Tinku Biswas, Surajit Bagchi, Swarup Sarkar, Akash Ku. Bhoi / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 5, September- October 2012, pp.1971-1975

Noninvasive Estimation Of Consciousness Level By Fft Method

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ABSTRACT

This paper introduces a two non-invasive electrode based electroencephalography (EEG) scheme to pick-up the bio-potential (generated by the neuron network of human brain) for the assessment of consciousness level. With the help of a suitable algorithm (developed by us), processed in Lab VIEW environment, real-time β-wave (frequency range 13-30 Hz.) is extracted (representing the consciousness level of the brain activities) from the complex bio-signal and reproduced on the computer monitor. The retrieved signal of interest is sampled for Fast Fourier Transform (FFT). The data array is further processed in MATLAB platform using FFT analysis to cross check the results of interpretation of one's awareness level as obtained from Lab VIEW environment. The results provided by our proposed device are in good agreements with the actual physiological actions of the subjects' brain and supported by the clinicians.

Key-words: Electrodes, EEG, β-wave, consciousness, Level of consciousness, FFT.

I. INTRODUCTION

EEG is a graphical record of the electrical activity of the brain. Three types of brainwaves are associated with different levels of arousal: theta waves occur during sleep, alpha waves are associated with wakefulness, and beta waves with excitement. EEGs can be used to monitor the effects of exercise since there is a close correlation between certain EEG wave patterns and fatigue or overtraining. They are also used to determine the extent of injuries inflicted to the head (for example, after a knockout in boxing).

An electroencephalogram (EEG), also called a brain wave test, is a diagnostic test which measures the electrical activity of the brain (brain waves) using highly sensitive recording equipment attached to the scalp by fine electrodes. This paper is based on the estimation of consciousness or awareness of human mind. In biomedical sense, consciousness is the abnormal generation and propagation of action potential of neurons. The action potential (AP) from neurons has been recorded with microelectrodes. The brain activities are different for different stages of human mind; like alert stage, relax stage, drowsy stage etc.

Recently, the driver's attention while driving a vehicle has to be taken seriously in a modernized society. Although some studies of attention while driving are being conducted now, the character of human activity is complicated for estimating attention while driving a vehicle. In the present study, the driver's attention was studied by driving performance and meandering of the vehicle. Two sets of drivers were used to compare with higher and lower states of consciousness. For driving performance, the degree of steering and the degree of acceleration were measured. For meandering, the shoulder line on the road was detected by a CCD camera to calculate the coordinates of the vehicles. These three values showed the dynamical degree of the driver's attention. The results show that the meandering values and the degree of steering values correlated with the degree of attention of the driver, and these results can be applied to make an alert system for drivers during decreased consciousness or concentration in order to realize a safe society for our modern roadways. [1]

II. BACKGROUND

A non-invasive system was developed by **Konkan Railway Corporation Limited** after the accident which was happened on Sainthia Station, Birbhum on 19th July, 2010. At least 60 people were killed in that accident. The main reason of that accident was the unconscious mind of the pilot. The signalman in-charge at the station claimed to have heard the station master trying to alert the driver of the Uttar Banga Express via walkie-talkie, but got no response. The guard, when questioned said that the driver did not respond to him on the walkie-talkie. The basic principle of their system was measuring the skin impedance between the skin surface electrodes, placed on the pilot's wrist. Depending upon the consciousness of the pilot/driver the skin impedance changes. The change of impedance is picked up by two skin surface electrodes, followed by a signal conditioning circuit. But their system gives erroneous result due to dirt, moisture etc. present in the pilot's hand, causing an increased impedance of the cell giving erroneous indications. The pilots have to drive train for a long time on railway track and the possibilities of presence of dirt and moisture in pilot's hand become greater. This is the main drawback of their system.

III. THEORY

The bio-electric potential generated by the neuronal activity of brain is recorded by the electroencephalography (EEG). The neuronal activities responsible for different stages of human brain are different. These neuronal activities were studied in terms of electrical signal to discriminate the different stages. Here, two non-disposal skin surface electrodes were used for collecting the signal from human brain and for differentiating the consciousness of the human mind. An alert person usually displays an unsynchronized high-frequency EEG signal. A drowsy person produces a large amount of rhythmic activity in the range of 8-13 Hz. A few EEG wave groups are listed below:

• Beta (14 – 26 Hz) waking rhythm associated with active thinking
• Alpha (8 – 13 Hz) indicate a relaxed awareness and inattention
• Theta (4 – 7 Hz) appears as consciousness slips into drowsiness
• Delta (0.5 – 4 Hz) associated with deep sleep

When there is severe diffuse brain abnormality, such as encephalitis or conditions causing coma, there will be usually be no alpha activity, whilst in the vegetative state there may be alpha activity that fails to desynchronize on eye opening. Faster frequencies (*beta*, at >13 Hz) or slower (*theta*, at 4-8 Hz) can be normal in infancy and childhood. Even slower 'delta' waves (<4 Hz) can be normal in sleep and in infancy, but in awake adults indicate severe abnormality. As a person begins to fall asleep, the amplitude as well as the frequency of the waveform decreases.

