International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Electrophysiological Analysis Of Agony And Consciousness In Comatose

S.M.Seeni Mohamed Aliar Maraikkayar, R.Tamilselvi, A. Sabah Afroze, M.Parisa Beham and K.Rajakumar

Abstract: ***An Interface is developed between human brain and a digital world, called as brain-computer interface (BCI). In various applications, BCI is used nowadays in our day to day activities. The recent researches focus on the BCI communication for coma patients for their thought related activities. BCI is an unconventional method to ordinary communication and direct feedback system. Due to the presence of neural relations, there will be an existence of different rhythms for different brain states. In consistent, the rhythms produces a different waves portrayed by different amplitudes and frequencies. This proposed work deals with the different brain state analysis by the Electroencephalography (EEG) signals due to the neuronal reactions. EEG signal is acquired from the brainwave sensor and the signals are detached from the various noises. The time domain features are extracted in terms of various frequency ranges and the respective commands are classified for analyzing the state of the coma patients. The proposed work is analyzed in the software as it involves human interaction.***

Keywords: ***BCI, Electroencephalograph, FFT (Fast Fourier Transform), cognitive state, comatose, agony.***

I. INTRODUCTION

A new computerized information transfer method is a Brain-Computer Interface (BCI), intended to proceed with orders to a technological device through the neuronal activity. These BCI systems mainly find its boom for communication for those exaggerated by vegetative state of coma. To control a BCI, the various brain activity patterns of vegetative state of comatose which are captured in form of Electroencephalogram and converted to commands by identifying the patterns by the system. These interfaces are intended for the subjects, who are with any loss of consciousness. The main operation involved in the BCI operation is the identification of the brain waves from the patients and deciphered in to directions .The main contribution of the proposed work is to analyze the EEG signals of the coma subjects to relate their neural activity and to execute the commands through BCI.

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
S.M.Seeni Mohamed Aliar Maraikkayar,
R.Tamilselvi,
A. Sabah Afrosze,
M.Parisa Beham
K.Rajakumar, Sethu Institute of Technology, Tamilnadu, India-626 115,

This method is Noninvasive since EEG is recorded from the scalp of a person. Though the technology has reached its ultimate and in the field of communication its growth its growth is dramatic [1]. In this work, we are aiming to take an initial step to design a prototype which differentiates the different states of the subject. The paper is systematized as: Section I deals with introduction of BCI and EMG analysis. Section II deals with the available literature survey. Section III discusses the complete portrayal about the proposed block diagram. Section IV deals with the hardware and software implementation of each blocks. Section V comprises the concluding part of the work.

II. RELATED WORKS

Even though a lot of survey is available separately for EMG and BCI, this survey portrays the BCI based EMG activities. Qiwei Shi et.al [2] presented an empirical mode decomposition (EMD) technique for extracting the features of brain activity from recorded EEG. The experimental results showed that this EMD method shows its potential for clinical EEG analysis. Rémy Lehembre et.al [3] studied the methods for providing the differences in the power spectra of the signals and also they worked on the method which provides significant differences in the EEG connectivity measures for the patients in the vegetative state (VS/UWS) and patients in the minimally conscious state (MCS).Modern multiple techniques are used to obtain the power spectra. Totally they computed 3 connectivity measures such as coherence, the imaginary part of coherency and the phase lag index. They concluded that the patients in the vegetative state demonstrate maximized delta power but reduced alpha power compared with the patients in the minimally conscious state. Peter B. Forgacset.al [4] used the traditional EEG which measures the assessment of cohort disorders of consciousness (DOC) patients. The results suggest that this traditional conventional EEG is a effortless approach which balanced the behavioral characteristics of DOC patients.

Azabou et al. [5] emphasized that the patients with impaired consciousness characterized by the reactive electroencephalogram. But the patients with nonreactive characterized by the electroencephalogram EEG-R. They also suggested that the existing estimation methods are heterogeneous and there is no consensus exists.

Jingzhi An et.al [6] identified that the variability in the amount of EEG suppression is high in treat RSE (Refractory status epilepticus) patients. Their analysis suggested that there is a need for developing an substitute archetype. Yao Miao et.al [7] analyzed 36 cases of EEG (coma: 19; quasi-brain-death: 17). The corresponding energy data EEG is acquired and were analyzed by using descriptive statistical analysis.

This analysis results showed that the energy obtained from the EEG of the coma patients is maximum than the energy obtained from the EEG of death patients.

