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# LabVIEW based Mental Status Monitoring System for Cognitive Wellness

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## Abstract

This paper delves into the analysis of various cognitive states by identifying the percentages of different types of brain waves, like alpha, beta, delta, and theta, present in an individual's EEG recording. These brain waves carry crucial information about an individual's cognitive health, and accurate readings are essential to classify and represent the signals accurately. To achieve this, the project aimed to develop a robust platform that utilizes LabVIEW software to obtain EEG signals and interpret cognitive health. The acquired data is meticulously preprocessed and filtered to obtain clean EEG signals, which are then subjected to several methods to determine the content of different brain waves present in the filtered EEG signals. Based on these values, the cognitive status of an individual can be accurately determined, providing valuable insights into their cognitive health. Understanding cognitive states through brain wave analysis has been an intriguing area of research, utilizing various electroencephalography (EEG) techniques to interpret neural activity. This paper aims to provide a detailed discussion on how cognitive states are mapped and interpreted based on brain waves. By exploring the characteristics of each brain wave frequency band, we elucidate their implications in cognitive processes such as attention, memory, and relaxation. This research aims to contribute in the advancement of cognitive neuroscience by consolidating current knowledge and identifying potential avenues for future research.

## LabVIEW based Mental Status Monitoring System for Cognitive Wellness

Emotions serve as a means of expressing internal sensations and communicating them to others through observable cues in the physical realm. These cues encompass gestures, such as facial expressions and bodily movements, which facilitate the translation of emotions into tangible actions.[1][2] Various models have been proposed in attempts to comprehend the intricate interactions among these components that give rise to different cognitive states. However, it is currently acknowledged that there exists no single formulation for emotions which is universally accepted. The modeling of emotions presents a highly challenging problem and has raised significant interest within the field of human-computer interaction. One significant limitation of utilizing behavioral modalities for recognizing mental wellbeing is the inherent uncertainty when it comes to individuals who deliberately control or naturally suppress their emotional displays. While facial expressions can be examined as an indicator of emotions, there is no guarantee that a person will exhibit the expected cue even if they are experiencing a particular emotion. This poses considerable challenges in certain contexts such as surveillance applications. Furthermore, another limitation of relying solely on behavioral modalities for mental status detection is that humans can deliberately manipulate their facial expressions and body movements to hide or disguise themselves. It can be challenging to accurately interpret cognitive states based only on facial expressions and behavior cues.

Cognitive wellness is a term used to describe an individual's overall cognitive health and functionality. This concept has gained increasing attention in the domain of cognitive neuroscience and mental health, as experts strive to understand the complexities of the human mind and promote well-being. One significant tool used for this purpose is the analysis of brain waves, which are electrical manifestations of cerebral activity captured through electroencephalography (EEG). It stands at the forefront of cognitive neuroscience, offering a window into the intricate workings of the human mind. By capturing the electrical activity generated by neurons in the brain, EEG provides a unique avenue for understanding various mental states and cognitive processes. It serves as a versatile tool, capable of unraveling the complexities of cognition and mental wellness. One of the most compelling aspects of EEG lies in its ability to monitor cognitive wellness. Through EEG, individuals and healthcare professionals can gain valuable insights into a spectrum of cognitive functions, including mental fatigue, stress levels, concentration abilities, and overall cognitive performance [3][4][5]. This capacity has sparked a growing interest in exploring the dynamic interplay between brain function and cognitive states. [6]

Advancements in technology and methodology have significantly augmented our ability to delve into cognition and mental wellness. Among these advancements, the analysis of brain waves stands out as a powerful instrument. Brain waves, characterized by alpha, beta, delta, and theta components, offer a direct glimpse into the nuanced spectrum of cognitive states. From the realms of relaxation and concentration to the profound depths of deep sleep and consciousness, each brain wave component holds a distinct correlation with various cognitive states. In the pursuit of understanding and harnessing the potential of EEG, researchers have turned to sophisticated tools and platforms. LabVIEW, a visual programming language-based environment, has emerged as a cornerstone in the efficient handling of EEG data. With its robust capabilities, LabVIEW empowers researchers to design and implement signal processing algorithms tailored to EEG analysis [7]. This facilitates a deeper exploration of the intricate relationship between brain waves and a myriad of cognitive and behavioral processes.[8][9] This research endeavors to delve into six primary methodologies essential to cognitive wellness assessment. These methodologies form a comprehensive framework, encompassing the stages of data acquisition, preprocessing, feature extraction, identification of cognitive states, interpretation, and validation. Through the diligent application of these methodologies, researchers can systematically analyze cognitive functioning, paving the way for a more nuanced understanding of mental wellness. For EEG signal processing, meticulous attention is paid to every facet of the data. Signals are meticulously generated using datasets available on platforms like Kaggle or simulated directly to ensure accuracy and reliability. Subsequent processing involves the extraction of statistical features, power spectral density, and Fast Fourier Transform (FFT) spectrum. This culminates in the division of EEG signals into five distinct frequency bands—Delta (0-3.5Hz), Theta (4-7Hz), Alpha (8-13Hz), Beta (14-34Hz), and Gamma (>35Hz)—each offering valuable insights into the power distribution across different frequency ranges. [10]

In essence, this research endeavor serves as a beacon of enlightenment in the realm of cognitive neuroscience. By shedding light on the intricate interplay between brain function and cognitive states, it lays the groundwork for transformative interventions aimed at enhancing mental wellness and cognitive resilience.

