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EFFECTIVE APPROACH FOR THE DRUNKEN DRIVING AND DROWSY STATE DETECTION USING EEG

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Abstract:

In today's scenario, more and more people are required to travel back and forth to various places. With the increasing vehicular population and their movements on the roads, accidents are also steadily increasing. It has become a nightmare for the authorities to prevent /reduce such fatal accidents on the roads. But the authorities' efforts are in vain. It is shocking to know the study results that around 50% of the road accidents are owing to drunken driving all over the world and Drowsiness also play a vital role. Any mechanism or device to reduce such deaths will be of great help. Drunken driving and its subsequent catastrophe can be avoided by monitoring the EEG of the driver. The power of the EEG signal in frontal region decreases with the increase in the amount of alcohol intake, and the power of the EEG signal in central, occipital region increases. For drowsiness detection, the frequency variations in EEG wave is to be used. Therefore, power spectral density can be used as a parameter to differentiate EEG of alcoholic from nonalcoholic and similarly Fourier transform is used for drowsiness detection, thereby reducing drunken as well as drowsiness driving.

Key Words: Alpha Wave, Electroencephalography, Theta Wave & Power Spectral Density

1. Introduction:

The proposed technology captures brain waves and stops drivers from causing accidents due to drunken driving as well as drowsiness. It is based on the fact that, alcohol affects the neuronal-activity of the brain i.e., alpha activity of alcoholic person decreases and theta activity increases (alpha and theta activity are various frequency bands of brain activity), [1], [2]. The smart cap consists of five embedded electrode in the form of forehead band, which is used to acquire the EEG signal. The acquired EEG signal is pre-processed and directed via Bluetooth to the intelligence unit which consists of microprocessor. This algorithm loaded processor is used to decompose the EEG signal into alpha, beta, gamma and delta waves. The decomposed EEG signal is analysed for alcoholic activity. The voltage produced by the algorithm is used to drive the relay system depending upon the presence or absence of abnormalities in the EEG.

2. Flaws in Conventional Methods:

Breath analyzer is the most common method of testing for blood-alcohol content in use today. Personal breath analyzers estimate the concentration of alcohol in the body by measuring the amount of alcohol exhaled from the lungs. The existing 'Automated Breath Analyzer' for detecting alcohol, consumed by the driver, is no longer useful because of its own limitations & demerits. This is based on the odour and the level of alcoholic (-OH) ions present in the breath. Hence, it can easily be cheated if the suspect takes in spices or other smell attenuators. The other demerit is that sensors for detecting alcohol content in air within the vehicle ambience by using 'reducing (-OH reductases) or oxidizing enzymes (- OH oxidases)' is ineffective because of its less sensitivity and accuracy. Also the enzymes used in the sensor have to be replaced periodically. Another method is using pulse oxymeters. Even though non invasive oxy-meters are available, a considerable amount of time is taken by the meters to detect -OH ions. Thus this is also not reliable and lacks practical application as an automated system for detecting drunk driving.

3. EEG:

Electroencephalography is the recording of electrical signals from the brain. Each nerve cell (neuron) in the brain produces a tiny electrical charge; when a number of neurons become active, the sum of these tiny electrical charges can be detected on the surface of the scalp. Small electrodes placed on the scalp detect this electrical activity, which is magnified and recorded as brain waves (neural oscillations). These brain waves illustrate the activity as it is taking place in various areas inside the brain. The rhythmic activity is divided into frequency bands*:* Delta is the frequency range up to 4Hz. It tends to be the highest in amplitude and the slowest waves. It is seen normally in adults in slow wave sleep. Theta is the frequency range from 4Hz to 7 Hz. Theta is seen normally in young children. It may be seen in drowsiness or arousal in older children and adults. Alpha is the frequency range from 8Hz to 12 Hz. This is activity in the 8–12 Hz range seen in the posterior regions of the head on both sides, being higher in amplitude on the dominant side. It is brought out by closing the eyes and by relaxation. Beta is the frequency range from 12Hz to about 30 Hz. It is seen usually on both sides in symmetrical distribution and is most evident frontally. Beta activity is closely linked to motor behavior and is generally attenuated during active movements.

4. Decomposition of EEG Using Stationary Wavelet Transform:

In order to detect the presence of alcohol in EEG, it is necessary to analyse the temporal and spectral features of EEG, [2]. The time-frequency analysis was carried using stationary wavelet transform. Stationary wavelet transform applies high and low pass filters to the data at each level without carrying out the process of decimation. Using stationary wavelet transform EEG was decomposed to 5 frequency levels (delta(0-4 hz), theta(4-8 hz), alpha(8- 12 hz), beta(12-20 hz), gamma(20 hz and above)).

