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BRAIN COMPUTER INTERFACES TECHNIQUES FOR STRESS MANAGEMENT

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Abstract:

BCI is one of the interesting areas of research from engineering, psychology, rehabilitation, neuroscience ,computer science and physiology. Providing communications capabilities to highly disabled people like totally paralyzed or 'locked in' by neuromuscular neurological disorders like amyotrophic lateral sclerosis, brain stem, stroke, spinal cord injury ; is the important goal of BCI. It is well known that a traditional technique has lowest performance as compare recent technologies in case of detection of stress or any psychological problem. Here, in this paper explained brain interface technique for detection /analysis of stress. The investigation aims to find out best combination of algorithm and classifier which is resulted in highest accuracy for recorded input based on alpha and beta waves. The average sensitivity, average specificity and F-scores are the parameters considered for the analysis purpose . The studied the k-NN, SVM, NB, CT and NN classifier in combination with KDE, RER, Hjorth, ELC and BFCC feature extraction algorithm. It was observed that the combination of k-NN classifier along with ELC features extraction algorithm gave highest percentage accuracy for happiness up to 89.03%. Similarly, we checked the accuracy for happy, sad, clamp and angry emotions.

Keywords: *Stress, prefrontal cortex, Brain signal, feature extraction, EEG Signal, Brain computer interface (BCI).*

I. INTRODUCTION

Software or hardware communications system that allows only cerebral activity to control external devices or computers is called a brain computer interface (BCI). Different technologies survey reported about BCI. BCI is an emerging technology widely used in various applications [1] [2]. Software or hardware communications system that allows only cerebral activity to control external devices or computers is called a brain computer interface (BCI).

Different technologies survey reported about BCI. BCI is an emerging technology widely used in various applications [1] [2]. It is most useful and highly accurate system. And hence it is used to observe the different brain activities like such as magnetic, metabolic or electrical activity. This technique is also useful to find out stressed or unstressed situation of human. Psychological response triggered by external factors is known as stress. Physical and mental are the two factors followed. Stress can be the results of new environments; increased demands at workplace, also emotional resulted due to loss of loved one, sudden changes in the life. Stress can affect performance of person in his day to day life [3]. It can negatively impact on the life by having risk about mental illness, and risk of psychiatric illness. Depression, hypertension, cardiovascular diseases, anxiety, cognitive dysfunctions are the some risk factors which are the result of stress [4]. Basically stress is the negative riposte which varies person to person and responsible to disorient person from the defined aim. Positive stress and negative are the types of stress. Positive stress is to keeping person to alert and also ready to avoid the danger and in case of negative stress person is suffering with mental disabilities [5]. The recognition and intensity varies according to situation occurrence as well as with person to person at different time, for example subsisting abilities and management approaches are different for everyone. To manage the stress experience continuous monitoring of stress is necessary. It is important to reduce human stress and there are many of methods available for reducing the issues of stress such as yoga, relaxation therapy (like music or drugs) etc. [3], [6]. Recently, it is observed that the population having range of 17-35 years, are under more stress which is anxieties issue because of different reasons like family problems, possessiveness about future and many more things [7].

Ways to identify patterns in the fluctuations in the stress, get from continued stress observance, it also provides the best clinical interference. There is a steady increase in users of personal health monitoring system, and it is in trend nowadays. At priority level, Many psychologist was analysed the behaviour of the stressed persons[8]. The facial

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expression, reactions, sudden behavioral change gives indication either the person is under frustration/stress or happy. Survey of previous years paper on stress taught about methologies used for stress detection and remidies for the same. In earlier years, sleep or complete bedrest was one of the important solution for stressed person. But this scenario was helpful for short time, for long time it fails. So for long term relaxation purpose, exercise becomes an effective solution to reduce their stress [9].

From last decade, the research is going with advance technologies, preferably sensors are used to do analysis of the stress. Use of sensor allows the system having minimum efforts. Access to the psychological and physiological signals became easier due to generated data of the devices. To create assumptions about person's basal health other behavior data can be used. In such studies of analysis of mental disorders and other mental diseases, there has been surge from last few years. Data including physiological parameters such as Galvanic Skin Response (GSR), Electrodermal activity, Electroencephalogram (EEG), Heart Rate Variability (HRV), Electrocardiogram (ECG), Blood Pressure (BP), Body Temperature, Respiration Rate are found from this, and data is used as classifiers on those studies resulting different accuracy levels[10],[11] and[12].

