A Study On Stress Based Emotional State Detection Using EEG Signals

A.Y. Mohamed Ibrahim, G.Malathi

Abstract: Emotion plays an important role in day today's life of human being. The brain is a central processing unit for every humans and responses to different emotions such as memory, anger, happiness, sad, frustration, fear, satisfaction, calm and pleasant. This paper focuses on the survey of stress based emotions using EEG signals and machine learning models that are used in the detection

1 INTRODUCTION

Emotions are inseparable part in the daily life of every human being. Many people experience 'stress' in there every day routine. There are positive emotions as well as negative emotions. In European countries 51% of workers are getting stressed day by day in their usual workdays. The positive emotions are love, happy, calm, satisfaction, hope etc. The negative emotions are hate, sad, anger, guilty, fear, shame etc. The emotion dataset can be obtained using electroencephalography that can collect EEG signals from human brain. The subject under consideration is initially brought under a calm state and signals are captured. Later allowed to enter into different emotional states and signals are recorded. Furthermore the facial expression or the voice tone can also be used to add flavor to the work in detecting the emotions in human.EEG is one of the most advanced techniques to communicate with machines and computers. It is non-invasive; it records only electromagnetic waves of the brain.

2 LITRATURE SURVEY

EEG (electroencephalography) is one of the method to gather the activity of the brain. It records an electrical activity with help of electrodes that is placed on the scalp and it displays a net average of all neurons that processes. It can get informationabout the functions of brain that is either the person is in emotional distress which can be associated with the possible diseases [1]. There are more than 11000(millions) of neurons present in brain which is a basic function of nervous system. The electrical activity is generated by the thousands of neurons in (volt). EEG is the advance technique to record the human brain activity and the recorded activity of brain can be displayed in voltage screen as EEG signals [2].

2.1 Stress Detection

The features of theta (4-7Hz) and beta (12-30Hz) waves can calculate the stress. The theta can records the difficult task of the brain [3, 4] and beta can notice the body movements such as limp and hind limp of Hand and Leg [5, 6]the sad emotion is considered as stress state of human being.

- *A.Y. Mohamed Ibrahim, School of Computer Science and Engineering, Vellore Institute of Technology Chennai, India, PH-7708501139. E-mail: aymohamedibrahim1999@gmail.com*
- *Dr. G. Malathi, Associate Professor Senior, School of Computer Science and Engineering,Vellore Institute of Technology, Chennai, India,PH-9840833337 E-mail: malathi.g@vit.ac.in*

2.2 Calm Detection

Here the calm state detection can be calculated by two signals they are delta (<4Hz) and alpha (7-12Hz), which can record the calm state. Delta signal can calculate the depth of sleep which is referred as slow wave sleep [7, 8] for example: If a person is in sleeping in a state referred as pleasant then it is called slow wave sleep.At this time the calm dream is occurred in human brain. Alpha wave can record the relaxation of the brain and it also linked inhibition and attention [9]. The calm state can be identified by involving the subject to hear music and can calculate the subjects brain activity with the help of EEG electrodes that is attached to the scalp [10, 11] here the given tabular column is showing the activity of a human brain that he/she response with that give music.

TABLE 1 *ANALYSIS IN THE BACIS OF STIMULATION ANDEMOTIONS*

STIMULUS/ DURATION TYPE	EMOTIONS
20s/electronic, classical and rock (music) [10]	Annoy, Cheerfulness, peaceful
30s/ 8 cross-culture instrument [11]	Delight, Worry, quite

3 DESIGN OF PROPOSED WORK

This work uses DEEP dataset to acquire the frequencies. The Figure 1 shows the entire operations of data gathering with the help of electrodes [12].

