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# BCI based EEG Signals for Emotion Classification

**K. Saranya, S. Jayanthy**

***Abstract:*** ***The human brain which is the central processing unit of the human machine is responsible for multiple tasks such as perception, cognition, attention,emotion, memory and action. In human life emotions significantly affect one's wellbeing. Providing methodologies to access to human emotions would be a key for successful human machine interaction. Understanding Brain Computer Interface (BCI) techniques to identify the emotions also help in aiding people to interact with the world like a common man. Many techniques were devised to identify the human emotions of which usage of EEG signals to classify the emotions as happiness, fear, anger and sadness were found promising. These emotions are evoked by many means such as showing subjects pictures of smile and cry facial expressions, by hearing to emotionally mixed audios or by watching videos and at time combination of these.This paper is a survey of all the optimized methods to filter the EEG signal and comparative study of the various classification methods used to classify the emotions is carried out and a multimodal classification technique which makes use of EEG signals and at the same time efficiency is measured with Natural Language Processing(NLP) is proposed for improving the accuracy.***

***Keywords: EEG signal, Emotion Classification, BCI, multimodal, NLP.***

## I.INTRODUCTION

Human beings are known for behavioral oscillations based on their mental state which is determined by their emotions. The technologies thirst to equip machine to understand human completely and the success of natural human machine communication will go in vain if the emotions of a person is not handled effectively. Therefore, the necessity for the machines to understand human emotions has become very important in recent days.

To understand what one thinks and what he feels, the access to the brain which is the central control of body becomes mandatory. The data from brain can be collected in multiple ways as MRI scan or as EEG, ECoG, MEG and there are many others signals that carry brain information. Among which the electroencephalogram (EEG) signals contains many valuable information about emotional states of the person that would help in understand psychology of thebrain. It is advantageous to measure the emotions using EEG signals are more advantageous as they are signals that depend on voltage and so it is very difficult to intentionally influence the electrical activity. Thus the emotion classification using EEG signals could help in improving the brain computer interface (BCI) system.

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The BCI system got multiple applications in recent days such as gaming and medical primary aim is treatment but thethat they could be used as an assistive device for those who were in need of physical and mental assistance to interact with the real world. This paper is a survey of techniques that are currently in use to filter the signals that are being collected and performs a deeper analyses of existing EEG signal classification techniques to efficiently detect the emotions. This paper also analyses the use of EEG in various applications and the recent development in understanding the features of the signal.The aim of this paper is propose an efficient algorithm for EEG classification by using a multimodal approach that not only considers the EEG signal for emotion classification but also verifies the result produced with the NLP technique so as to obtain results of higher accuracy. The particular features that are being considered were that temporal pair of channels (T7 and T8) and high frequency band gave better result which was not dependent on the duration of signal captured. In the proposed method multi-emotions can be classified based on EEG signals of Brain. An EEG signal capturing headset with minimal number of channels is used so that a significant range of signals can be obtained. The system composes three stages on is obtaining the signals offline and perform preprocessing which involves removal of noise and outliers. And using that data to train the classifier on multi emotions and the second stage is the testing data where the data is collected real time and the classifier runs on it to find the emotion of the subject. The third stage is that the subjects were asked to see a picture or hear a music and were asked to comment on it as text. The text is processed using NLP and emotion is being analyzed which is done simultaneously along with processing the EEG signals captured during that time. Both the results were combined to give better results. The paper explains the basic concepts of brain computer interface in the Section II and in its following session the deep literature survey of the existing classification techniques and the various applications of EEG signals dealt in detail. The various methodologies of signalcollectionare in Section IVand the proposed system in dealt in depth in Section V followed by conclusion and future works.