In this paper ,we observed the stress condition with the Electroencephalography (EEG) signal. EEG signal catches the electrical sign created in the mind. These signals are used to measure electric pulses which are transmitted by the brain. In this signals it uses single electrode or multiple electrode configurations are measured in the difference in voltage [13]. For recording of the electrical activities of an individual's scalp this is used.

This signals measures the fluctuation in voltages because flow of current pulses within neurons during any neural activity of the human brain.

EEG signals are divided into bandwidths [14] and they describe their activities, but these divisions are depends on the continuous bandwidth spectrum of consciousness. Delta waves become slow in frequencies and loud in amplitude and also functional in this case. And Gamma waves can be fast in terms of frequencies, complex and subtle. We used alpha and beta wave for performance analysis. It is also helpful analogy to learn about Brainwaves as musical notes [13] and [15]. Frequency with lower value behaves like extremely piercing drum beat whereas frequency waves with high value behave like casted flute ultrafine. Belows fig.1 shows the standard brain wave chart.

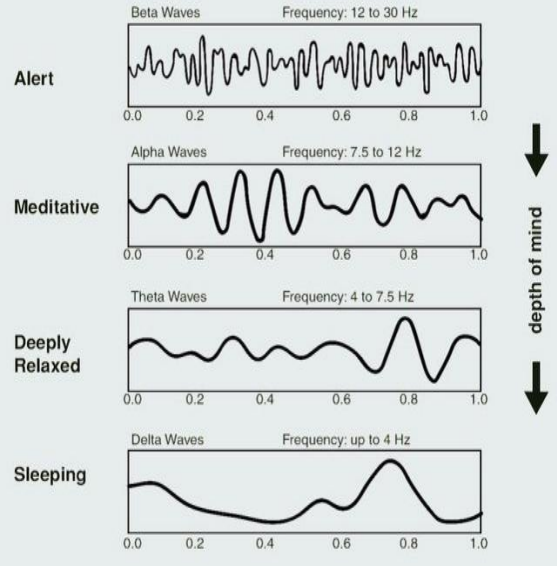

Fig.1 Brain waves chart

Rest of paper is organized as: Section II gives the literature survey. In section III, proposed model is discussed in detail for real time system. Results are summarized in section IV. In Section V, conclusion is written. Lastly references are listed in section VI.

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II. Literature survey:

Table 1: literature survey

Sr. No	Author and year	Physiological Signals	Research Scenario	Accuracy	Observations
1.	*Doma V & Pirouz M. 2020*	EEG Signals	Collection of sample data by video's from 32 participants.	84.73%	They proposed system using different classifiers such as SVM, k-N N,LR.They concluded that binary training class and segmentation class with different model give better result. They suggested that to use different for analysis of stress at different environment.
2.	*Attallah O. 2020*	EEG signals Feedback model was used.	66 participants were observed during analysis. Real time analysis presence of neuro feedback system. Used hybrid feature set with five different models.	98.48%	MSD scheme is proposed having two electrode kept at different side of scalp. System has highest accuracy in real time. They proposed arithmetic tasks.
3.	*Norizam Sulaiman 2020*	EEG signals	Calculation and analysis of 180 data sample was done.	88.89%	Classification of stress in a respective group was done. Used classifier: k-NN taking advantage of combination of SC and RER.
4	*Huijun Zhang et al 2020*	Heart Rate Variability (HRV), ECG, Galvanic Skin Response (GSR), Blood Pressure(BP), Electromyogram(EMG), EEG	Used TSD Net. Collection of video dataset.	85.42%	2 Leveled analysis of stress detection. Analysis was performed on the basis of face and action level detection i.e. facial expressions and the action for observation of the stress.
5.	*Sanay U. et al 2020*	EEG Signals	EEG signal collected from 33 participants. They had used five channels for analysis purpose with EEG headset	85.20%	Used Classifiers : SVM and LR.They concluded that classification was better when done with control group. For classification of long duration stress (α) asymmetry used as potential bio-marker along with SVM classifier.