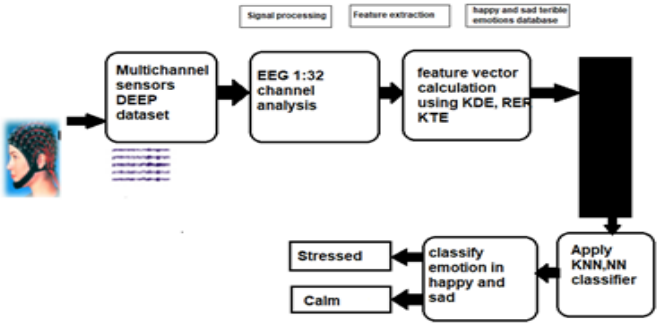

Fig.1*.Recording of EEG signal in subjects induced with emotions*

Here the person in a diagram wearing electrodes cap around his head (scalp) and the work of EEG gathering a data from the brain via the waves and displays in the screen, Further after the calculation it can be found that the person is in stressed or calm state. The EEG electrodes are arranged in 13 functional scalp areas [13], as shown in Figure 2. The performance of the EEG waves (delta, theta, alpha ,beta, gamma), was recorded in the base of brain functions that are recorded by the set of electrodes. Those activities are recorded in the nonlinear nature of EEG signals.

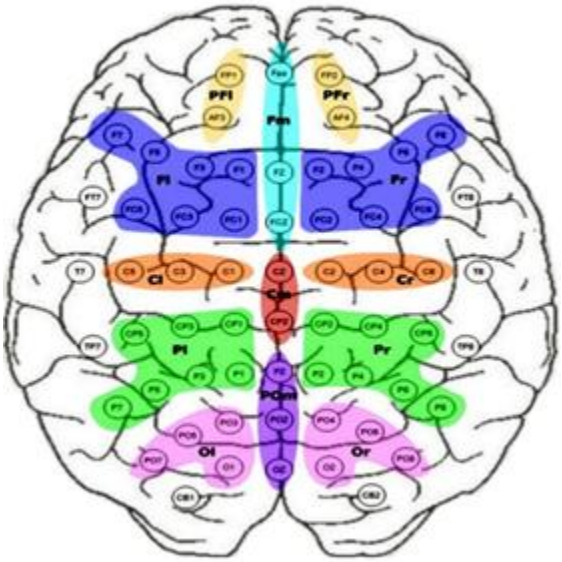

Fig. *2. Set of 13 functional electrodes*

4 FEATURE EXTRACTION

The feature extraction method consists of various time frequencies and most of the extraction has in critical stage in design of EEG signals. Pre-production of EEG signals are split into its domain features according functions and there is no enough learning data for this machine learning algorithm. The feature extractions are statistical features, frequency domain features and so on. Frequency domain: The most predominant uses in study of emotion state detection using EEG signals is the power pre frequency band according to those five signals Alpha, Beta, Gamma, Theta, as well as Delta [14, 15, 16]. Delta waves are recording the deep sleep activity of our brain, and Theta waves asses the sleepy state of the human, Alpha wave denotes the awake comfortably of human. The beta signals examine the concentration level of human and the gamma wave become visible in EEG monitor rarely. All of those are used in EEG analysis in related reference [17]Here the given below tabular column is showing the frequency band ranges of recording EEG signals.

TABLE 2 *FREQUENCY SCOPES OF RECORDED EEG SIGNALS WHICH IS CARRIED OUT BY THEEXPERIMENT AS SHOWN IN [3].*

No. of frequency band	Frequency volume (Hz)
1	4-7.2Hz
2	7.2-10.4Hz
3	10.4-13.8Hz
4	13.8-17Hz
5	17-20Hz
6	20-23Hz
7	23-60Hz

These seven frequency are withdraw for each 32 channels of EEG the number of the frequency domain will carried out as per experiment as shown in reference [2].

5 CLASSIFICATION

This paper is focused on k-NN classification [12, 2]k-NN classifier is one of most favored grouping technique and its plan of action is very simple in computational planning. And it proportional to classes by differentiates the features from the quality extraction and feature selection operation with the closest k study data. Reducing the possibility of determined outputs for specific study data, we use k-fold confirmation to split the training and test information's.

6 EEG WAVES AND FUNCTIONS

There are five types of EEG waves, such as delta, theta, alpha, beta and gamma each waves have its frequency limit. The delta wave as in Figure 3 can calculate the depth of the sleep, and its frequency (1-4Hz). Delta wave can be indentifying the slow wave sleep using EEG, in slow wave sleep brain waves are very slow so this is called dream less sleep, and Dreams are occur very often. Nightmares occur during this sleep but, we are not able to recall the dreams. The following rates are decreasing during this sleep BP, respiratory rate and BMR [7, 8].

