International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

Human Emotions Classification using EEG Signals in Virtual Instrumentation Platform

Ch. Kusma Kumari, K. PremSai, K. Mounika Satya Gowri, K. Srujan Kumar, K. Naveen Murthy

Abstract*: This article presents the frequency band classification of emotions and detection of emotional condition of a person. This is done by the analysis of the biological signal, EEG (Electroencephalogram). The EEG is considered as the main biological signal, which signifies the electrical activity of the human brain and hence becomes main source of information for studying the neurological disorders. This analysis is done using one of the popular virtual instrumentation platform LabVIEW (Laboratory Virtual Instrumentation Engineering workbench) software. The EEG signals that are used for the analysis are taken from the open source database and are undergone different stages like preprocessing for noise elimination, classification and feature extraction. The feature extraction is done by performing Fast Fourier Transform (FFT) of the signal. This analysis helps us to identify the abnormality of the person (if any) from whom the signal is taken.

***Keywords*: EEG, FFT, LabVIEW tools, Preprocessing**

I. INTRODUCTION

The EEG signal is the most important biological signal as it is used for the study of neurological behavior or study of brain. It is used for the analysis of disorders related to brain and identifying any abnormalities or diseases if present. The EEG signals are recorded by placing the electrodes on scalps of the head [1].

Manuscript published on November 30, 2019.
* Correspondence Author
Kusma Kumari Cheepurupalli*, Associate Professor Department of Ece Gayatri Vidya Parishad College of Engineering (A)Visakhapatnam India
K. PremSai, UG Students Department of Ece Gayatri Vidya Parishad College Of Engineering (A) Visakhapatnam India
K. Mounika Satya Gowri, UG Students Department of Ece Gayatri Vidya Parishad College Of Engineering (A) Visakhapatnam India
K. Srujan Kumar, UG Students Department of Ece Gayatri Vidya Parishad College Of Engineering (A) Visakhapatnam India
K. Naveen Murthy, UG Students Department of Ece Gayatri Vidya Parishad College Of Engineering (A) Visakhapatnam India

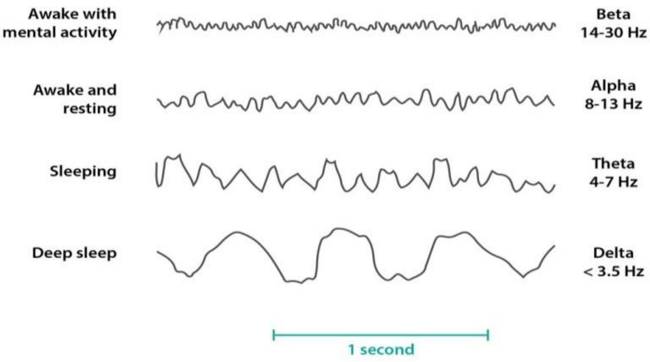

Fig. 1.Comparison of various brain waves

The EEG signals are generated by the electrical activity formed in the neurons while doing any functions of the body. Therefore, there are different electric potentials developed inside the brain. The electrodes sited on the brain produced the EEG Signals by measuring the potential difference between them [2]. The EEG signals are mainly categorized into four dissimilar frequency bands namely Delta, Theta, Alpha and Beta components. The percentage of different components determines the condition and emotion of the person from whom the signal is recorded. LabVIEW is a flexible language that contains large number of functions and tools. Hence in this paper Bio-medical tool kit is used for the analysis of EEG signals [3,4].

II. METHODOLOGY

The steps involved in the classification process is visually related in Fig. 2.

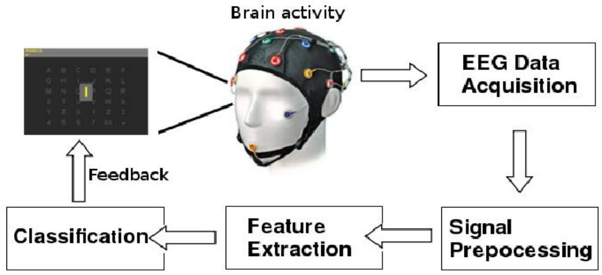

Fig. 2.Steps involved in EEG signal classification

A. EEG Data Acquisition

The EEG signal data is acquired from the open source database [5]. This database contains large number of EEG signal recordings collected from different persons during different conditions. These signals from databases are present in text format.

So, these are converted into analog form by using the read from measurement file block in LabVIEW.