In this approach the bio-potential is collected by a sensor, reusable non-invasive skin surface electrode. Information lies in the frequency of the waves collected by the electrodes. At rest, relaxed and with the eyes closed, the frequency of these waves is 8-12 Hz (cycles/sec). This 'alpha' activity is believed to reflect the brain in 'idling' mode, because if the person then either opens the eyes, or does mental arithmetic with the eyes closed, these waves disappear, to be replaced by irregular patterns (so-called *desynchronized activity*). In normal sleep there is characteristic higher voltage activity, in patterns which vary according to the level of sleep.

Standard Waveforms:

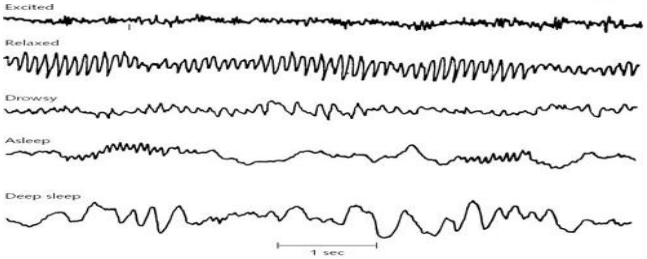

Figure 1: Signal pattern for different stages of human brain

Block Diagram:

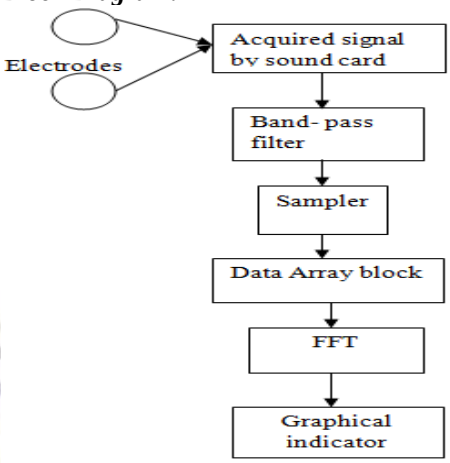

Figure 2: Block diagram of the system

i. Sensors

Brain cells communicate by producing tiny electrical impulses, also called brain waves. These electrical signals have certain rhythms and shapes, and EEG is a technique that measures, records, and analyzes these signals to help make a diagnosis. Electrodes are used to detect the electrical signals. They come in the shape of small discs that are applied to the skin surface. The bio-potential, generated by the neurons, are collected by two non-disposal skin surface Ag-AgCl electrode. One of the electrodes is placed on the surface of subject's forehead with the conducting paste. This electrode is actually responsible for the extraction of signal from forehead. Another electrode is placed on the ear-lobe. This electrode is working as reference electrode.

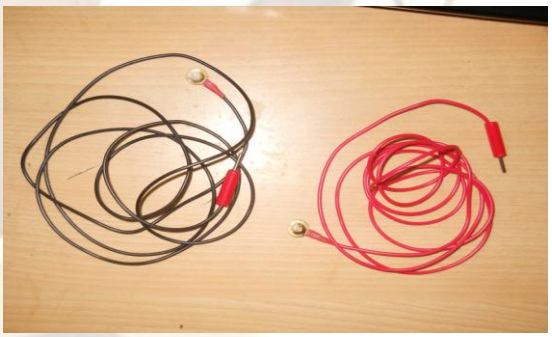

Figure 3: Figure of used electrodes during the experiment.

ii. Signal conditioner

The signal conditioner block consists of an amplifier circuit, followed by a filter circuit. The signals collected from the human brain are in the range of microvolt. This voltage will be first amplified by an amplifier. After that, the amplified signal will be fed to an active band pass filter to eliminate the unwanted noise signals. However, EEG signals are not easily obtained. This is due to the signals' electrical characteristics. They are

extremely weak signals, in the range of 1 – 160 µVpp. They are band limited to a very low frequency range, 0Hz - 100Hz for EEG. These signals are so small that they exist in the level of ambient noise. Our objective is concerned about the frequency range 'Beta' (13 - 30 Hz).

iii. Filter design

Our target is to design an Active band pass filter whose bandwidth is 13 -30 Hz.
f1=13Hz and f2=30Hz

iv. Fast Fourier Transform:

FFT = Fast Fourier Transform. The FFT is a faster version of the Discrete Fourier Transform (DFT). The DFT is extremely important in the area of frequency (spectrum) analysis because it takes a discrete signal in the time domain and transforms that signal into its discrete frequency domain representation. Without a discrete-time to discrete-frequency transform we would not be able to compute the Fourier transform with a microprocessor or DSP based system.

