Performance Analysis of Human Brain Waves for the Detection of Concentration Level

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Abstract *— Concentration is an important part of our life especially during learning or thinking. To understand the concentration process of humans, the brain activity is monitored using EEG signals. Electroencephalogram (EEG) is test used to track and record the brain wave patterns based on the electrical activity of the brain. It is a very versatile tool for the detection of brain activity. Based on concentration and thinking the brain waves will get change due to their change in brain activity. The variations in brain waves are analyzed and the features are extracted using various methods. Here EEG data's are collected for various persons under two different age groups of 20 to 23 age and 29 to 31 aged people because the concentration varies with respect to age. From the collected EEG signal the features are extracted using FFT, mean, standard deviation, median and root mean square. On comparing the extracted features for various aged people the concentration level is determined.*

Key words: **Electroencephalogram (EEG) signal, concentration, FFT, LabVIEW**

I. INTRODUCTION

Brain is composed of various lobes whereas prefrontal cortex region of the brain is responsible for concentration and thinking. EEG of various persons with different tasks is analyzed and the features are extracted from the EEG signal to determine their concentration. It can be implemented in gaming industry for monitoring the gamer's thinking, attention and involvement to the game for the improvisation and innovation of new games.

A. Brain

It is composed of three main parts as cerebrum, cerebellum, and brainstem. The cerebrum is divided into four lobes called frontal lobe, temporal lobe, parietal lobe and occipital lobe. Each lobe is responsible for several activities. The frontal lobe is responsible for problem solving, concentration, judgment and motor function. The parietal lobe manages sensation, handwriting, and body position. The temporal lobe is involved in memory and hearing activity. The occipital lobe contains the brain's visual processing system. The prefrontal cortex region is primarily involved in concentration.

B. EEG Signal

Electroencephalogram (EEG) is a measure of brain waves. It tracks and records the brain wave patterns. The brainwaves change according to the persons feeling and their movements. When slower brainwaves are dominant, it shows that the persons are feeling tired, slow, sluggish, or dreamy. When the higher frequencies are dominant, it shows that the persons are feeling wired, or hyper-alert. Brainwave speed is measured in Hertz (cycles per second) and they are divided into bands. EEG signals are classified as alpha, beta, theta, delta and gamma waves based on their frequency range is shown in the Table I.

TABLE I. EEG WAVES

Wave	Frequency	State
Delta	Below 4 Hz	Dreamless sleep, loss of bodily awareness
Theta	4-8 Hz	Reduced consciousness, deep meditation, light sleep
Alpha	9-13 Hz	Physically and mentally relaxed, awake but drowsy
Beta	14-30 Hz	Awake, alert and consciousness

Gamma	Above 30 Hz	Heightened perception

II. Related Work

Some literature survey has been focused on EEG signal analysis and its feature extraction and classification. Di Xiao proposed the measurement of degree of concentration level of humans by determining the focus value R [9]. Chetna Nagpal uses frequency distribution, standard deviation, variance for feature extraction and fuzzy logic for the classification of EEG signals that are measured from the rats [8]. Tae Jin Choi implements a method for the estimation of concentration state using multiple EEG channels. Eight channels are used for the measurement during resting and concentrating periods. Kalaivani proposed to diagnose the abnormalities present in the brain using EEG signals. It includes pre-processing, feature extraction, feature selection and classification. The discrete wavelet transform is used to decompose the EEG signal and the features are extracted using mean, standard deviation, maximum and minimum. The signals are classified using k means classifier as normal or abnormal condition [12].

III. Analysis of Human Brainwaves

The main aim of proposed work is to analyze the concentration level of humans based on their brain activity. As the root of thoughts, emotions and behaviors the communication occurs between neurons within the brains. Brainwaves are produced by synchronized electrical pulses from masses of neurons communicating with each other. Electroencephalography uses electrical leads placed all over the scalp to measure the collective electrical activity of the cerebral cortex. This spontaneous activity is classified based on the frequency produced at the time of activity as alpha, beta, gamma, theta and delta.

EEG 10-20 amplifier system is used for the measurement of the brain analysis. It consists of silver cup electrodes which are placed over the scalp. This system has three leads one is ground and the other two are active and reference electrodes. These three electrodes are used for monitoring the EEG signal of various persons during different activities. The electrodes are placed over the fore head of the testing person and their brain activity is monitored by using DSO.

The notch filter is used for removing noise present in the raw EEG signal [3]. The notch is a very selective filter with a very high rejection just for a tiny frequency band around the selected frequency. After the noise removal the output is fed to the DSO. The proposed system consists of various stages for analyzing the brain waves of humans as data collection, feature extraction and feature selection.

A. Data Collection

Based on age, the individuals involvement, paying attention, thinking and concentration changes. The data's are collected for group of people under different age category in two different timings. The persons under the age of 20 to 23 are group 1 and the persons under the age of 29 to 31 are group 2, 15 participants are tested with various activities. For every individual certain tasks are given like reading books, solving puzzles, hearing music and counting numbers in reverse manner for the duration of 10 minutes.