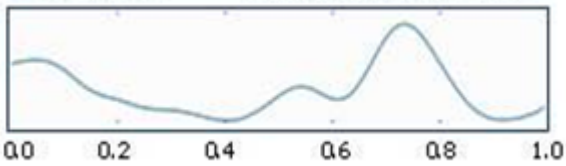

Fig. 3.Delta wave

Theta wave, Figure 4, can be used to know the functions of the brain, which means that the difficult task of the brain and its associated with the weakness level. The frequency is about to (4-7Hz), Theta is connected with all around cerebral processing such as memory conceal and cognitive workload, it is also calculate the tired level of human [3, 4].

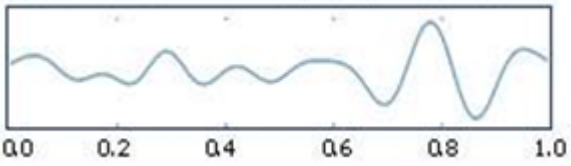

Fig. 4.Theta wave

Alpha as represented in Figure 5, denotes our mind released state, and it records the relaxation of the brain whenever we closed our eyes we turns into a clam state at that time alpha wave take over, and it is related with shyness and attention, the frequency of alpha is (7-12Hz) [9].

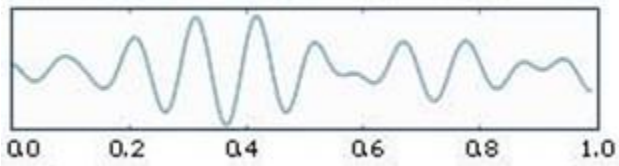

Fig. 5.Alpha wave

Beta waves with frequencies of (12-30Hz) as given in Figure 6, it can noticethe body movements, such as limp movement fore limp (hand) hind limp (leg), this increase in beta also perceptible as we notice bodily movements of other peoples[5, 6]. Human brains apparently imitate their limbs movements, and indicating the mirror neuron system [1].

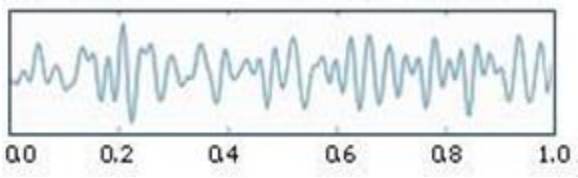

Fig. 6*. Beta waves*

The Gamma waves, typically the gamma frequency are (>30Hz to 40Hz). Gamma waves can give the information about our sensory inputs. These waves are similar with the REM (rapid eye movement). It is shown in Figure 7.

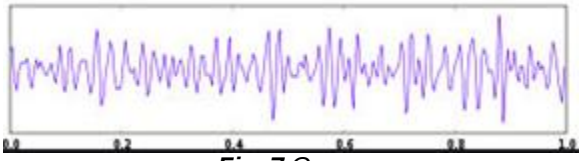

Fig. 7*.Gamma waves*

This means that each and every day when sleeping, a wake up between every (5-30mins). It is not even known to the individual whether they are waking or not which is called REM. During the REM the brain is very active the eye moves more rapidly, then the night mare occurred Slow Wave Sleep happens between every 90-mins. EEG decides the neural occupation that happens in the upper layer of our brain poorly[7].Frequently EEG takes long amount of time to connect its theme.It displays the low resolution on the scalp which is nothing but the skin covering the head.

7 RESULT

The output from channel 1 and 17 is classified using different classifiers such as KNN and NN. These two electrodes give information about the stress and calm emotions. The accurate output of different types of algorithms using different classifier for happy and sad emotions are given in Table 3[12].