## II. REVIEW OF BRAIN COMPUTER INTERFACE

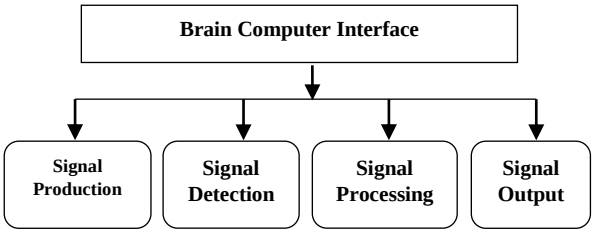


**Fig 1. General Steps in BCI Classification**


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There is a growing demand in the field of human computer interaction and the necessity to do it in a natural way has become The most significant need in it. The expectation of human that system must understand what they think instead of understanding only given commands became the root for the development of Brain computer interface(BCI) technology and that must be established efficiently to bring to satisfy the need of the modern world.

As shown in Fig 1, the Brain Computer Interface BCI is generally classified as follows:

1. Signal Production: A subject is needed to be the source of the signals.
2. Signal Detection. The electrodes of the EEG kit must detect them amidst all other signals
3. Signal Processing. The signals would have noise and outlier and they need to be processed to make it ready to use.
4. Signal Output. Some useful information from processed signal need to be attained

Each of these is a vast research area and it got more detailed explanation as follows

### A. Signal Production

The signal production is the first stage where subject (source of signal) has to produce the signals and there are two ways by which this can be done.

One important way that helps in real time signal collection is the collection of active signals by generating the signals by presenting forced stimuli or showing pictures or asking to imagine movements. The other method is passive way where one can sue the signals that were already collected form the subject. Actively generating signals is very advantageous as the signal detection is easier as the control over the stimuli is completely with us but still it suffers a disadvantage that Noise and outliers are more in active stimuli and electrodes easily corrode on real time experimental usage. Passively generated signals require reading the full brain waves of the subject as the parts of interest could not be found easily.

### B. Signal Detection

The brain signal can be detected by different means. There are many signals like MEG and ECoG other than EEG and fMRI.The EEG signals are electroencephalogram (EEG) signals which are used to find electrical activity of the brain and fMRI studies the blood flow of the brain. Each of these have their own advantages such that few depend on temporal and few on special resolution (i.e) when and where it happens respectively.

### C. Signal Processing

The main problem with the collected EEG signals is that the data contains too much noise. Small actions like grinding teeth, eyelid and eye movement would yield to wide deviation in the single production. The most important work is to filter out the noise and then after this preprocessing the actual signal can be used. When the subject is actively involved in generating signal generation as in case I of signal production, the knowledge about the kind of signal and the time of signal production could be known which would make signal processing easy.

### D. Signal Transduction

The completion of signal processing step tells that the right signals for analysis is being detected. Now this signal has to used efficiently to satisfy the need of the subject. The subject could have any intension such as moving a cursor, moving legs or as in our case its simple knowing the emotion of a person. The main thing that one has to be cautious about is that signals must be efficiently used as Signal cannot be collected any time and also the entire system is prone to error as the signal collected is very weak.

## III.LITERATURE SURVEY

EEG signal is being used in wide area of research to find the mental state of people. Than the common man these signals help in analyzing the emotion of autism kids who are generally said to have social behavioral impairment and difficulties in stereotyped movements and hesitations in interaction with people. In [1], a mobile robot attached to a laser sensor component was used to locate the kid and find the distance between them. A wireless EEG cap was placed over kids head and the signals were captured and processed to enable further interactions. Two ways of interactions were designed one using dog mode where the mobile robot identifies the kid and moves towards it and the other was follower mode where the robot moves away allowing the child to follow it based on the interest shown by the kid which was understood by analyzing the EEG signals.

EEG signal can also be used to predict rating of video advertisements. A multimodal approach was proposed in [2] where EEG signals were collected making the subject watch an online video and at the same time the global rating for the video was being calculated by using NLP. The random forest based technique was used for prediction of rating using EEG data and this fused approach gave an encouraging result when tried over 25 subjects.The EEG signals can be used to classify happy and unhappy emotions that were elicited by pictures as suggested in [3]. They used PSD as a feature and SVM as a classifier and obtained an average accuracy of 71.20%and derived to the conclusion that temporal pair of channels (T7 and T8) and high frequency band gave better result which was not dependent on the duration of signal captured. In [4], a multimodal system was used which compared the brain(EEG) and other peripheral signals for detecting the emotion of the person. The system took multiple inputs that include electroencephalogram, galvanic skin resistance, temperature, blood pressure and respiration, which could reflect the emotion of a person. The emotions were elicited with pictures corresponding to different valance-arousal emotions. The Quadratic Discriminant Classifier was used for evaluation and found the result that EEG signals perform better than other peripheral signals thus concluding that as best feature for understanding emotion of a person. As per the analysis in paper [5] the inner state a person could be recognized using their EEG signals. The appropriate placement of electrodes and selecting the features for the experiment needed deeper understanding of all the features.