P. Skibsted et.al [8] anticipated that the addition of the proposed multimodal approach provides essential clinical information. Tomasz Wielek et.al [9] investigated the multivariate machine learning based technique. Supervised classifier is used to classify the disorders.

Li Zhu et.al [10] presented the hybrid approach for differentiating the coma patients and brain death which is generally based on canonical correlation analysis (CCA) of power spectral density, complexity features, and feature fusion for group analysis.

It is noted that, most of the work is only about the review of EEG techniques used in various applications. None of the papers have presented for the betterment of treatment of BCI based on the diagnosis of the consciousness. Only a few of the university or medical hospitals is undergoing BCI research with lack of performance analysis. Keeping all those issues in mind, our main motive in this proposal is to implement the proposed BCI system for the analysis of agony and consciousness for comatose patients.

III. PROPOSED SOLUTION

Brain sensors produces an output of EEG signals and the signals are fed to a signal conditioning circuit for preprocessing. The various noises are removed through the filtering process and amplification is done for boosting up of the signal. The analyses of the signals are made after taking Fast Fourier Transformations.The monitor displays the state of consciousness in Comatose.

The Fig.1 shows an blocks involved in the BCI syastem for coma patients. The different blocks in Brain computer Interfacing are Signal Acquirement,Pre-processing of the EEG signals, Feature abstraction and Grouping & Computer Interaction. The various modules used in the proposed system is explained as follows:

The EEG electrodes are intended for extracting the Brains electrical activities i.e. Electroencephalogram .Neural signals are extracted by the by Brain wave sensors through the electrodes. The electrodes are tailored on to the scalp region of the forehead for acquiring the EEG signal.The signal is transferred to the filtering process for signal amplification and enhancement process..

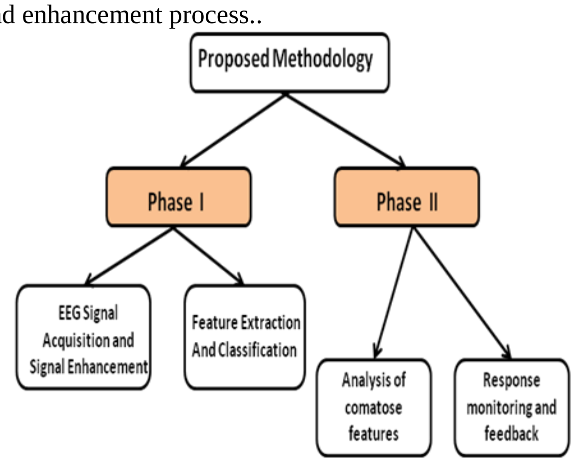

Fig.1. Flow diagram of the proposed Methodology

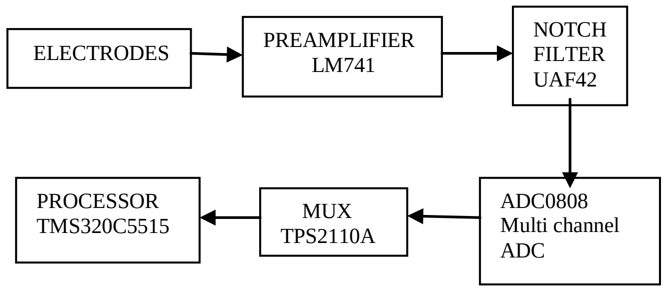

Fig. 2. Block Diagram for Signal Acquisition

A. EEG Signal Acquisition

Signal processing involves filtering process and time domain analysis of the EEG signals. The time domain features involves the FFT process for transforming in to various frequency ranges. The EEG signals have various frequency ranges for the analysis of states of the subjects. The features are translated into preferred commands for computer. The signals are classified based on the frequency range.

B. Signal Classification

The FFT has been used for extracting the frequency ranges and an onset frequency rule is decided for the classification. Fast Fourier Transform is used to alter periodic nature of signals into frequency nature for analyzing the signals. Frequency ranges are shown in Table.

i. Delta Waves:
The waves are represented as higher in magnitude and very slower in the frequency domain. Delta waves are visualized in adults during their sleepy state. [11]

Table 1. Band of EEG signal with frequency range

Band of the signal (EEG)	Frequencyrange (Hz)
Delta	0.5-3
Theta	3-8
Alpha	8 – 12
Beta	12-30
Gamma	30+

ii. Theta Waves:
Theta waves are characterized by lower frequency range. This is commonly visualized in infants.

iii. Alpha Waves:
The larger variations and information is achieved during the relaxed state. The signal is attenuated with eye opening or mental force.

iv. Beta Waves:
The waves are symmetrical are generally linked with the movement actions and the motions behavior.

v. Gamma Waves:
The gamma waves are like a central hub wave for adding all the necessary neural activities in to a network to perform movements and understanding actions.