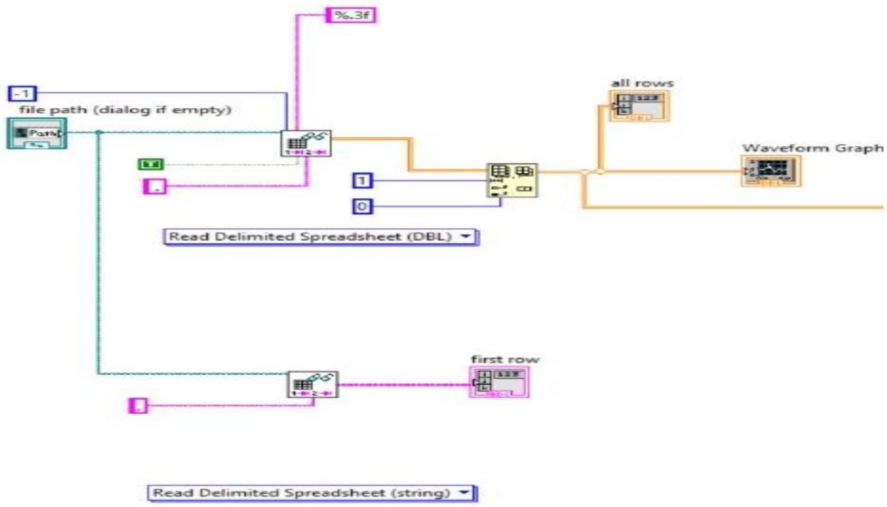
## Methodology

### A. *Data Acquisition & Pre-processing*

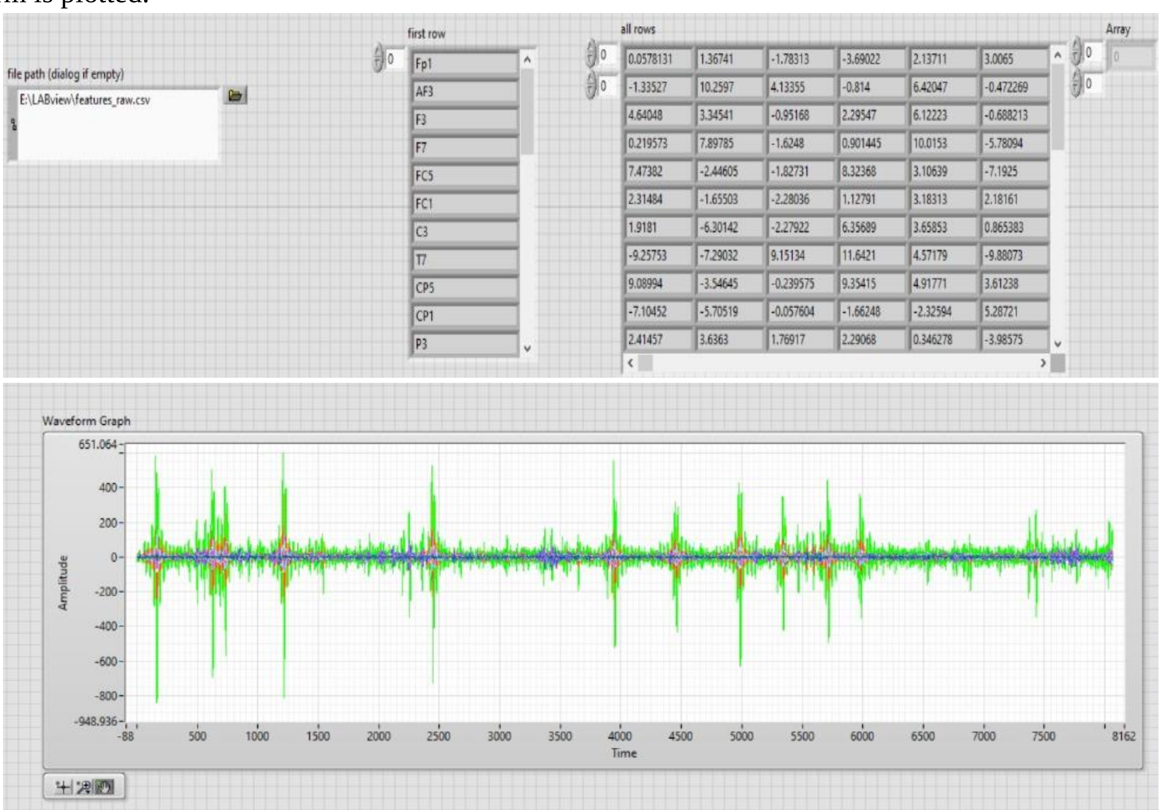
The initial step deploys collection of EEG data. The acquisition of electroencephalogram (EEG) signals, commonly called brainwave data, can be accomplished by either accessing pre-existing datasets available online or simulating the signal directly.

In LabVIEW, for the purpose of acquiring raw data, it offers a specialized biomedical toolkit that includes “EEG SIMULATE” block to directly simulate the signals. [11]

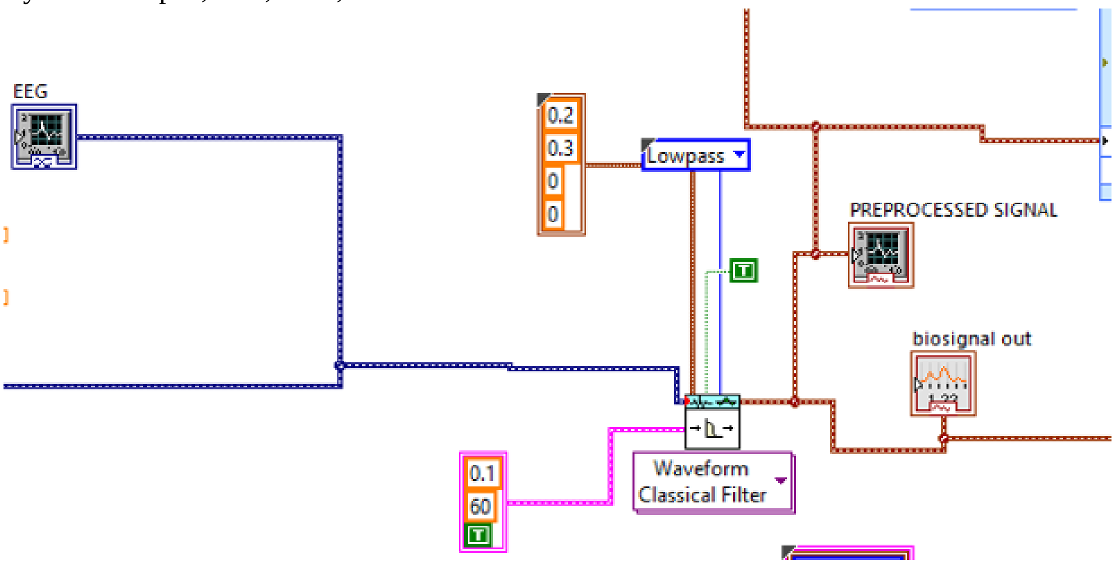
The LabVIEW coding is generated to read the recorded data from the EEG amplifier in a .csv file. **Read Delimited Spreadsheet** is used for reading the EEG recordings through various channels. These recordings are displayed using the **Plot Waveform** function at the block diagram panel as shown in the below figure.