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The experiment is conducted comparing all the features using machine learning techniques on a data set that was self-recorded and it was found that features selected by multivariate methods perform better and the best position to place electrodes were over parietal and Centro-parietal lobes. In paper [6], a new functional model for BCI System design to match up with the communication hindrances due to lack of common vocabulary was proposed. A taxonomy was developed and along with the model delivered a framework for BCI system and its effectiveness was testedwith other equivalent technologies and found to be successful.

The brain computer interface gained so much craze as it supports the unblessed people to act as blessed ones in the world. The paper [7] does a survey on all the research efforts taken to develop BCI research for unblessed people with supportive aids. The usual Electro-Encephalogram (EEG) based BCI system was proposed which could assist the paralyzed or physically challenged people in performing their various routine tasks.The BCI research has gone through number of stages of development and at present stage they could be used in wider range of applications. The BCIs started understanding the emotional state of the person. Having access to brain activity they could provide significant insight into the user's emotional state. As suggested in [8], understanding the emotion pattern could be used in two ways. One way is that knowing the emotion signal pattern, they can be identified and removed from the original data signal so that the intention of the user is correctly met irrespective of their emotion and the other thing is that the emotion of a person would help in communicating with other machine in a much natural way.

In [9], two different feature selection techniques of EEG signals were being proposed and they wereconcluding the features mostly used for emotion recognition. The techniques that were proposed consist of statistical characteristics features based on PSD (Power Spectral Density) andfeatures based on HOC (High Order Crossings) and the best results were achieved was follows: PSD based technique provided 70%, and HOCbased technique provided 69.5% respectively and thus both proved to be equally good to use for selecting features in EEG signals. Researchers on EEG signals were keen on the signal production standard as noise free signals were the ultimate aim of it. So they restrict facial, eyeball, jaw movement and rely on large number of electrodes when capturing EEG signals which was not practically possible in real scenario. In paper [10], experiments were carried out on highly contaminated and noisy datawith fewer number of electrodes that ranges from 4 to 6 electrodes and an average classification accuracy of 33% for joy emotion, 38% for anger, 33%for fear and 37.5% for sadness was achieved.

The research on EEG signal classification drawn many attention and in [11], the effectiveness of classification techniques was examined for a movie induction experiment that made subjects to spontaneously evoke real emotional states and collect an EEG data set of six subjects. The experimental results on the EEG data set drawn few conclusions that power spectrum feature turned out to be superior and a linear dynamic system based feature smoothing method improves accuracyand also the trajectory of changes in emotion can be visualized by subject-independent features reduction with manifold learning. In [12],a real-world multimodal Brain Computing Interface (BCI) data capture metadata model was proposed which makes use of the ability to voluntarily controlling alpha waves through eye movement. This system could be used for the control of external devices like wheelchairs using the alpha brain waves. The response generated through the movement of the eye (detecting and controlling the amplitude of the alpha brain waves) is interfaced and processed and provided as input to smart control devices. The occipital lobe provides signals that differentiate the amplitude of the alpha waves generated due to these several movements. In the testing period, subjects were asked to close and open their eyes and they were able to control limited movements of a Robot with it and similarly the other movements were also tried and with the help of the alpha waves the system was successful in doing the respective action.