The EEG waveforms are monitored and recorded as shown in the Fig. 1 for each task during first two minutes and last two minutes of the task. Based on the person's activity, the neurons in the cortex region

get activated [13]. If for example a person is hearing music, the sound waves will hit the ear drums and the signal will be transferred to brainstem and reach the cortex region of the brain and it gets activated that will be monitored using the EEG 10-20 amplifier system.

Fig. 1 Measurement of EEG Signal

B. Feature Extraction

The features are extracted from the EEG signal to minimize the loss of important information embedded in the signal. Different methods have been widely used to extract the features from EEG signals. Most commonly used are FFT and mean, standard deviation and variance determination [14].

a) FFT Transformation

The raw EEG signal is converted into frequency domain using FFT to determine the frequency range of measured signal. Based on the resultant frequency, the signal is classified among the five brain waves as alpha, beta, gamma, theta and delta waves.

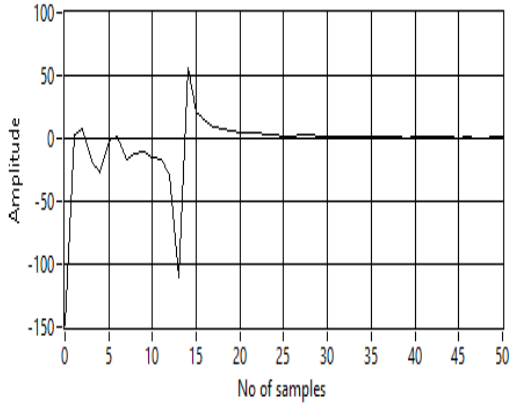

Fig. 2 FFT of Puzzle Solving (first 2 min)

For one person, after FFT transformation the EEG signal of puzzle solving for first two minutes is shown in the Fig. 2. The frequency lies in the signal is 14 Hz so the type of brain wave generated at first two minutes is beta wave. It will be produced during alert and conscious condition. It is evident that the person is concentrating on solving the puzzles for the first two minutes.

Similarly for the same person, the EEG signal in transformed domain while solving puzzles for the last two minutes is shown in the Fig. 3. It indicates the frequency of about 0.5 Hz, delta waves are generated at last two minutes of the task. It shows the person is not concentrating and in the state of loss of awareness during end of the given task. For all the collected EEG signals of 15 participants for various tasks, the FFT transformation should be made and based on the frequency present in the signal, the type of brain waves present in the obtained signal is measured. The determination of type of brain waves provides better analysis of the person's concentration while doing the task.

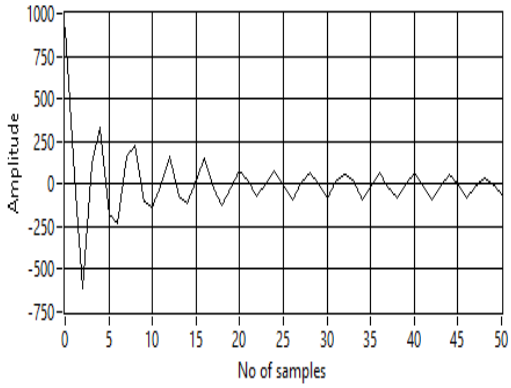

Fig. 3 FFT of Puzzle Solving (last 2 min)

b) Computation of Mean, S.D, RMS and Variance

The another method of feature extraction is evaluating the parameters like mean, standard deviation, root mean square and variance for the determination of the individual persons concentration during their various activities.

TABLE II. PARAMETER ESTIMATION FOR PUZZLE SOLVING

PARAMETERS	FIRST 2 MIN	LAST 2 MIN
Mean	0.57536	0.40888
RMS	28.107	24.4458
S.D	28.1096	24.4432
Variance	790.148	597.47

The Table II shows the different estimated parameters while solving the puzzles in two different timings. The data represents maximum for the first two minutes of puzzle solving and minimum for the last two minutes [8]. From both the methods of feature extraction, it is evident that the person is concentrating towards the puzzle solving for first two minutes and lags their concentration at the end of the task. Similarly for all the tested participants their concentration is analyzed for the entire task of relaxed state, reading books, counting numbers in reverse order, solving puzzles and hearing melody.

C. Feature Selection

This is the process of eliminating the features containing negligible information. The feature with more information provides better results and accuracy. On comparing both the methods of feature extraction, the FFT transformation method provides high accuracy than parameter estimation method with less time consumption.

IV. RESULTS AND DISCUSSION

The EEG signal is measured at the fore head where the prefrontal cortex region presents. Based on the individual activities, the activity of neurons in the brain changes.

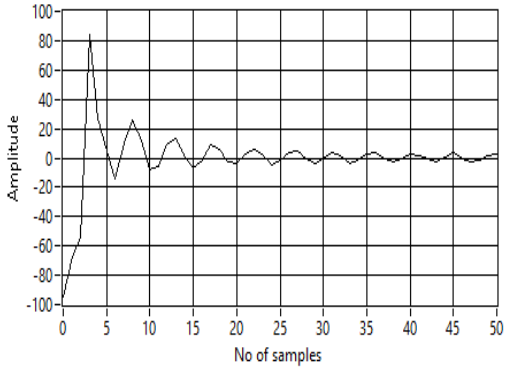

Fig. 4 FFT of Person while Sleeping

The Fig. 4 shows the transformed EEG signal for a person in sleeping state. It indicates the frequency of 3 Hz where the delta waves are generated it is proven that the person is in dreamless sleep condition.