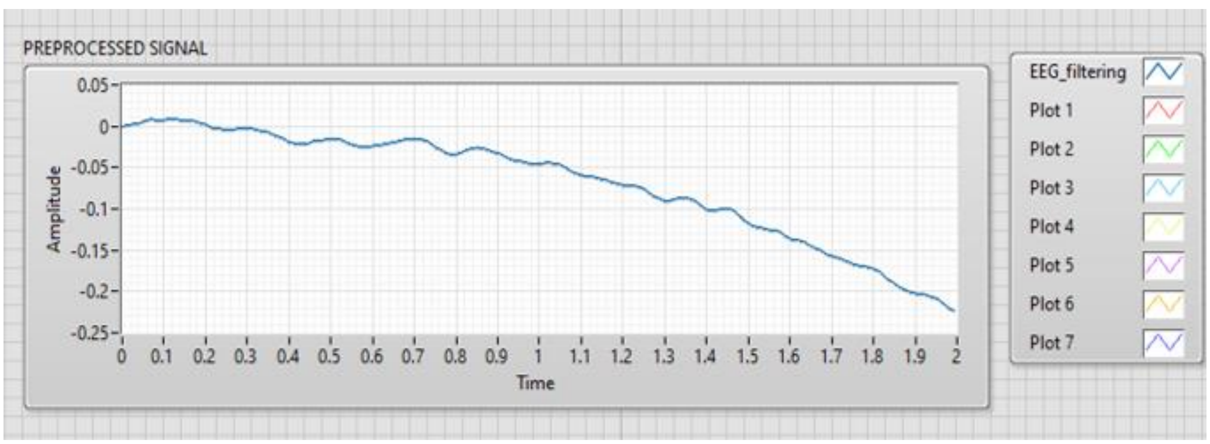



In the front panel, after giving the location address of the CSV file, the data is displayed and according to it waveform is plotted.




In the process of preprocessing acquired EEG data in LabVIEW, several intricate steps are meticulously undertaken to ensure data integrity and accuracy. The raw EEG data undergoes rigorous filtering techniques to eliminate unwanted noise and artifacts, which could obscure genuine neural activity. These filtering methods encompass a range of algorithms, including band-pass filtering to isolate specific frequency bands relevant to brainwave activity such as alpha, beta, theta, and delta waves.




*B. Feature Extraction*

In EEG analysis, feature extraction is a crucial step that involves identifying specific characteristics or patterns within the EEG signal. These patterns are extracted and used as inputs for further analysis, such as classification or clustering.[12] Following methods are used to extract the relevant features:

1) Statistical method: Making inferences and generalizations based on sample data. [13]
   i. Mean
   ii. Standard deviation
   iii. Power Spectral Density
2) FFT spectrum: On giving input of processed EEG waves, FFT spectrum is calculated Susing which further identification and detection is performed.