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6	*Vikrant Doma and Matin Pirouz 2020*	EEG signals	Data was collected from in 32 biosemi form with 48 channel recorded at frequency of 512 Hz.	70-86%	They performed the comparative analysis of the different machine learning techniques. Analysis was carried out for different model with /without PCA (principle component analysis)
7	*Plechawska-Wójcik M 2019*	EEG signals	Estimation of the cognitive workload along with subject independent approach	Approximate 91%	Data acquisition was used as base. Different model with different levels were analyzed.
8	*Matteo Zanetti et.al 2019*	Physiological Signals ECG, respiratory signal, blood volume pulse, and EEG.	Recording sessions performed=20 Total peoples under analysis=17	76.5%	Classification of stress doe on psychological signals. 59 times, total 300 samples were processed (structured). Used classifiers: Random forest classifier, logistic regression.
9	*Yekta C. 2019*	Heart rate variability HRV, EEG signals, EMG Signals	Data base was generated based on multiple bio signals received from different sensing devices. Counting, storage as well as processing of large data was done.	94%	Detection of stress by using smartphones and wearable devices.
10	*Hasan M.J. and Kim J.-M. A. 2019*	EEG signals	Parameters considered for analysis purpose: DEAP Dataset. Down sampling of recorded signal done at 128 Hz. Band pass filter= 4Hz to 45 Hz.	73.38%	Elimination of G artifacts. Model based on Mental state classification. Used Classifier: k-NN. Analysis of stress was done with hybrid pool in presence of Boruta.
11	*Zamanian H. et. al 2019*	ECG signal	Data was collected from 16 participants involved in study	93.86%	Followed technique of processing of discrete signal. Used Classifier: support vector machine. used Algorithm: genetic evolutionary algorithm
12	*Chin Z.Y et. al 2018*	ECG signal,BCI	Analysis was carried out on 10 subjective. They used ECG signals Base of analysis = performed mental addition. Use levels : 1. Easy ; 2.Medium; 3.Hard	90%	Brain-Computer Interface (BCI) was used to resolve the difficulty depth. Base of research Perform mental arithmetical tasks.

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13	*Saeed S.M.U et. al 2018*	EEG signal	33 participants were considered for analysis from education field.	85.20%	By using two different labeling methods for the classification of long-term stress in humans using EEG signals.
14	*Zyma I et. al 2018*	EEG Signals 10/20 system	36 persons were put under observations.	73%	Data base of Mental cognitive workload and background ECG reference parameter was considered for analysis. Base of analysis-Mental serial subtraction.
15	*Saeed U. et. al 2018*	EEG Signals	Analysis is carried out on the basis of PSS-10 form filling	78.57%	Neural oscillation was the key feature used for classification of stress.
16	*Minguillc on J. 2018*	EEG, ECG, EMG, and GSR Signals	Analysis is carried out on 10 persons. Age range:18-23(Count:5 male and 5 female mean=20 ± 2 years.	86%	Real time system. They considered different bio signals such as ECG, EMG etc.
17	*Ryan Hefron 2018*	EEG signals	Participants age range =19 to 27 Mean value =21.9 Deviation value=2.57 year	80%	They used model of zero data cross participants. It was resulted into improves and increased sequence length.
18	*Shargie F et al. 2018*	EEG Signals-Brain system-Master 24E	SCW test for 10 min is carried out on 20 peoples belongs to age group 20 to 24 in three different phases: 1st phase: with EEG+ fNIRS Signal was recorded (for 1st day). 2nd phase: 40 min aerobic exercise (from 2nd day to 6th day. 3rd phase: Measurement of EEG+ fNIRS signal (7th day)	94.79	Analysis bassed on EEG signals to reliably discriminate between mental stress levels. Remarkable increment in power of α and θ with decrement in β rhythm was observed after completion of exercise after 5days
19	*Bairagi V.and Kulkarni S. 2018*	EEG Signals	Collection and Analysis of EEG signal is carried out for age group (23 to 28 years)	88%	Measurement of stress levels of human using EEG signal analysis as done.
20	*Dongkoo Shon et.al 2018*	EEG Signals.	Trial for stress examination direct on 17 participants.	68 %	feature selection using genetic algorithm-based detecting enthusiastic stress state.