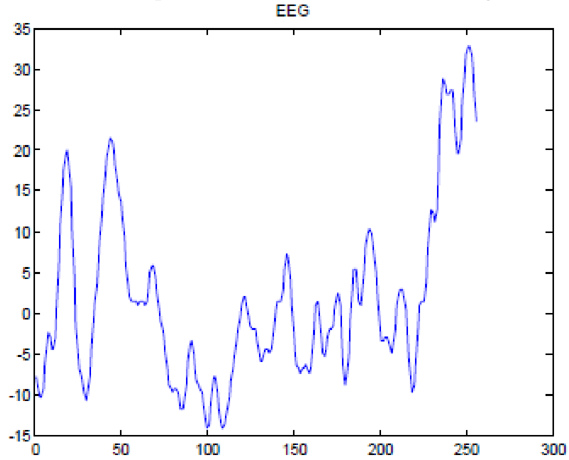

Figure 1: EEG wave

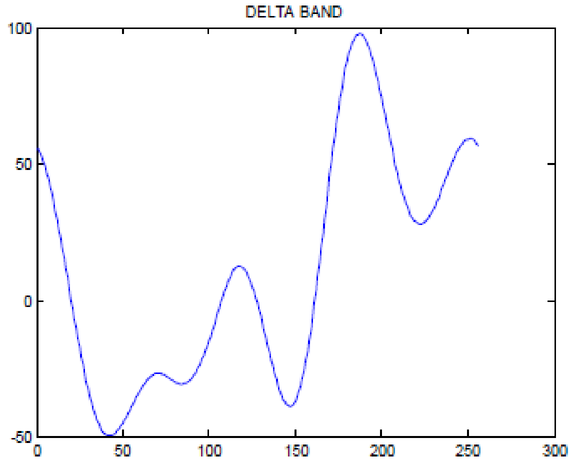

Figure 2: Delta Band of EEG Wave Decomposed Using Stationary Wavelet Transform

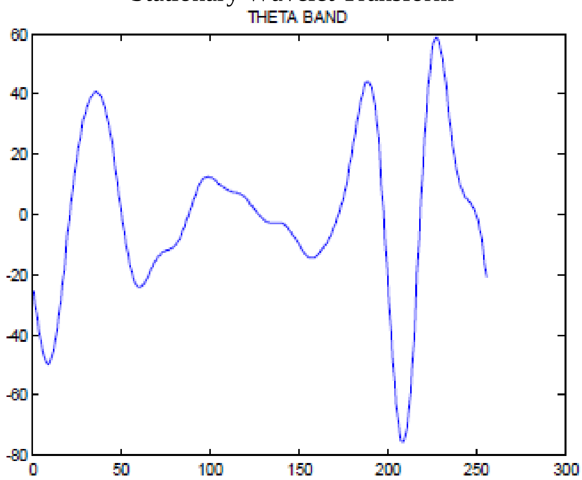

Figure 3: Theta band of EEG wave decomposed using stationary wavelet transform

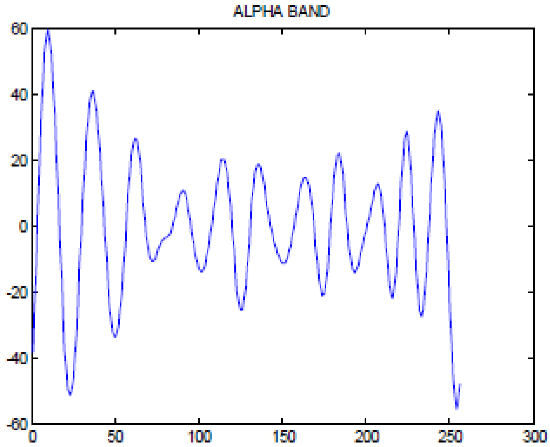

Figure 4: Alpha band of EEG wave decomposed using Stationary wavelet transform

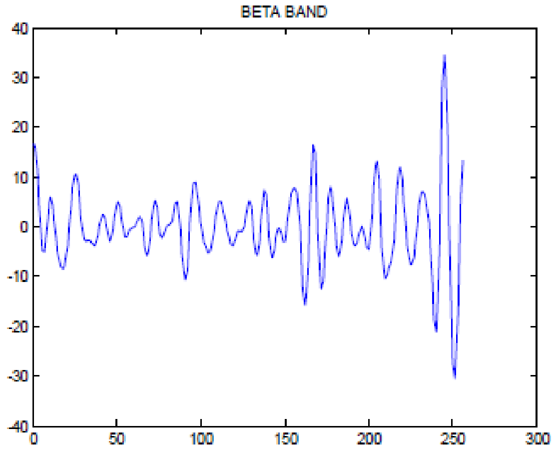

Figure 5: Beta band of EEG wave decomposed using Stationary wavelet transform

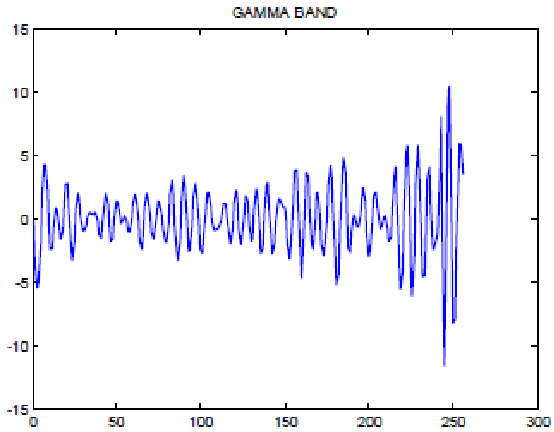

Figure 6: Gamma band of EEG wave decomposed using stationary wavelet transform

5. Power Spectral Density Analysis:

The Power Spectral Density analysis is performed for finding out the power of the signal over a particular frequency band. The literature survey reveals that the power of the EEG signal in frontal region decreases with the increase in the amount of alcohol intake, and the power of the EEG signal in central, occipital region increases. This indicates that nerve stimulation of alcohol has a strong influence on central region, so people will become excited after drinking.