TABLE3 *VOLUME OF TWO DIFFER EMOTIONS HAPPY AND SAD WHICH ARE DISSIMILAR AS DEPICTED BY USING KNN CLASSIFIER USING THE REFERENCE[12].*

KNN Classifier				
Channel	Band	KDE% Accuracy Happy and Sad	RER% Accuracy Happy and Sad	KTE% Accuracy Happy and Sad
1	Alpha	83.33	85	88.33
17	Alpha	85.33	81.66	86.66
1	Beta	85.33	85	86.66
17	Beta	86.66	81.66	87

The Figure8 given below shows the performance of the KNN classifier that was compared with the literature.

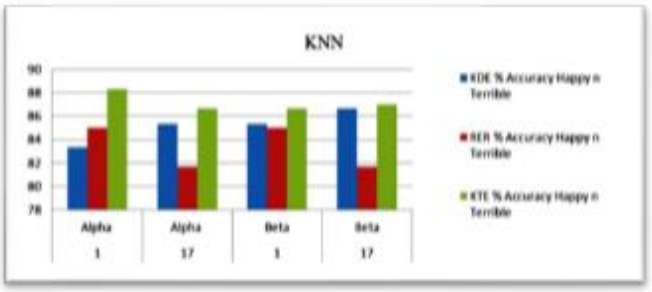

Fig. 8*. Result using KNN classifier*

The Table 4 shows the level of happiness which is non-identical as seen in the reference [12].

TABLE 4LEVELSOF TWO NON-IDENTICAL EMOTIONS USING NN CLASSIFIER

Neural Network				
n Channel	Band	KDE% Accuracy Happy and sad	RER% Accuracy Happy and Sad	KTE% Accuracy Happy and Sad
1	Alpha	50	90	93
17	Alpha	76.66	88.33	90
1	Beta	85	89	90
17	Beta	85	88.3333	90

The Figure 9 shows the accuracy of the NN classifier that is mapped against the input waves as per the study.

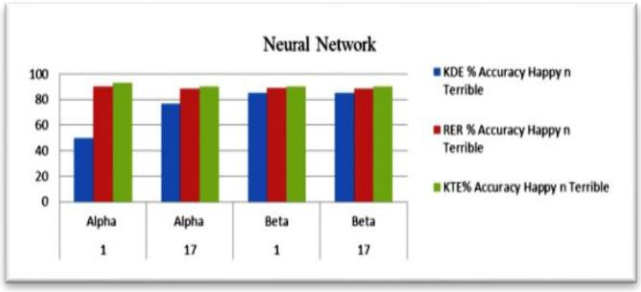

Fig. 9*. Result using NN classifier*

The table 5 shows the level of happiness and sad emotions which are dissimilar as depicted by classification tree using the reference [12]

TABLE5 LEVEL OF TWO DISSIMILAR RESPONSEHAPPY AND SAD USING CLASSIFICATION TREE

Classification Tree				
Channel	Band	KDE% Accuracy Happy and Sad	RER% Accuracy Happy and Sad	KET% Accuracy Happy and Sad
1	Alpha	76.66	80	88.33
17	Alpha	76.66	85	86
1	Beta	80	80	83.33
17	Beta	71.66	80	83

Figure 10 Shows the graphical representation of the results using classification tree

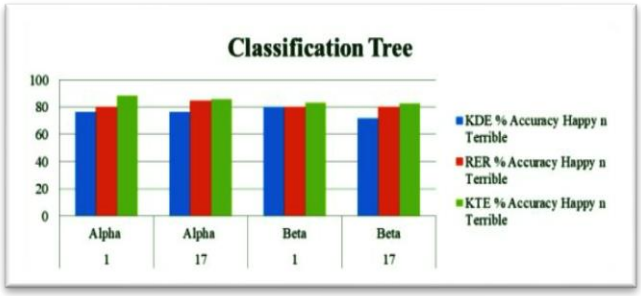

***Fig. 10**. Result for using Classification Tree*

8 CONCLUSION

This study was done in order to detect and classify the emotions using EEG signals according to different emotions from different humans. It is based on stress and calm emotions using the features which are gathered from the EEG waves Delta, Alpha, Beta, Theta, and Gamma band width as directed by an EEG signals.