The continuous-time Fourier transform (CTFT) can be found by evaluating the Laplace transform at s= jw. The discrete-time Fourier transform (DTFT) can be found by evaluating the z-transform at z = e^jw. The FFT does not directly give you the spectrum of a signal. As we have seen with the last two experiments, the FFT can vary dramatically depending on the number of points (N) of the FFT, and the number of periods of the signal that are represented. The FFT contains information between 0 and fs; however, we know that the sampling frequency must be at least twice the highest frequency component. Therefore, the signal's spectrum should be entirely below fs/2, the Nyquist frequency.

IV. SIMULATION TOOLS

For the FFT analysis of the acquired EEG signal from human brain here, we used Lab VIEW 2009 software. In Lab VIEW platform we used the power spectrum analysis to get the frequency components present in the acquired bio-logical signal. We used graphical indicator in the labview platform to show the output responses of the system. There were a number of graphical indicators in the front panel of the labview which were used to plot the signal pattern as well as the fast furrier responses. Matlab 7.0 is also used to cross check the results of interpretation of one's awareness level as obtained from Lab VIEW environment.

V. RESULTS AND DISCUSSIONS

In this paper, the samples have taken different types of drug to estimate the consciousness of their brain. The following types of drug and alcohol were being used during the experiment:

- **Heroin:** Heroin is an opiate drug that is synthesized from morphine, a naturally occurring substance extracted from the seed pod of the Asian opium poppy plant. Heroin usually appears as a white or brown powder or as a black sticky substance, known as "black tar heroin."

- **Locally Made Alcohol (LMA):** Locally produced moonshine is known in India as tharra, and also (among other names) as desi, latta, gawathi, Haathbhatti, desi daru, hooch, Potli, kothli, dheno, mohua, chullu, Narangi, Neera, kaju, cholai, Saaraayi and santra. It is made by fermenting the mash of sugar cane pulp in large spherical containers made from waterproof ceramic (terra cotta). However, it is dangerous, mainly because of the risk of alcohol or copper formaldehyde poisoning.

- **Whisky:** Whisky or whiskey is a type of distilled alcoholic beverage made from fermented grain mash. Different grains are used for different varieties, including barley, malted barley, rye, malted rye, wheat, and corn. Whisky is typically aged in wooden casks, made generally of charred white oak. Whisky is a strictly regulated spirit worldwide with many classes and types. The typical unifying characteristics of the different classes and types are the fermentation of grains, distillation, and aging in wooden barrels.

- **Cannabis:** Cannabis a genus of flowering plants that includes three putative varieties, *Cannabis sativa*, *Cannabis indica* and *Cannabis ruderalis*. These three taxa are indigenous to Central Asia, and South Asia. *Cannabis* has long been used for fibre (hemp), for seed and seed oils, for medicinal purposes, and as a recreational drug. Industrial hemp products are made from *Cannabis* plants selected to produce an abundance of fiber.

1. (a) The FFT of the same subject before taking drug is shown below:

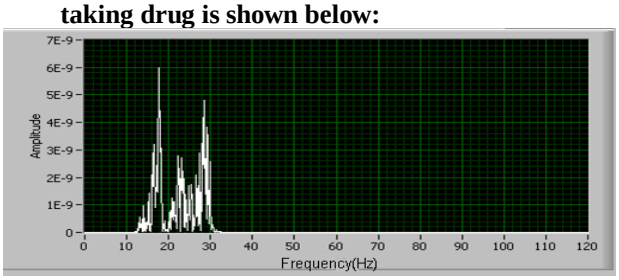

Figure 4(a): FFT before taking drug.

(b) The FFT of the same subject after taking drug:

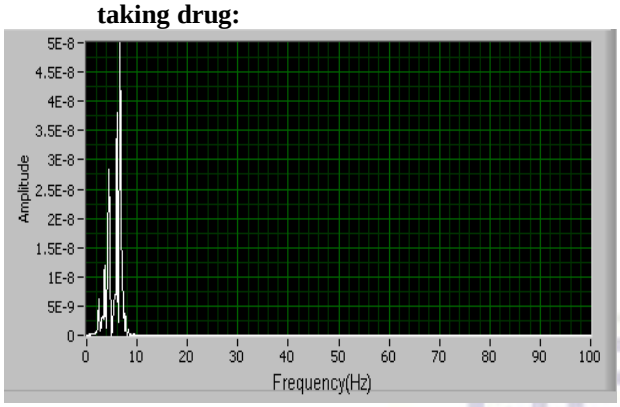

Figure 4(b): FFT after taking drug.