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Section III : Methodology

This section includes the methodology, proposed model and its working. It also summarizes the EEG preprocessing, feature extraction and classification in detail.

This proposed technique is applicable for the real time mode for stress detection which uses bio signal electroencephalography (EEG) generated by sensors for analysis purpose. Bio signal is recorded with the help of electrodes which is put at the prefrontal area of the head (cortex) [30], [31] ,[32]. There are total 32 spectral channels can be available for the analysis. Out of that, one channel used for real time analysis named as FP1 i.e. prefrontal cortex. This area has been embroiled in personal as well as social behavior, decision ability etc. [33] and [34]. For the validation of this proposed model, we studied the different methodologies estimated in previous year research published on same topic [35], [36],[37] and [38]. With the reference of these techniques, we proposed model for the real time analysis.

In this study, persons were analyzed under two conditions i.e. stressed and relaxed, by their recorded bio signals.

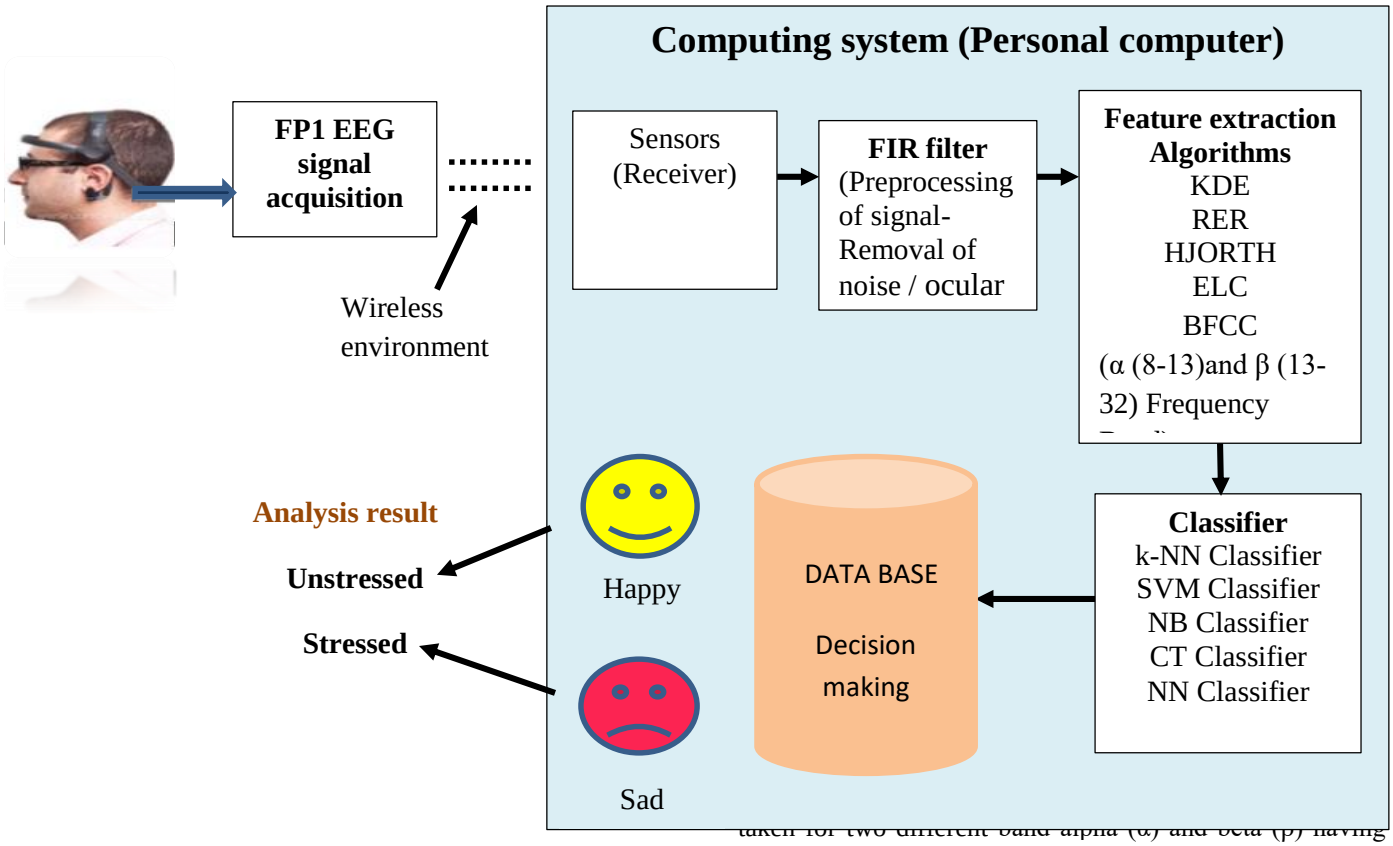

Fig 2: brain interface technique for real time stress analysis

Here we con observations and analysis; one is happy for 'unstressed' person and sad for 'stressed' person. For analysis K-nearest Neighbor (KNN) [39], [40] and[41] ,Support Vector Machine (SVM) [42], Naive Bayes (NB) [43], classification tree (CT) [44] and[45],Neural network (NN) [46] ,[47] and [48]classifiers are used along with different algorithms [49],[50],[51],[52] and [53]. The proposed algorithms are: Kernel Density Estimation (KDE) [54], Relative Energy Ratio(RER), Energy Logistic Coefficient (ELC) , Hjorth coefficient/ parameters and Band Frequency Cepstral Coefficient (BSCC) .

Brain interface technique is highly preferable among the other techniques as it has high accuracy for stress analysis with different combinations of algorithms for feature extraction and classifier. On the basis of literature study, methodology for stress analysis with brain interface technique shown in belows fig.2. The bio signal is recorded via the electrodes which contain highly sensitive sensors who respond to minor fluctuations, pressure in prefrontal area of head i.e. brain rhythms. This observed bio signal converted into electrical signal with appropriate transducer. Further processing of feature extractions is done with application of different algorithm.