## IV. METHODLOGIES FOR EEG SIGNAL COLLECTION

A brain–computer interface (BCI) is a direct communication pathway between a brain and an external device. The aim of BCI is that it is Assisting, augmenting or repairing cognitive or sensory-motor functions, Gaming, developing technologies for people with disabilities, assist blind people to visualize external images, assist paralyzed people to operate external devices without physical movement, decode information stored on human brain

There are three types of Human BCI EEG acquisition process. They are

1. Invasive
2. Partially invasive
3. Non Invasive

The invasive type is the process of implanting electrodes directly into the grey matter of the brain during neurosurgery while the Partially-Invasive method implants BCI devices inside the skull but rest outside the brain and among all method Non-Invasive method is highly used in research as the electrodes placed outside the skull. The techniques for BCI that are frequently used are Electro Cortico Graphy (ECoG), which is of partial Invasive type and Magnetic Resonance Imaging (MRI) and Electro Encephalography (EEG) are non-invasive and they have electrodes placed from Scalp.

Electroencephalogram (EEG) is used in measuring the electrical activity of the brain which is generated by billions of nerve cells called neurons. This EEG activity is recorded through electrodes placed on the scalp. EEG signals categorized into different rhythms frequencies ranging from 0.5 Hz to 30 Hz. The EEG waves are classified as Delta, Theta, Alpha, Beta and Gamma waves as shown in Fig 2. After proper training, subjects generatebrain signals (Features) and a feature of the continuous EEG output is used that the user can reliably generate (waves), one can also evoke an EEG response with an external stimulus (evoked potential).


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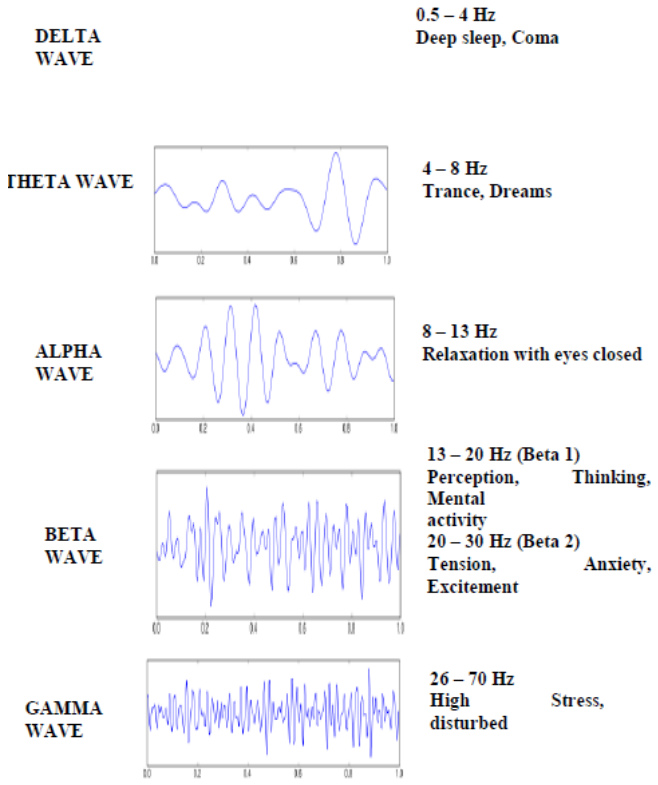


**Fig 2. Different waves of EEG signal**

At relaxed state, Alpha has high amplitude and during Excited state, Beta has high amplitude. When a person is shifting from relaxed to excited state then that could be easily be recognized with the amplitude shift from alpha to beta waves. A Standard "10-20 System" with Spaced apart 10-20% is used to capture the EEG signals. The letters showing the various regions of the lobes of the brain as in Fig.3 are

- F - Frontal Lobe
- T - Temporal Lobe
- C - Central Lobe
- O- Occipital Lobe

Number for exact position of placements of electrode are Odd numbers to the left and even numbers to the right. The electroencephalogram (EEG) used for measuring cognitive workload as it is lower cost with easy handling and it has wireless connectivity and adding to it has lower maintenance cost. The raw EEG signals are usually corrupted with various types of noises, trends and artifacts that occur due to eye blinks, muscular activities etc.