B. Preprocessing

The preprocessing of the EEG signal is done in three stages:

- *Sampling:* The EEG signal obtained from the databases contains large amount of signal which cannot be directly processed in LabVIEW. So, the input EEG signal is sampled using build waveform functional block and the obtained output is used for analyzing the data.
- Pre-amplification: The EEG signal obtained has very low amplitudes and is difficult to be processed directly. So, the signal is pre-amplified using multiplier block to increase its amplitude.
- *Filtering:* Noise mainly generated by electricity in the electrodes corrupts the EEG signal while acquiring data from the person. This noise is generally present at 50Hz frequency because electricity is transmitted at that frequency. This noise can be eliminated by passing the signal through a Butterworth low pass filter with 30Hz cutoff frequency. LabVIEW already has predesigned filters which can be used directly without the need of redesigning.

C. Feature extraction

As mentioned above, the EEG signals contain components in four different frequency bands. The features of the signal in those different frequency bands should be extracted in order to analyze the signal. So, classification of these signals into those frequency bands is done by using the four band pass filters with cutoff frequencies according to the bands range.

The features extracted are of two types. They are:

- *Time domain features:* These are the features obtained from the EEG signal in time scale. These features are time dependent and frequency independent. These include mean, standard deviation, variance and skewness. All these features are obtained by using the respective functional blocks in LabVIEW. These features can be directly obtained from the input EEG signal.
- *Frequency domain features:* These are the features which are obtained from the EEG signal in frequency domain. These are time independent and frequency dependent. These include band powers and their percentages. These features cannot be obtained directly and can only be extracted using FFT analysis.

  FFT computes the discrete Fourier transform of a sequence or its inverse i.e. it converts signal from the original domain (here time domain) to frequency domain and vice versa. This is done by using the EEG FFT Spectrum block.

The outputs of all the frequency bands are merged and given to FFT spectrum block. The block measures the powers and percentages of all the frequency bands. The output can be obtained by placing a cluster at output of FFT spectrum line. The frequency band representation is also given from the output.

D. Classification

The band ranges and the respective emotion of all the frequency bands is as below Table- I:

Table- I: Frequency band ranges and emotions

Type of wave	Frequency	Normal state(emotion)
Delta	0.5 – 4 Hz	Deep sleep, Coma
Theta	4 – 8 Hz	Trance, Dreams
Alpha	8 – 13 Hz	Relaxation with eyes closed but still awake
Beta	13 – 30 Hz	Beta 1 : 13 – 20 Hz Perception, Thinking, Mental Activity

The amount of powers and percentages of each frequency band are obtained determine the type of EEG signal. The frequency band with highest percentage/power is the base-band signal and the corresponding emotion can be determined. The complete block diagram implementation in LabVIEW is shown in Fig. 5.

III. RESULTS AND ANALYSIS

Using the above classification the base signal band is identified and the condition of the person from whom the signal is taken is known by observing the mean value of all the frequency bands.

By using both the frequency band percentages and mean values, the condition of the person is determined as below

- *Normal state:* If the corresponding mean of the base band signal is the highest among means of all the frequency bands then that person is in Normal State.
- *Transition state:* If the mean of the adjacent band of the base band signal is the highest among mean of all the frequency band signals then the person is in Transition State.
- *Abnormal state:* If the mean of the base band and its adjacent band signal is less than mean of any other frequency band signals then the person is in Abnormal State.

The values of the features extracted and the condition and emotion represented by some of the EEG signals is given in the Fig. 3.

Signal	frequency	Delta %	Delta mean	Theta %	Theta mean	Alpha %	Alpha mean	Beta %	Beta mean	Condition	Emotion
EEG-1	6	26.513	-1613.12	39.335	-1637.09	20.591	-1695.67	13.561	-1844.97	Transition	Relaxation of Mind
EEG-2	0	85.638	14080.8	6.8764	14281.31	4.4419	14793.68	3.0436	16102.91	Abnormal	Mental Stress
EEG -3	3	65.262	-1123.53	11.105	-1132.8	12.031	-1173.4	11.602	-1277.03	Normal	Deep Sleep
EEG-4	29	4.7006	-2698.18	8.042	-2683.49	21.877	-2779.23	65.381	-3022.61	Abnormal	Distracted Thinking or Absent Mind
EEG-5	20	7.1071	7420.72	6.1549	7692.95	27.301	7969.79	59.437	8679.52	Normal	Thinking(mental activity)
EEG-6	3.9	46.805	-3617.06	32.348	-3496.4	17.483	-3620.8	3.3642	-3936.09	Transition	Feeling Mental Anxiety

Fig. 3.EEG signal frequency band ranges and emotions

All the conditions possible for the EEG signals are explained:

i. Normal state

The Fig. 4.shows the output of EEG-1 Signal and its corresponding mean and percentage values.