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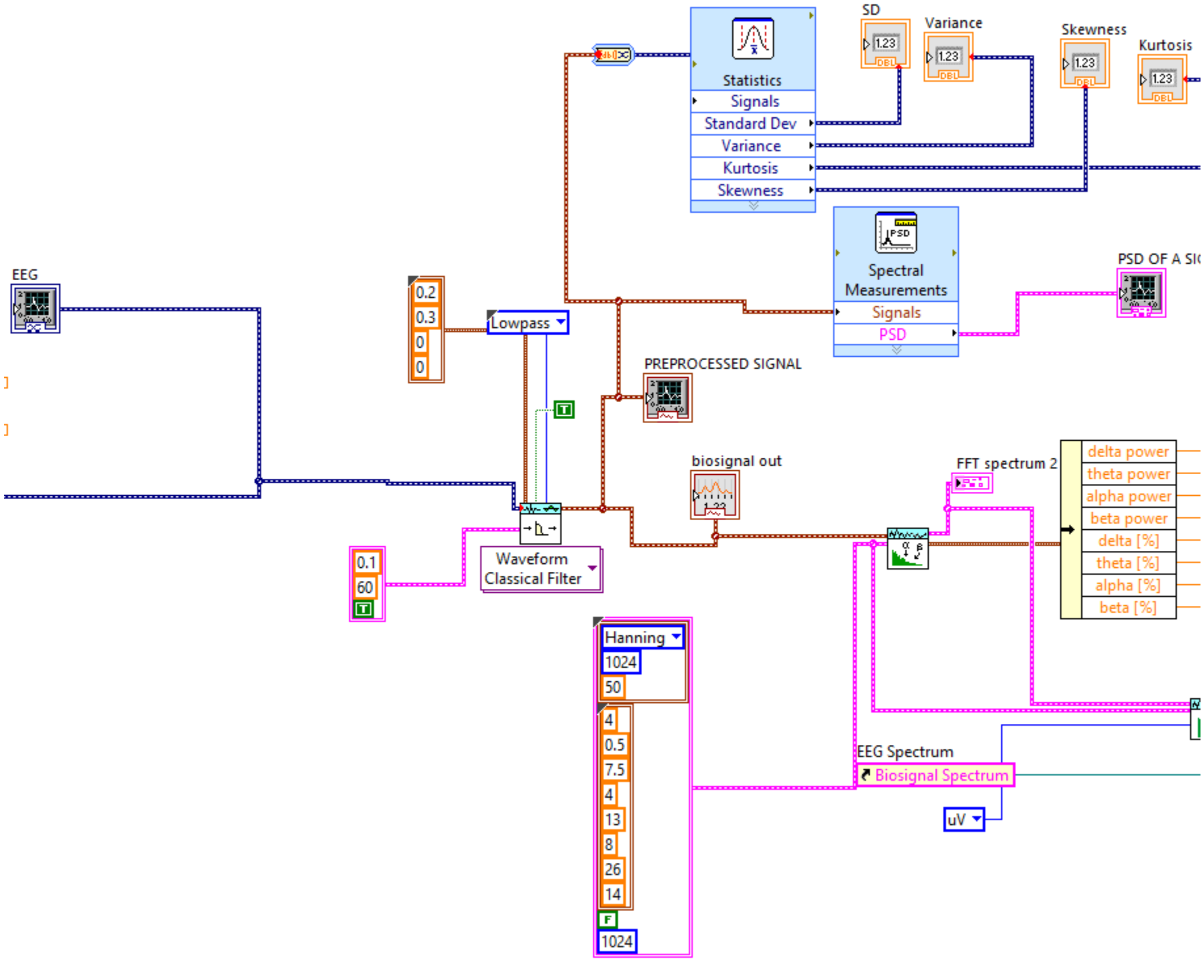
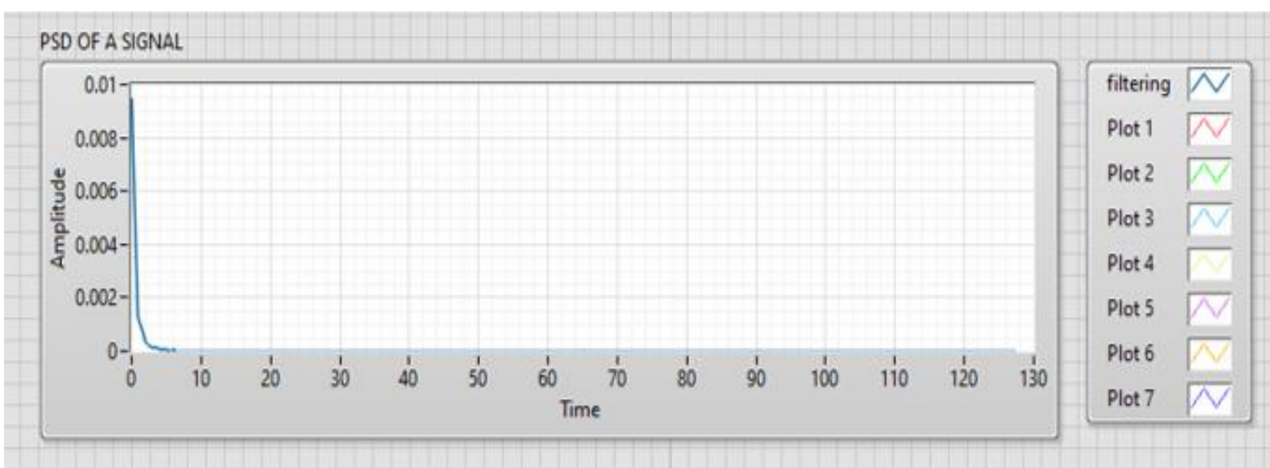
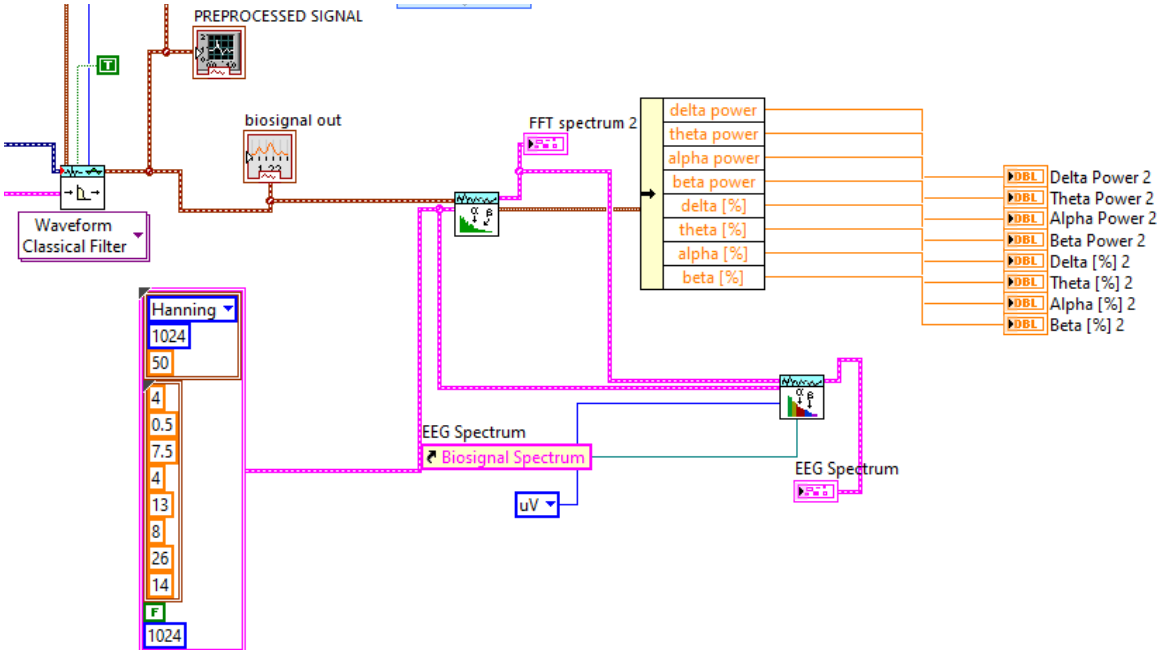



*C. Identification of Brain Wave Content*

Identification of different brain wave power and their content present is based on the FFT spectrum obtained as a part of Feature Extraction. The FFT spectrum calculated in the process of feature extraction is applied as input in the EEG FFT Spectrum block that gives the power and percentage component of alpha, beta, delta and theta waves.




*D. Interpretation of Cognitive States*

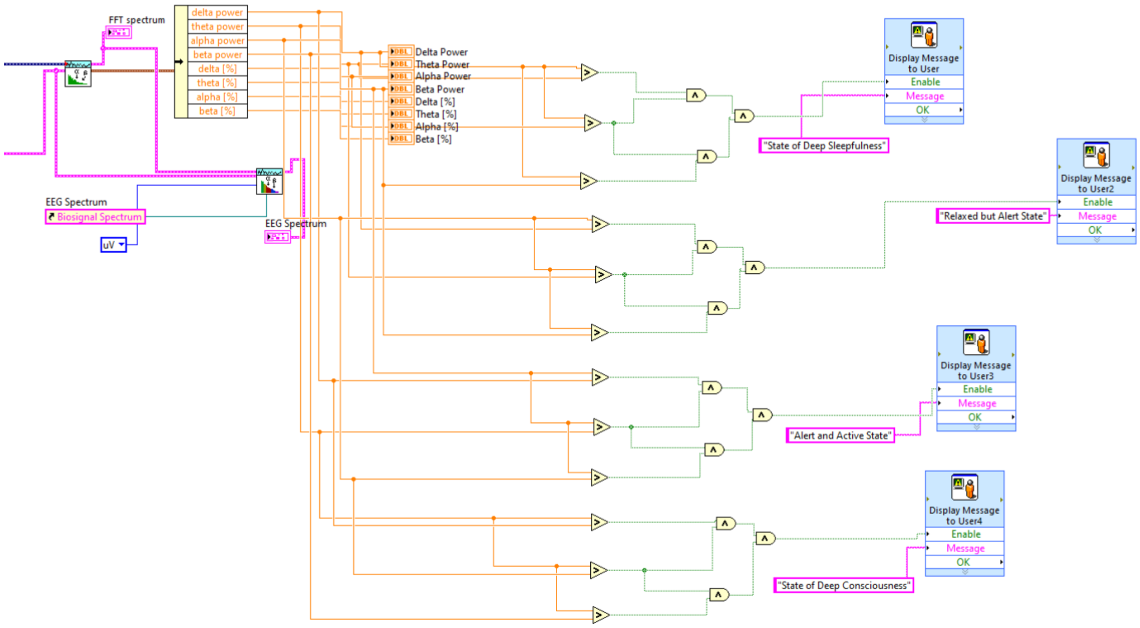
The cognitive states are classified and analysed to interpret underlying cognitive patterns and assess their validity. With help of brainwave analysis, the signals are mapped with their cognitive states on basis of frequency parameters:

- Delta& theta (0.4-7 Hz): Deep, dreamless sleep, Light Sleep, or Extreme Relaxation
- Alpha (8-13 Hz): Deep relaxation, daylight meditation
- Beta (14-40 Hz): Consciousness and state of alertness, logical and reasoning
- Gamma (40hz above): Formation of ideas, Language, and learning

In an EEG signal, each component of brain wave is present. Cognitive state of an individual will depend on the component with highest percentage content and highest power among the four. [14] After obtaining powers of different brain wave components we have compared each brain wave with the other remaining three brain waves using logical gates i.e., greater than function and AND gates.

In a brain wave where all components are present, the cognitive status of a person's mind depends upon the highest percentage component or the highest power present among the other components. For Example, if in the analysis of a EEG signal, it has been found that the beta percentage is highest among the other three waves, the person's brain will be considered in an alert and active state.

The result of these gates is then applied to the "Display message to the user" block. The cognitive status of the individual is shown using that block for each type of component.

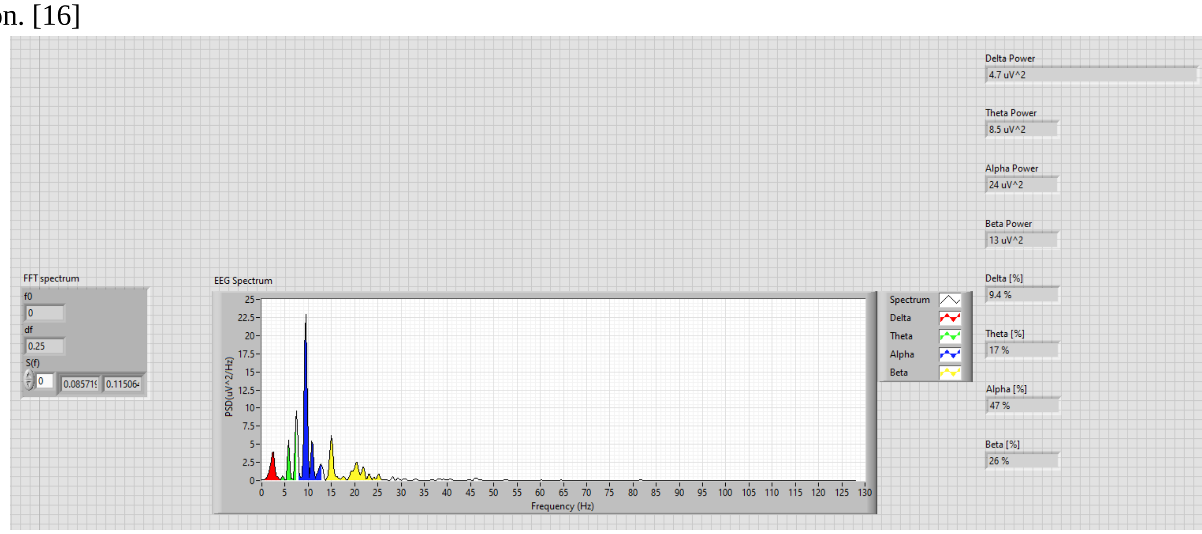



## Results and Discussions

Alpha waves:

Alpha waves (8-13 Hz) occur in a relaxed, alert state, with eyes closed. They are more prominent in the back of the brain, indicating calmness and relaxation. An increase in alpha power is associated with decreased focus, while a decrease in alpha power is associated with increased alertness and attention. Mapping alpha wave activity can provide insight into levels of relaxation or arousal, making it valuable in assessing stress, meditation, and performance. [15]

Consider a person engaged in meditation. EEG recordings during this exercise likely show increased alpha activity, indicating relaxation and decreased extraneous thoughts. Clinically, abnormalities in the alpha system have been associated with disorders such as attention deficit hyperactivity disorder (ADHD), anxiety disorders, and Alzheimer's disease. For example, ADHD patients can exhibit alpha power during tasks that require sustained attention. [16]