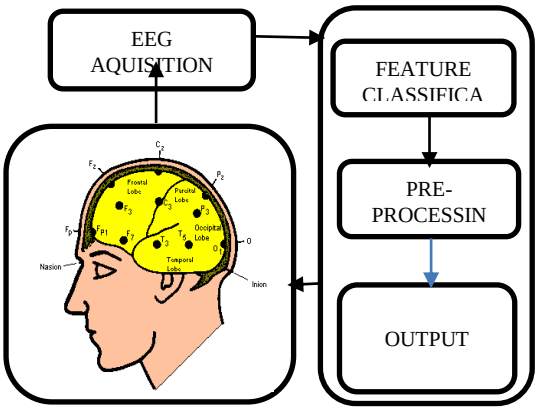


**Fig 3.EEG Signal Processing Unit**

## V.PROPOSED SYSTEM

The proposed system makes use of EEG signals to understand the emotion and at the same time its effectiveness is checked with NLP method of classification. The first step is that, the original EEG signals that was obtained requires two actions to be done, one is independent component analysis (ICA) as it transforms multivariate random signals into its mutually independent components and the other one is Moving Average (MA) which is used for signal smoothing that simply replaces each data value with the average of neighboring values. The above techniques have been used to remove the effect of such unwanted artifacts before extracting features. Later regression analysis on EEG signals is performed using random forest regression. The second step is the textual identification of the subject's emotion by the comments posted by him and are classified using natural language processing toolkit (text blob). Finally, EEG based rating is combined with sentiment score to improve the overall prediction. This entire proposed system is depicted in Fig 4.

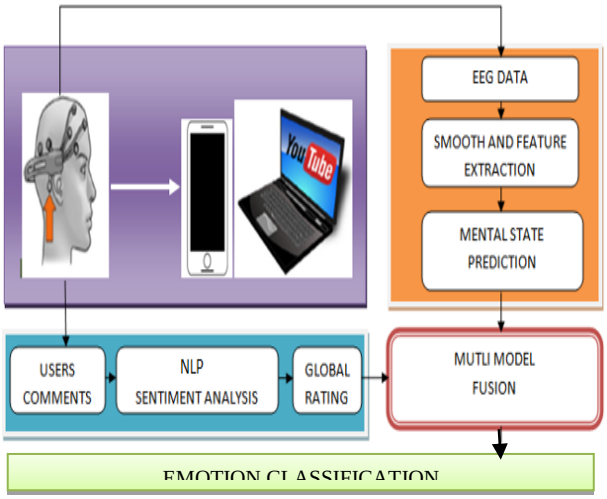


**Fig 4. Proposed system**

The proposed system is designed so as to classify the emotions into four classes but each of which got a number of sub classes as shown in fig 5. It was easy to classify the main emotions using the EEG signals and the sub classes were derived only with the help of NLP. Thus the system could efficiently classify the emotions into one of the sub classes.

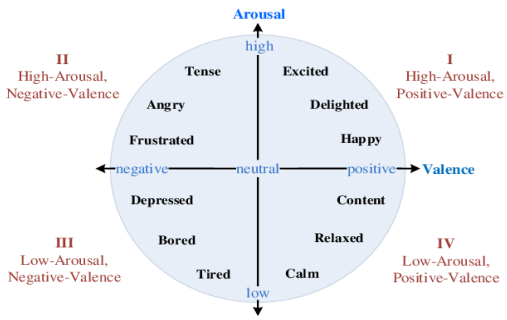


**Fig 5 Classes of Emotions**



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## VI.CONCLUSION AND FUTURE WORKS

There are lot more challenges inhybrid BCI architectures, user-machine adaptation algorithms and also in BCI reliability analysis by exploiting users' mental states. There is a need for development of novel EEG devices and the few areas that have scope of research in this area are

- Color Meditation – Effect of color on Human emotions, thought and its side effects
- Design of an EEG based Emotion Recognition –An Application to Music Therapy
- Brain Browser using BCI – An application for physically challenged
- Study on the effect of Yoga and Meditation on Human physical system
- Study on early diagnosis of Brain related diseases based on EEG
- Study for Reducing Stress and Strain by Applying Music Therapy
- Real-time BCI-Based Target Selection - 2-D Cursor Control
- Design of Robotic Wheelchair Through BCI
- On board Chess playing through BCI

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