REFERENCES

[1]What is EEG (Electroencephalography) and How Does it Work ... https://imotions.com › blog by B Farnsworth -Cited by 1 - Related articlesJul 15, 2019

[2] Dongkoo Shon, KichangIm, Jeong-Ho Par, Dong-Sun Lim, Byungtae Jang and Jong-Myon Kim Emotional Stress State Detection Using Genetic Algorithm-Based Feature Selection on EEG Signals.IJERPH-November 2018, 15, 2461;doi:10.3390

[3] Klimesch, W. 1999 EEG alpha and theta oscillation reflect cognitive and memory performance: a review and analysis, brain Res. Rev, 29(2-3), 169-195

[4] Craig, A., Tran, Y., Wijesuriya, N., Nguyen, H. (2012). Regional brain wave activity changes associated with fatigue. Psychophysiology 49:574–582

[5] Takahashi, K., Saleh, M., Penn, R. D., Hatsopoulos, N. G. (2011). Propagating waves in human motor cortex. Front Hum Neurosci. 5(40):4

[6] Halder, S., Agorastos, D., Veit, R., Hammer, E. M., Lee, S., Varkuti, B., et al. (2011). Neural mechanisms of brain-computer interface control. Neuroimage 55, 1779–1790. Doi: 10.1016/j.neuroimage.2011.01.021

[7] Tmt. KannakiPrabakaran, Dr.Flankit Thomas, T. Sekar, N. KumaravelZoology higher secondary- second year (old syllabus) Government of Tamil Nadu - 2015

[8] Harmony, t. 2013 The functional significance of delta oscillations in cognitive processing. Frontiers in integrative neuroscience 7:83 10.3389/fnint.2013.00083

[9] Klimesch, W. (2012). Alpha-band oscilaltions, attention, and controlled access to stored information. Trends CognSci.16(12):606–17. 10.1016/j.tics.2012.10.007

[10] Kaur B, Singh D, Roy P (2016) A Novel framework of EEG-based user identification by analyzing music-listening behavior. Multimed Tools Appl. https://doi.org/10.1007/s11042

[11] Sengupta S, Biswas S, Sanyal S, Banerjee A, Sengupta R, Ghosh D (2016) Quantification and categorization of emotion using cross cultural music: an EEG based fractal study. In: 2nd international conference on next generation computing technologies (NGCT), Dehradun, pp 759–764. https://doi.org/10.1109/NGCT.2016.7877512

[12] Prashant Lahane and MythiliThirugnanamSASSHuman Emotion Detection and Stress Analysis using EEG Signals. IJITE-March 2019 volume-8 issue-4S2ISSN:2278-3075

[13] Jennifer Sorinasa, b*, Juan C. Fernandez-Troyano, Mikel Val-Calvob, Jose Manuel Ferrándezb and Eduardo FernandezaA new model for the implementation of positive and negative emotion recognition.Neurocomputing (ID)

[14] Lin, Y.P.; Wang, C.H.; Jung, T.P.; Wu, T.L.; Jeng, S.K.; Duann, J.R.; Chen, J.H. EEG-based emotion recognition in music listening. IEEE Trans. Biomed. Eng. 2010, 57, 1798–1806. [PubMed]

[15] Rozgi´c, V.; Vitaladevuni, S.N.; Prasad, R. Robust EEG emotion classification using segment level decision fusion. In Proceedings of the 2013 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Vancouver, BC, Canada, 26–31 May 2013; pp. 1286–1290.

[16] Ackermann, P.; Kohlschein, C.; Bitsch, J.A.; Wehrle, K.; Jeschke, S. EEG-based automatic emotion recognition: Feature extraction, selection and classification methods. In Proceedings of the 18th IEEE International Conference on e-Health Networking, Applications and Services (Healthcom), Munich, Germany, 14–16 September 2016; pp. 1–6.

[17] Bastos-Filho, T.F.; Ferreira, A.; Atencio, A.C.; Arjunan, S.; Kumar, D. Evaluation of feature extraction techniques in emotional state recognition. In Intelligent human computer interaction (IHCI). In Proceedings of the IEEE 4th international Conference on Intelligent Human Computer Interaction, Kharagpur, India, 27–29 December 2012; pp. 1–6