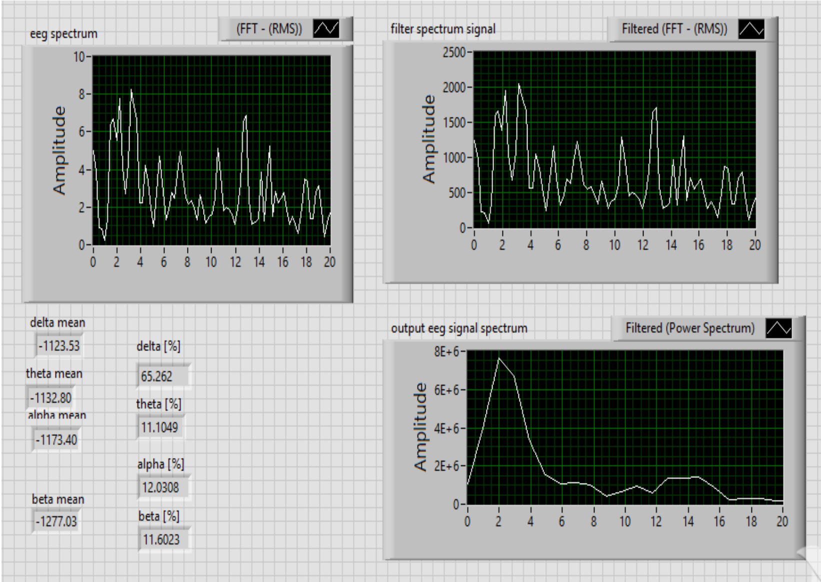

Fig. 4.Outputs of EEG-3 signal (Normal state)

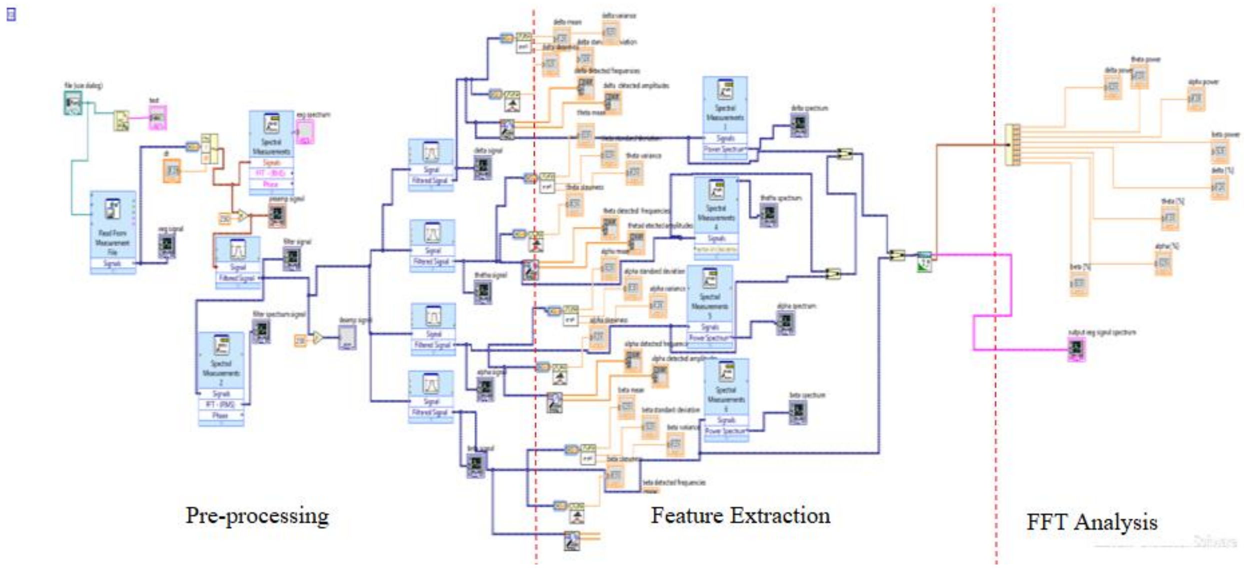

Fig. 5.Block diagram for EEG signal classification

Analysis of EEG-3 signal:

- The input spectrum of EEG-3 signal is 3.5Hz.
- The above picture shows that the percentage of Delta component is high.
- Therefore baseband signal is Delta signal.
- The mean value of Delta signal is also high, so it is considered as Normal state condition.
- The emotion identified from the above EEG-3 signal is Deep Sleep.

ii. Transition state:

The Fig. 6.shows the output of EEG-6 signal and its corresponding mean and percentage values.