From the above two FFTs, we have found that the frequency of the subject shifts towards the alpha band from the frequency (beta band) when he was in normal state.

2. **(a) FFT of the same subject before smoking cannabis:**

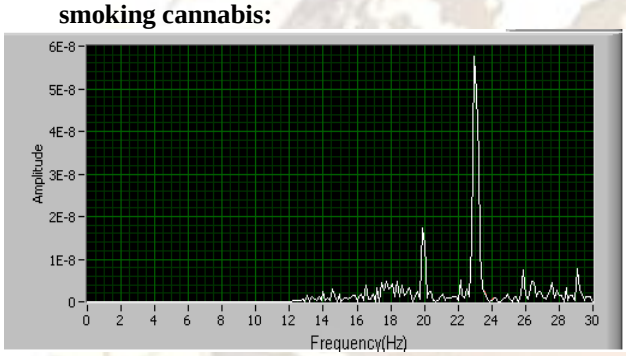

Figure5(a) : FFT at conscious stage.

(b) FFT of the same subject after smoking cannabis:

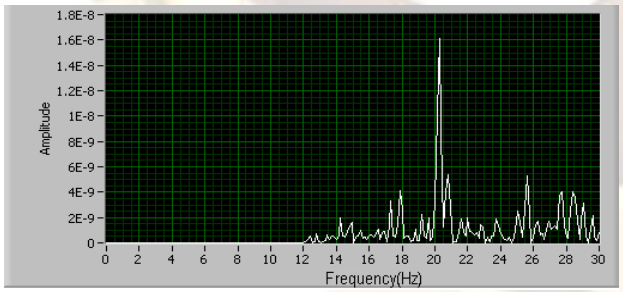

Figure 5(b) : FFT after smoking cannabis.

For this subject, we have got the frequency component at 23 Hz when the subject was in conscious stage. Now We have taken the reading of the same subject after 30 minutes of smoking cannabis. Here we got the frequency at 20 Hz. We can say that the frequency shifts down towards the alpha band from the frequency band, found before smoking cannabis.

3. **(a)The FFT of SUBJECT 3 before drinking alcohol:**

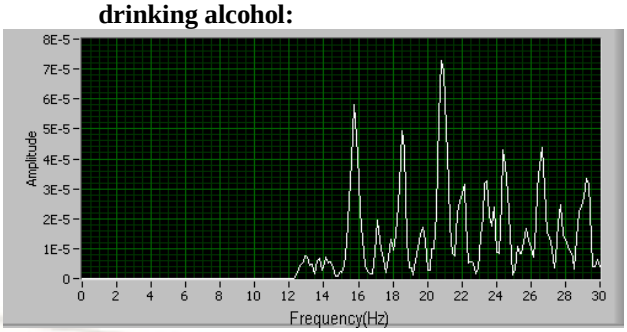

Figure 6(a): FFT for subject3 before drinking alcohol.

(b) The FFT of SUBJECT 3 after drinking alcohol:

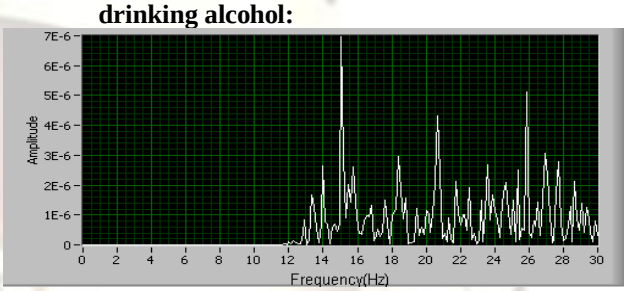

Figure 6(b): FFT for subject3 after drinking alcohol.

In the above two FFT of SUBJECT 3 we got the frequency component at 21Hz in first case i.e. in conscious stage. In the second case when SUBJECT 3 was drunk, we got the frequency at 15 Hz. This means that the frequency component shifts towards the alpha stage.

VI.CONCLUSION

We have shown the signal patterns and FFTs for four different groups of subjects. The FFTs patterns of all the groups were used for the analysis purpose. The corresponding frequencies were found very significant and represent the level of consciousness of the subjects. When the consciousness level deteriorates the frequencies shift towards alpha band. Hence frequency information are representative of the level of consciousness.

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