The input EEG signal use FFT to excerpt the signal which differentiates all thoughts from raw EEG. From the frequency 9Hz to 14 Hz the wake up range is associated. Filtering process is used to extract the exact frequency ranges for the various waves.

C. Feature Extraction

The features are extracted by taking FFT on the EEG signals obtained from physionet database and from that the results are analyzed. The higher upper theta is normally noticed in the frequency of 6–8 Hz, delta waves frequency range is 0.1–4 Hz and alpha frequency range is 8–12 Hz. Theta waves are very robust in the course of subconscious state and sleep condition; The alpha waves are in charge of transformation from conscious to the subconscious state.

IV. IMPLEMENTATION

The implementation includes Hardware parts and Software part. The main hardware part is EEG Sensor. Interfacing hardware with Personal Computer, Code Composer Studio has been used.

A. Hardware Implementation

The signals from the brain are logged using TMS320C6745 (EEG sensor).When the periodic series of an EEG data from the channel is experimented separately; the standard frequency range is measured with the traditional sampling frequency range.

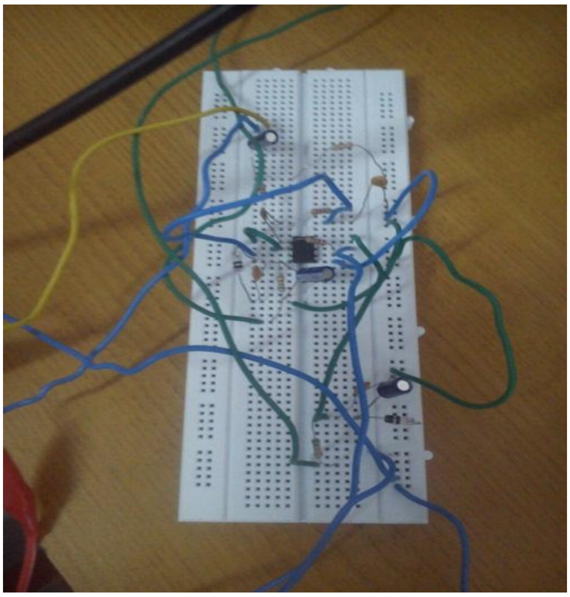

Fig. 3. Implementation of signal conditioning

For example; with a 1000 sample/sec analog to digital conversion rate, the maximum frequency that can be committed is 500Hz. In actuality, because of phase alignment it is necessary to discretely sample (digitalize) the signal at a rate of at least 2.5 times the maximum frequency component of the signal. The discrete sampling of continuous signals is a well characterized problem in time series acquisition and analysis. The general perception is Nyquist criterion, which is given as:

$$F_d \geq 2 * F_m \quad (1)$$

where F_d is the sampling rate and Fm is the maximum frequency of the signal. For instance, if the signal is a sinusoid at 20Hz, a minimum sampling rate of 40Hz is essential to note the signal digitally without aliasing [12]. After acquiring the signals using TMS320C745, it is amplified by LM741 which is a pre amplifier. An implementation of signal conditioning circuit is shown in Fig. 3.

B. Software Implementation:

Coding part is engraved in C. The software used is the Code Composer Studio version 4. The source is available in TMS320C5515 web page.

Fig.4. Implementation of software using CCS

Assembler source is used for proper collation.225 bytes of data memory are used for the transfer rate of the EEG signal and 64 bytes of persistent memory. This is the 25% of the available free C compiler in the Code Composer Studio. The CPU could shots, at a frequency of 2.097152 MHz using the FLL to source MCLK. The whole EEG code, counting the FIR filters, detection of alpha waves, customs about 1 MIPS of the CPU bandwidth.

An implementation of FFT for EEG signal was done by using the software module in the tool of code composer studio version 4. The interfacing between hardware module and TMS320x will be done in prospect.