taken for two different band alpha (α) and beta (β) having ctively. From that band, we alue near to upper value of that respective band. Once the featured values are recorded, then these values are trained with different classifier. At end of training of algorithm, the signal are classified for happy and sad emotions depending on training output.

EEG pre-processing:

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Basically, EEG signal is electroencephalography associated with brain rhythms. In case of any portable system, for real time analysis many bio signal sensors are available. Preprocessing is nothing but the conversion of the physical signal (bio signal) into system compatible signal for further processing. Few sensors are EMG electrodes, ECG electrodes, EEG electrodes etc. EEG is a raw input data for system consist of unwanted signal from the environment during recording. Normally, strength of EEG signal is at low level. Hence removal of that primary artifacts (noise and ocular) is little bit difficult task. Solution to this problem is to use FIR filter for filtration of noise.

Feature extraction

Features observed in the above section used under visual inspection of signals behavior and literature survey, to detect the anxiety and stress states from EEG signal. Stress is inversely related to the frontal asymmetry within the alpha band. Alpha and beta band powers are used to calculate feature. From the natural logarithms, subtraction of right side channel and left channel is takes place, i.e. (L-R). Feature set is formulated by calculating the features. Power in the vast majority of electrodes and bands are correlated between two states of stressed (sad) and relaxed (happy) across subjects, cause brain activity patterns and also the power presents wide variability in inter – subject. Pair should be in between two states should followed is suggested in these findings.

