrode systems. EEG signals will be collected with different cases like with eyes open and closed and various visual, audio or audio-visual stimuli. During the entire process the person should be relaxed state should not move and even should not blink eyes because these introduce artifacts into the signals. In order to avoid artifacts band pass filter is used as eye blinking cannot be avoided. The problem with these systems is positions of the electrodes should be chosen carefully. No explicit artifact removal methods are used may increase the amplitude of the signal and the can be predicted as noise. To overcome these disadvantages neuro-sky mind wave sensors are used to collect the EEG signals. We have collected the signal from reliable sources of internet and neuro sky mind wave sensor.

II. PRE-PROCESSING AND FEATURE EXTRACTION

Before processing and analyzing signal processing is necessary as it contains artifacts and has to be down sampled has got particular range of frequencies. As the signal has five band of frequencies delta (0-4hz), theta (4-8hz), alpha (8-13hz), beta (13-30hz), gamma (30-64hz)

In this paper we are using moving average filter for smoothening purposes as it takes the average of two samples plot the average value in between them.

\[ Y[i] = \frac{1}{M} \sum_{j=0}^{M-1} x[j + 1] \]  

Where \( x \) is input, \( y \) is output m-no of point as the m increases the smoothening of the increases Fig 1 and fig 2 shows the original and filtered signal

![Fig 2: original signal](image)

![Fig 3: filtered signal](image)

III. FEATURE EXTRACTION

Emotion recognition mainly includes feature extraction and classification. The main aim of feature extraction is to derive salient features that map the EEG data into corresponding emotional states.

There are various methods for feature extraction in this paper we have used wavelets. First we had found out which is the best among haar, orthogonal filter and db wavelet. Db wavelet is the best among them.

*Why wavelets?*

Wavelets are the advantage over fourier transform, an improved version of fourier transform. Fourier transform allows us to analyze the stationary components but failed to analyze the non-stationary signal. These wavelets allow us to decompose the complex information such as speech, images, music and patterns at different scales and reconstruct them precisely too.

- It is advantageous over discrete fourier transform because of its high localization in time and frequency domain
- It is very fast in computation
- It helps to find the very small details of a wavelet
- It helps to obtain the approximation values of a function

In our project we are using daubechies8 wavelet which decomposes the signal into detailed coefficients and approximate coefficients. Fig (2) shows the generic view of db wavelet. Approximate coefficients are low frequency components and detailed are high frequency components. At every level the signals are divided by 2 and this is called sub sampling and it results in half of the number of samples as shown in fig 4.

Dual tree complex wavelet transform

This mainly decomposes the complex signals into two trees hence the name dual tree; this mainly contains real and imaginary tree as shown in fig 5. Real tree decomposition is similar to the dwt and imaginary tree uses the different filter. After the decomposition of a signal we convert the signal into frequency domain for the computation of various parameters and their analysis.

Artificial neural network

In this project to train the network we are using neural network. Ann’s are the classifiers and it consists of large number of interconnected elements and these elements are called neurons. One of the most used ann’s is multi layer perceptron neural network (mlpnn). This network mainly consists of input layer, hidden layer and output layer. The advantage of using mlpnn is it requires small number of training sets. The complexity of the network can be predicted by the number of hidden layer in it. In this project we are giving energy values as input to the neural network for classification of emotions.
IV. CONCLUSION

In this paper we have discussed about the emotions and their association with the different parts of the brain and how they help in controlling and finding the state of a person which helps the person who is physically challenged. With the above explained algorithms we were able to classify the five emotions of a person.

Future work can be done for more emotions with different parameters as input to the classifier. This paper also helps others to work in bci field as the flow has been explained.

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