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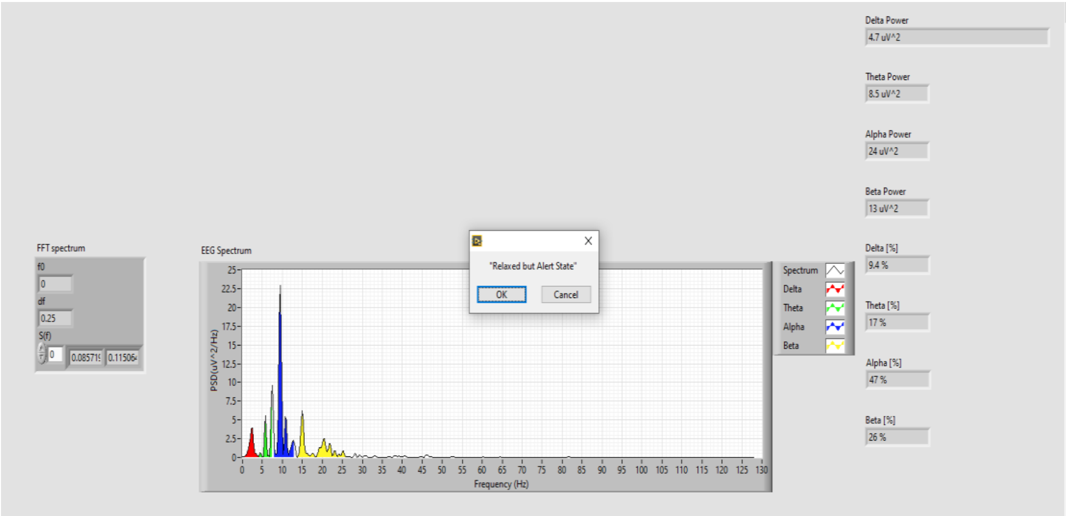
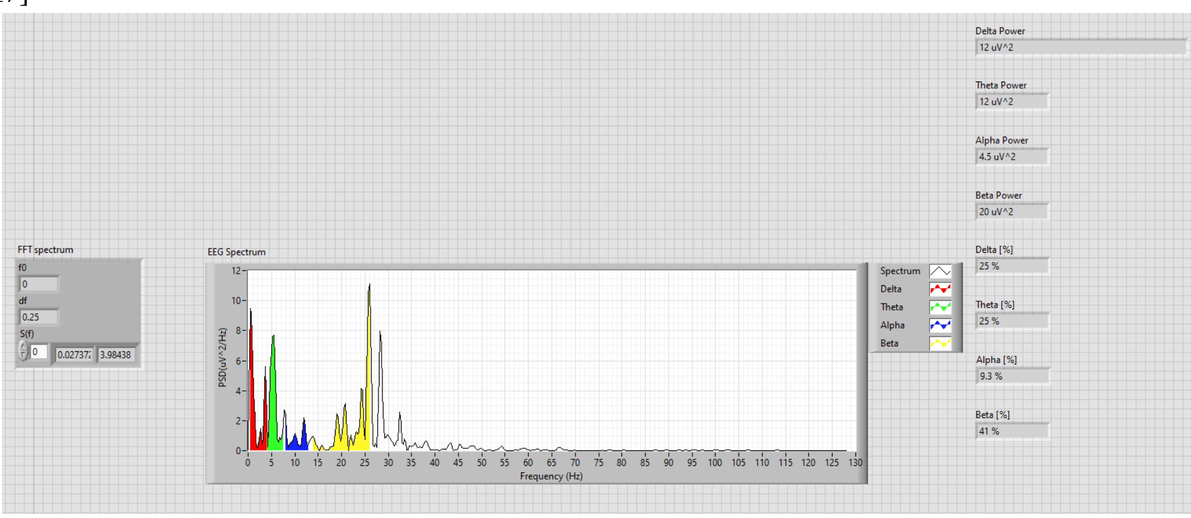
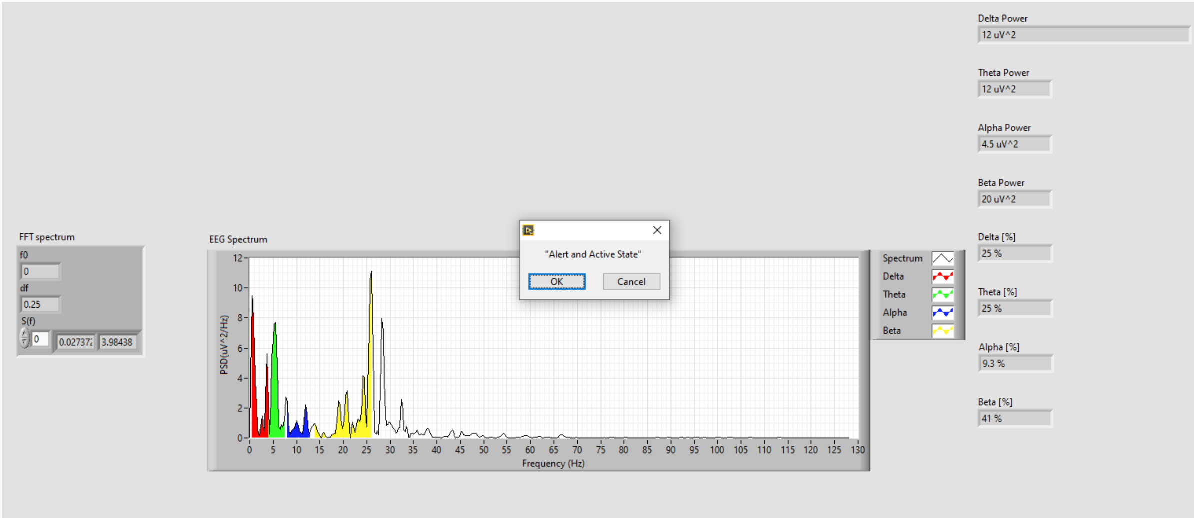



Beta wave:

Beta waves (14-30 Hz) are characteristic of an active, alert mind and are most prominent in the frontal and midbrain regions. It is related to concentration, cognitive control and motor functions. Higher beta power is associated with increased energy and cognitive performance, while lower beta power may indicate relaxation or withdrawal from cognitive functions. Analyzing beta wave activity is useful in assessing cognitive function, attentional resources, and tasks. [17]