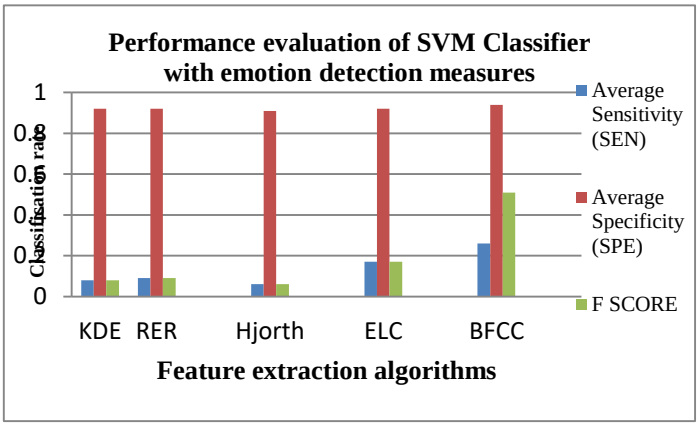
Classifications

Classification is basically termed as the grouping. The output signal from feature extraction block is classified depending on their nature with the help of different classifiers. Classifiers used for analysis are listed above. K–nearest neighbor (KNN) was the first algorithms were applied to system. KNN is a non-parametric in case of functions; it is supervised algorithm useful for classification. Data is separated into classes to detect new data classes that are used in dataset. Data based structure model. In KNN, no explicit in training phase and it is important than the other algorithms. That's why, phase of training is quick. Output is obtained as a discrete variable. Majority vote of neighbors is used to determine assigning classes to an object. High accuracy is imparted by KNN.

In sentiment analysis Naïve Bayes is used most of the times. It works on the theorem of Bayes. Algorithm works on text prediction by the words frequency and categorization. In many of the real word situations as document classification this classifier works very well. Small amount of training data is required to estimate the essential parameters. As compared to others this one is superfast. For classification and regression problems, Support Vector Machines (SVM) is used, it is supervised machine learning algorithm. For the purpose of study, algorithm classification is used. With n dimensions, every value of the data is plotted in the dimension space, n is feature numbers chosen.Each feature determinates the value of coordinate. To find best hyper plane which differentiates different classes, classification is performed. Kernel is used to implement SVM algorithm.

The Decision Tree classifier algorithm is one more algorithm is applied. It is the most powerful and also popular algorithm for regression and classification. It is a tree where every node represents a feature, every branch represent decision and each of the leaf represents an outcome. Many subsets are formed from dataset based on attribute value test and also the training phase is performed.

Recursive partitioning is the recursive fashion that is the process performed repetitively. System is tested using test set, after training phase. For both classification and regression analysis Support Vector Machine is used. To separate hyperplane discriminative classifier is used. Additionally it performs nonlinear classification but basically it is a linear classifier. It performs nonlinear classification by points mapping the implicitly into HD features. To train and test the system database is required, trained data is responsible for the results. As compared to



any other machine it gives accurate results. Final categorized result is provided at this stage. Neural network is more algorithm is use to classify the data. Basic idea behind it to train the network continuously till the threshold is crossed. One the condition becomes true it put that input in one group and if condition is false it put input at that time in another group. Neural network algorithms are much powerful as compare to others. Depending upon the result obtained at this output stage of each classifier, the confirmation received either the person is stressed (sad) or unstressed (happy).

IV.Results:

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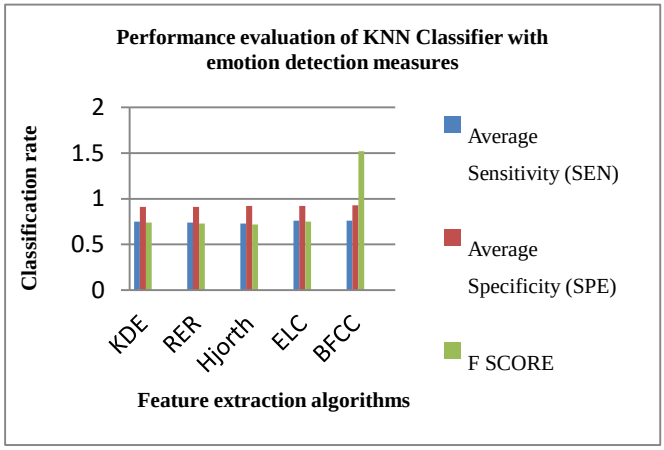