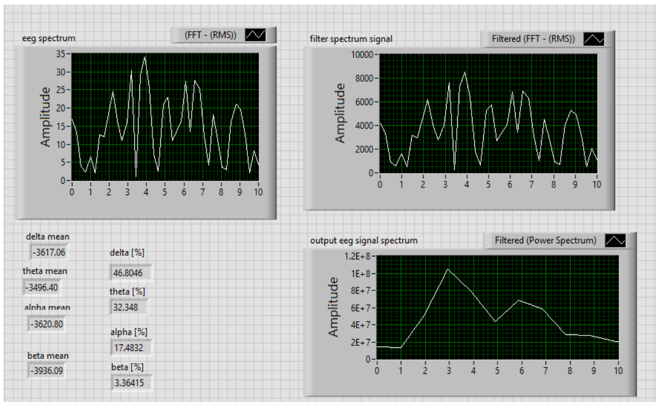

Fig. 6.Outputs of EEG-6 signal (Transition state)

Analysis of EEG-6 Signal:

- The input spectrum of EEG-6 signal is 4Hz
- The above picture shows that the percentage of Delta component is high
- Therefore baseband signal is Delta signal

- But the adjacent signal of Delta i.e., Theta signal has higher mean value, so it is considered as Transition state condition
- The emotion identified in EEG-6 signal is feeling Mental Anxiety.

iii. Abnormal state

The Fig. 7.shows the output of EEG-3 signal and its corresponding mean and percentage values.

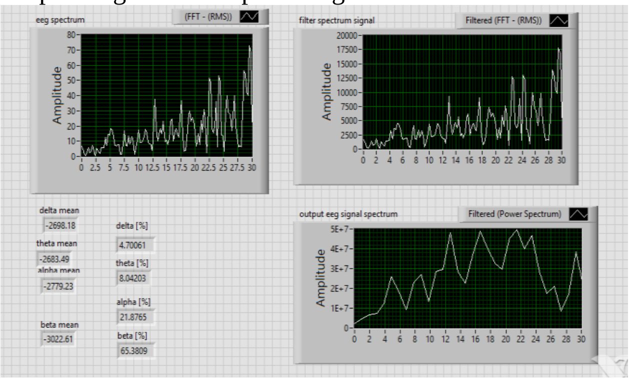

Fig. 7.Outputs of EEG-4 signal (Abnormal state)

Analysis of EEG-4 Signal:

- The input spectrum of EEG-4 signal is 2Hz.
- The above picture shows that the percentage of Beta component is high.
- Therefore, baseband signal is Beta signal.
- The mean value of theta signal is high, so it is considered as Abnormal state condition.
- The emotion identified from the above EEG-4 signal is Distracted Thinking or Absent Minded.

IV. CONCLUSION

The efficient design of architecture for classification of emotions and detection of condition of a person using LabVIEW is done in this paper. This kind of analysis helps in detecting abnormalities in the person from whom the recordings are taken. The EEG signals are preprocessed and extracted time domain, frequency domain features using FFT analysis and are analyzed to known the condition of abnormalities. This work can be further extended in online recording of EEG data, identifying diseases and for making wearable devices that can monitor brain activity.

REFERENCES

1. Millán, J. del R., et al. "Local neural classifier for EEG-based recognition
2. of mental tasks," *Proceedings of the IEEE-INNS-ENNS International*
3. *Joint Conference on Neural Networks. IJCNN 2000. Neural Computing:*
4. *New Challenges and Perspectives for the New Millennium*. Vol. 3. IEEE,
5. 2000.
6. McFarland, Dennis J., et al. "Spatial filter selection for EEG-based
7. Communication," *Electroencephalography and clinical*
8. *Neurophysiology* 103.3 (1997): 386-394.
9. http://epileptologiebonn.de/cms/front_content.php?idcat=193&lang=3 changelang=3
10. Dumitrescu, Catalin, et al. "LabVIEW brain computer interface for EEG
11. analysis during sleep stages," *2015 9th International Symposium on Advanced Topics in Electrical Engineering (ATEE)*. IEEE, 2015.
12. Guin, Agneev. "Brain Controlled Wheelchair using LabVIEW," 2013.

AUTHORS FROFILE

Kusma Kumari Cheepurupalli, received her Ph.D degree in the area of Signal processingfrom Andhra University, Visakhapatnam. She obtained her Post Graduation degree in VLSI System Design. She is the Principal Investigator for the project titled “Robust Signal Processing Techniques for RADAR/SONAR Communications”, funded by DST under Women Scientist Scheme. She got two best paper awards in the IETE conferences conducted by NSTL, Visakhapatnam. She published more than 20 papers in the reputed journals and conferences. Currently, she is working as Associate Professor in the Department of ECE, Gayatri Vidya Parishad College of Engineering (Autonomous) Visakhapatnam, AP, India.

K.PremSai, K. Mounika SatyaGowri, K.Srujan Kumar, K. Naveen Murthy, Under Graduate Students of ECE department who completed thesis work in Gayatri Vidya Parishad College of Engineering (Autonomous), Visakhapatnam, AP, India.