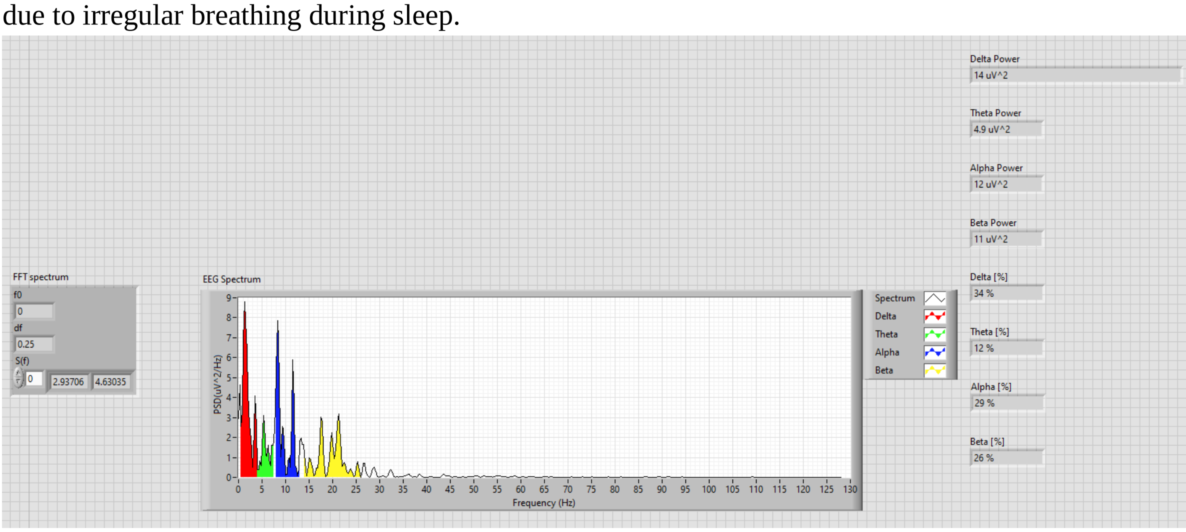


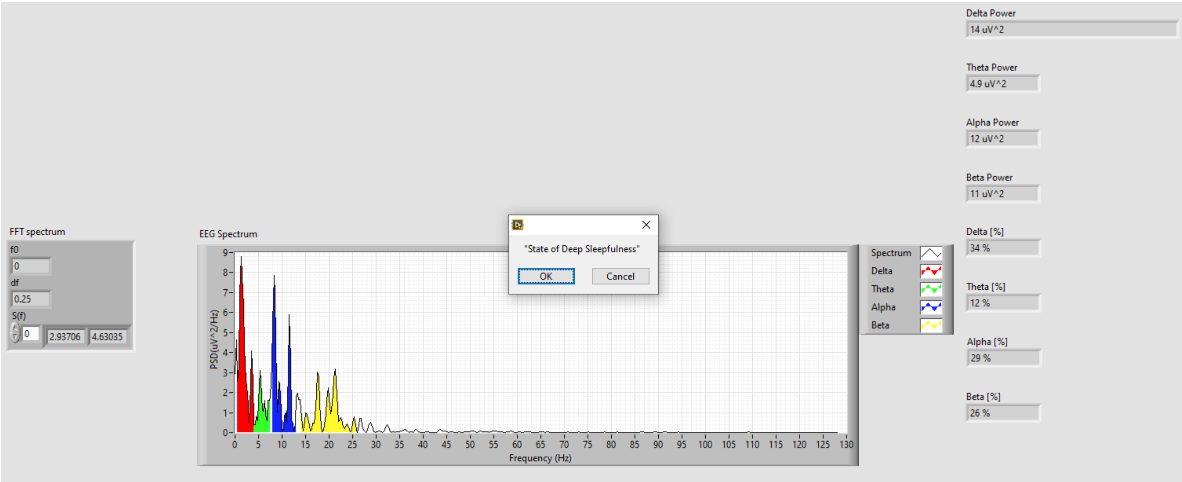

Observe a person's ability to solve complex mathematical problems. EEG sounds during this activity may show increased beta activity in the frontal lobes, indicating increased intelligence and concentration. Clinically, abnormalities in the beta wave pattern are associated with conditions such as Parkinson's disease, schizophrenia, and depression. For example, patients with Parkinson's disease may exhibit excess beta, which contributes to motor impairment.

Delta waves:

Delta waves (0.5-4 Hz) are observed during deep sleep, indicating that sleep is gradually restored. They are often found in more than one cortical area, indicating synchronized neural activity. Delta oscillations play an important role in memory consolidation, synaptic plasticity, and overall brain healing. Delta mapping can provide insight into sleep quality, cognitive impairment, and neurodegenerative disorders associated with sleep disorders. [18]

Observe EEG sounds during deep sleep. Delta activity will predominate, reflecting the neural activity associated with restorative sleep. Clinically, abnormalities in the delta pattern indicate sleep disorders such as insomnia, sedation, and parasomnias. For example, people with sleep apnea may experience fragmented delta waves due to irregular breathing during sleep.






Theta waves:

Theta waves (4-8 Hz) are dominant during sleep, meditation and REM sleep. It is located mainly in the hippocampus and frontal cortex and is involved in memory encoding, spatial navigation and emotional processing. An increase in theta power is associated with creativity, imagination and episodic memory. Mapping theta wave activity facilitates understanding of cognitive processes such as learning, memory formation, and emotional regulation. [19]

Consider someone walking through a virtual maze. EEG recordings during this activity may show increased theta wave activity in hippocampus areas, suggesting a process associated with memory encoding. Clinically, abnormalities in the theta wave pattern have been associated with conditions such as epilepsy, Alzheimer's disease, and traumatic brain injury. For example, people with epilepsy may show abnormal coordination patterns before a seizu

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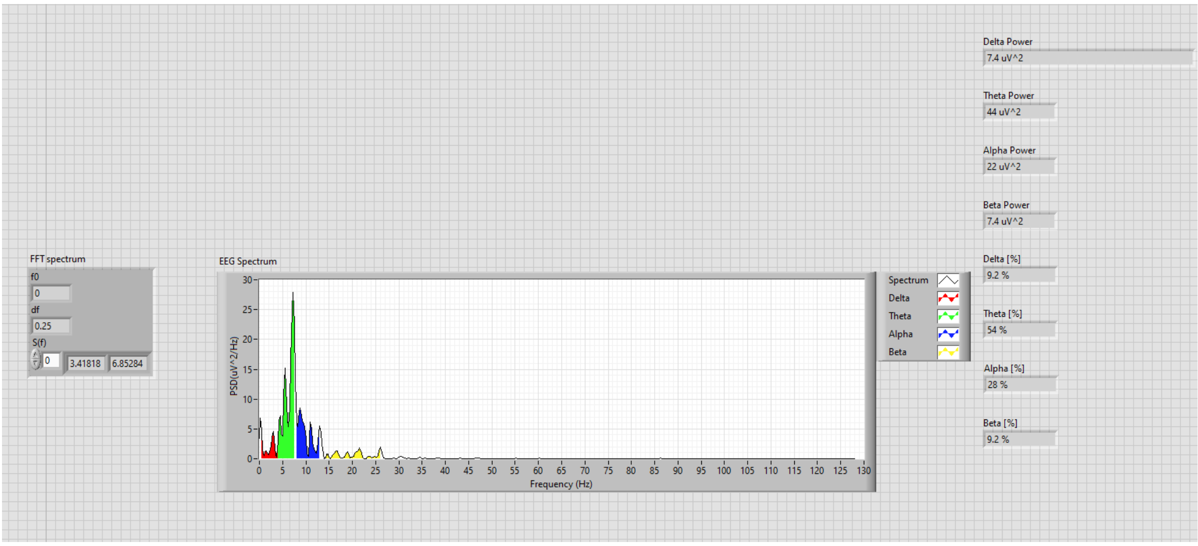