Fig. 3: Performance evaluation of KNN Classifier with emotion detection measures

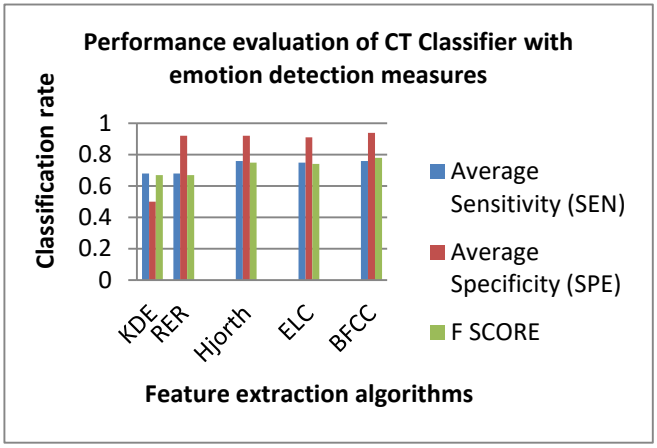

Fig. 4: Performance evaluation of SVM Classifier with emotion detection measures

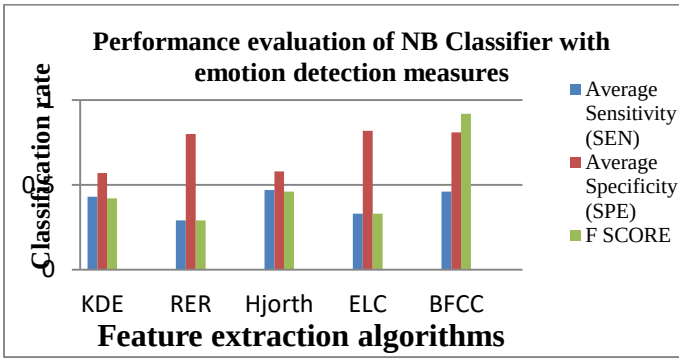

Fig. 5: Performance evaluation of NB Classifier with emotion detection measures

Fig. 6: Performance evaluation of CT Classifier with emotion detection measures

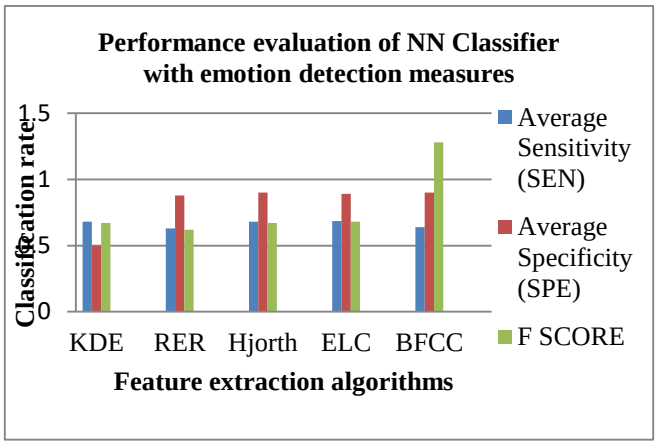

Fig. 7: Performance evaluation of NN Classifier with emotion detection measures

Discussion on result: Average sensitivity, average specificity and F-score are the parameters considered for analysis. Sensitivity indicate that how those algorithms and classifiers are react for minimum input signal. Sensitivity should be 100% for real time system. It measures the positive rate i.e. input those are correctly identified. Specificity is another important parameter used to measure the negative rate i.e. wrong result measure correctly. Here F factor indicates more precise value. It's range varying from 0 to1.

Accuracy alpha and beta band was plotted for channel 1 and channel 17 respectively. From obtained result, it is clearly observed that the combination of NN classifier and BFCC feature extraction result gave high accuracy as compare to other combinations.

Conclusion: Research of BCI is nearly young multidisciplinary field combining researchers from computer science, psychology, rehabilitation, engineering, neuroscience, physiology, and other health care disciplines and technical. As a conclusion, BCI is best and highly accurate technology for stress detection. This research work is an effort to design a user-independent human emotion detection framework utilizing EEG signals. To discover optimal and efficient features for human emotion detection, feature extraction techniques have been proposed. In this research, human emotion happy (unstressed) and angry (stressed) detection based is done with different feature extraction algorithms and classifiers. Kernel Density Estimation (KDE), Relative Energy Ratio(RER), Energy Logistic Coefficient (ELC), Hjorth coefficient/ parameters and Band Frequency Cepstral Coefficient(BFCC) are used feature extraction algorithm along with K-nearest Neighbor (KNN), Support Vector Machine (SVM), Naive Bayes (NB), classification tree (CT) and Neural network (NN) classifiers for real-time stress recognition system have been developed for human emotion detection. It was observed

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that NN with BFCC resulted in highest accuracy with 89.03%.

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