V. EXPERIMENTAL RESULTS

The signals acquired from database for the normal persons and subjects in sleep state and for comatose. Comparison plots are shown in Fig 5, 6 and 7. The figure 5 shows the higher variations in the amplitude from 0 to 8 Hz. That is in the coma state, the presence of EEG signal variations are noticed in the frequency range of 8 Hz. Theta waves are stronger in this state.

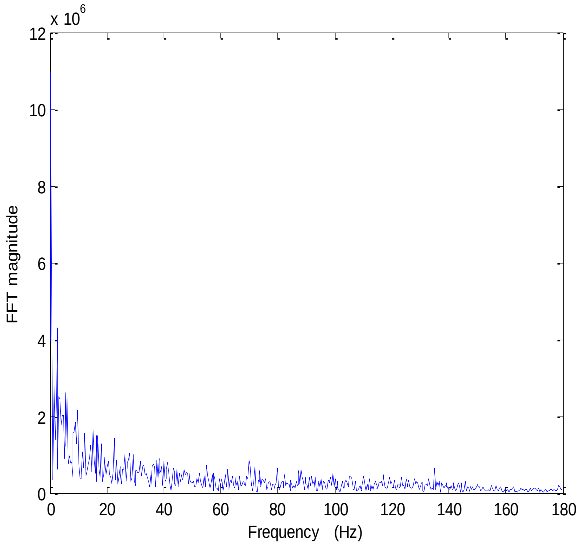

Fig. 5. Signal analysis in coma state

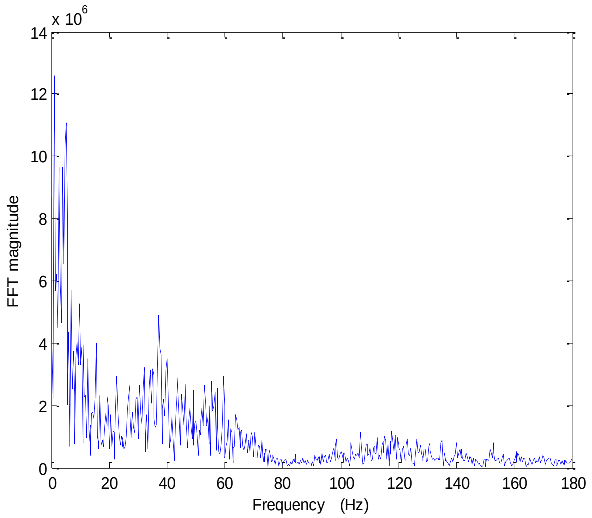

Fig. 6. Signal analysis in sleep state

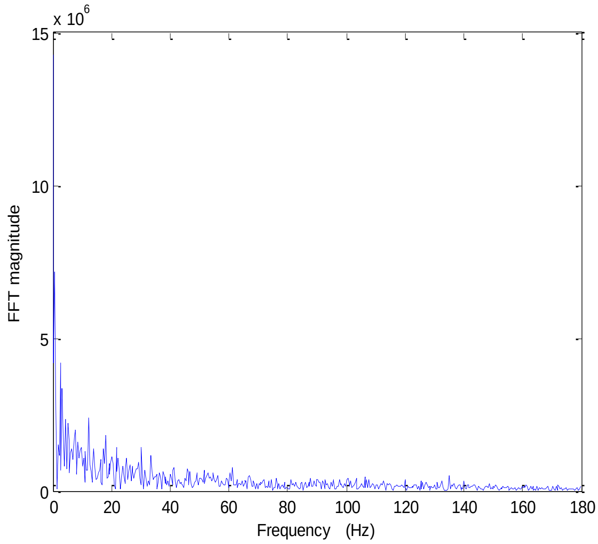

Fig. 7. Signal analysis in normal state

The fig 6 shows only minimal amplitude variations in the amplitude from 0 to 12 Hz. That is in the sleeping state, the presence of EEG signal variations are noticed in the alpha frequency range. The fig.7 shows the higher amplitude variations in the amplitude in the frequency range of 0.1 to 4 Hz. It implicate the presence of delta waves and says the normal condition. That is in normal state, the presence of EEG signal variations are noticed only in the lower frequency range. From these features the signals are classified as pain or normal condition for the coma patients.

VI. CONCLUSION

Our work provides a supportive tool for analysis and recognition of cognizance in patients with syndrome of cognizance by analyzing the various responses to commands. The current study affords an indication whether the patients are affected with the various altered state of consciousness based on the various commands. Therefore, the BCI that is going to be developed by this work will surely provide a communication of the comatose patients.

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