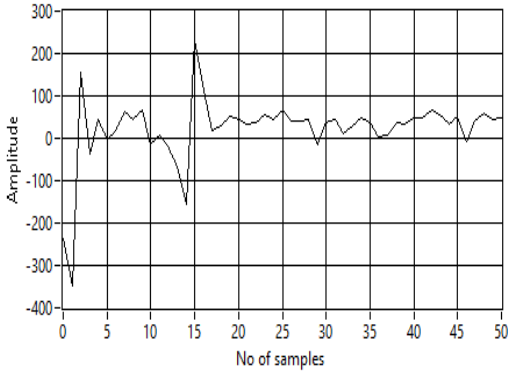

Fig. 5 FFT of Person from Sudden Awake

The EEG signal of person when wakes suddenly from sleep is depicted in the Fig. 5 with the frequency of 15 Hz. The produced frequency indicates that the generated EEG signal has beta waves. The beta waves are produced during awake and alert condition so it is proven that the person is conscious and alert at the moment of waking from sleep.

The FFT transformation is an effective method of feature extraction from the EEG signals to determine the persons concentration level.

V. Conclusion and Future Scope

The concentration level of various persons with different activities are monitored. Based on the persons attention to the given task, the frequency range and the type of brainwaves varies. From the obtained brain waves at the starting of the task and the ending of the task, the persons concentration is determined.

In future, the concentration level can be classified as normal, high and low concentration using fuzzy logic algorithm.

References

[1] *Amod Kumar, Ritu Bindal, Sanjeev Kumar, "Denoising of Electroencephalogram Signals Using Digital Signal Processor" , International Journal of Computer Applications, Vol. 3, pp. 38-41, 2014*

[2] *Anastasios E. Malissovas, Christos I. Salis, Paschalis A.Bizopoulos, "Denoising Simulated EEG Signals: A Comparative Study of EMD, Wavelet Transform and Kalman Filter", IEEE Journal , 2013*

[3] Amitash Ojha, Jun-Su Kang, Minho Lee, "Concentration monitoring with high accuracy but low cost EEG device", Springer-Verlag Berlin Heidelberg, 2011

[4] Aurobinda Routray, Mayank Bhagat, Sibsambhu Kar , "EEG signal analysis for the assessment and quantification of driver's fatigue", ELSEVIER Transportation Research Part F, p.no. 297–306,2010

[5] Andre L.V. Coelho, Clodoaldo A.M. Lima andMarcioEisencraft, "Tackling EEG Signal Classification with Least Squares Support Vector Machines: A Sensitivity Analysis Study", Elsevier Transactions on Computers in Biology and Medicine, Vol.40, pp.705-714, 2010

[6] Abdulhamit Subasi and Ergun Ercelebi, "Classification of EEG Signals Using Neural Network and Logistic Regression", Elsevier Transactions on Computer Methods and Programs in Biomedicine, Vol.78 pp.87-99, 2005

[7] BehshadHosseinifarda, Mohammad Hassan Moradia and Reza Rostamib, "Classifying Depression Patients and Normal Subjects Using Machine Learning Techniques and Nonlinear Features from EEG Signal", Elsevier Transactions on Computer methods and Programs, Vol.109, pp.339-345, 2013

[8] Chetna Nagpal, Dr PK Upadhyay, "Sleep EEG Classification Using Fuzzy Logic", International Journal of Recent Development in Engineering and Technology, Vol.4, 2015

[9] Di Xiao, Wentao Zhang, "Electroencephalogram Based Brain Concentration and Its Human Computer Interface Application", IEEE Transactions on Biomedical Enginnering, Vol.2, pp. 21-24, 2015

[10] Gilwon Yoon, Jong Ok Kim, Sang Min Jin, Tae Jin Choi, "Determination of the Concentrated State Using Multiple EEG Channels", World Academy of Science, Engineering and Technology, Vol.8, No.8, 2014

[11] Juliana Yordanova , Osvaldo A. Rosso, Susana Blanco, Vasil Kolev , "Wavelet entropy: a new tool for analysis of short duration brain electrical signals", ELSEVIER Journal of Neuroscience Methods , p.no.65–75, 2001

[12] M.Kalaivani, V.Kalaivani, V.Anusuya Devi, "Analysis of EEG Signal for the Detection of Brain Abnormalities", International Journal of Computer Applications, 2014

[13] Kemalasari, Mauridhi Hery Purnomo, "Analysis the Dominant Location of Brain Activity in Frontal Lobe Using K-means Method", IEEE – VOL 2, 2010

[14] Pradkij Panavaranan, Yodchanan Wongsawat, "EEG-based Pain Estimation via Fuzzy logic and polynomial kernel Support Vector Machine", IEEE International Journal of Biomedical Engineering, 2013