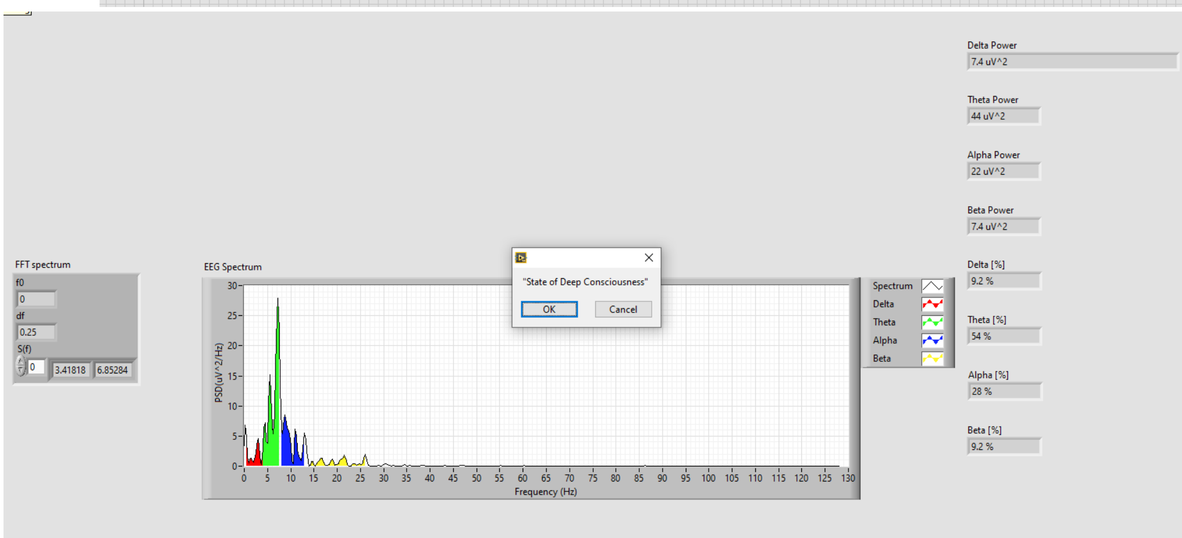


## Conclusion

The MENTAL STATE MONITORING SYSTEM, which uses LabVIEW, is a significant step forward in the proactive management of cognitive wellness. The research shows that the system has the potential to detect early cognitive decline and stress-related conditions, enabling early intervention and customized strategies. By combining the versatility of LabVIEW's platform with state-of-the-art physiological sensors and cognitive challenges, this research has demonstrated the effectiveness of the MENTAL STATE MONITORING SYSTEM in real-time cognitive monitoring and analysis. The system's ability to detect subtle cognitive changes and its user-friendly interface makes it a promising addition to the emerging field of online mental health interventions. In summary, the MENTAL STATE MONITORING SYSTEM presented in this study not only advances the science of cognitive wellness but also has practical applications for healthcare and personal well-being.

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## References

[1] Woaswi, Wan & Hamzah, Noraini. (2018). Human Emotion Detection Via Brain Waves Study by Using Electroencephalogram (EEG).

[2] Ismail, W., Hanif, M. A., Mohamed, S. B., Hamzah, N., & Rizman, Z. I. (2016). Human emotion detection via brain waves study by using electroencephalogram (EEG). International Journal on Advanced Science, Engineering and Information Technology/International Journal of Advanced Science, Engineering and Information Technology, 6(6), 1005.

[3] Agrafioti, F.; Hatzinakos, D. Anderson, A.K. (2012). ECG Pattern Analysis for Emotion Detection. , 3(1), 102–115. doi:10.1109/t-affc.2011.28

[4] Li, T. M., Chao, H. C., & Zhang, J. (2019). Emotion classification based on brain wave: a survey. Human-centric Computing and Information Sciences, 9, 1-17.

[5] Shih, J. J., Krusienski, D. J., & Wolpaw, J. R. (2012). Brain-Computer interfaces in medicine.Mayo Clinic Proceedings, 87(3), 268-279.

[6] Niedermeyer, F. Lopes da Silva, "Electroencephalography: basic principles, clinical applications and related fields", Urban and Schwarzenberg, 1987.

[7] Martin, David C. "The mental status examination." Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd edition (1990).

[8] Akhanda, A. B. S., Islam, S. M. F., & Rahman, M. (2014). Detection of cognitive state for Brain-Computer interfaces. 2013 International Conference on Electrical Information and Communication Technology (EICT).

[9] Medvedev, A. V., Temkina, V., Մակարյան, Sivolenko, E., Hovhannisyan, B., & Ayvazyan, H. (2022, January 1). Extracting Human Brain Signals from the EEG Records Using LabVIEW and Advanced Signal Processing.

[10] Abhang, P. A., Gawali, B. W., & Mehrotra, S. C. (2016). Introduction to EEG-and speech-based emotion recognition. Academic Press.

[11] Nageshwar, V., Sai, Y. P., & Rao, K. S. (2016, February). Design and implementation of data acquisition system for eeg analysis. In 2016 IEEE 6th International Conference on Advanced Computing (IACC) (pp. 792-795). IEEE.

 

[12] Pooja, Pahuja, S., & Veer, K. (2022). Recent Approaches on Classification and Feature Extraction of EEG Signal: A Review. Robotica, 40(1), 77–101.

[13] A. S. Al-Fahoum and A. A. Al-Fraihat, "Methods of EEG signal features extraction using linear analysis in frequency and time-frequency domains," ISRN Neurosci. 2014, 1–7 (2014).

[14] Xavier G, Su Ting A, Fauzan N. Exploratory study of brain waves and corresponding brain regions of fatigue on-call doctors using quantitative electroencephalogram. J Occup Health. 2020 Jan;62(1):e12121.

[15] Isa, I. S., Zainuddin, B. S., Hussain, Z., & Sulaiman, S. N. (2014). *Preliminary Study on* Analyzing EEG Alpha Brainwave Signal Activities Based on Visual Stimulation. Procedia Computer Science, 42, 85–92.

[16] Roohi-Azizi, M., Azimi, L., Heysieattalab, S., & Aamidfar, M. (2017, September 3). Changes of the brain's bioelectrical activity in cognition, consciousness, and some mental disorders. Medical journal of the Islamic Republic of Iran.

[17] Fauzan, N., & Amran, N. H. (2015). Early detection of mild cognitive impairment, dementia and Alzheimer's using QEEG. European Journal of Interdisciplinary Studies, 3(1), 149.

[18] Assenza, G., & Di Lazzaro, V. (2015). A useful electroencephalography (EEG) marker of brain plasticity: delta waves. Neural regeneration research, 10(8), 1216-1217.

[19] Schacter, D. L. (1977). EEG theta waves and psychological phenomena: A review and analysis. Biological psychology, 5(1), 47-82.