1) Theta (θ) Waves: Theta (θ) waves begin to appear and gradually enhances after consuming alcohol as the subjects are driven in to the state of sleepy and the central nervous system of the subjects is inhibited.

2) Alpha (α) Waves: Alpha (α) waves gradually decreases and the region of alpha (α) waves is expanded after consuming alcohol.

3) Beta (β) Waves: The cerebral cortex remains in an excitable condition after consuming alcohol, which leads to beta (**β**) waves gradually enhanced and the area of beta (β) waves are expanded.

6. Results:

Based on the methodology discussed above, this section describes the results and their interpretation EEG signals of 5 normal people and 5 alcoholic people were used and further analysis was carried out to find the correlation between EEG of normal person and alcoholic. EEG signal was decomposed into 4 frequency bands (alpha, beta, delta and theta) and their power spectrum was analyzed and following results were obtained using MATLAB.

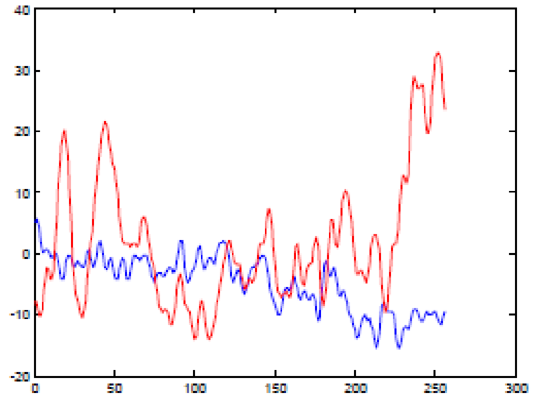

Figure 7: EEG of normal person (red) vs. alcoholic person (blue)

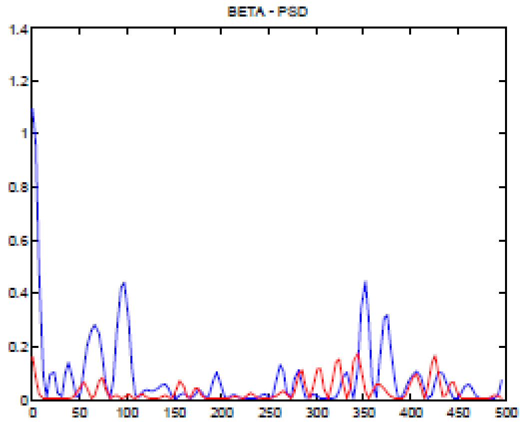

Figure 9: Power spectrum density of beta wave of normal person (red) and alcoholic person (blue)

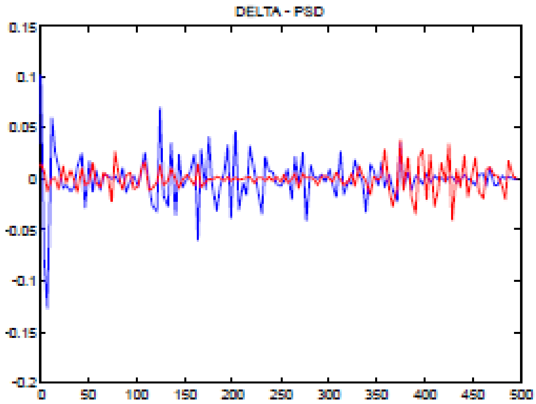

Figure 8: Power spectrum density of delta wave of normal person (red) and alcoholic person (blue)

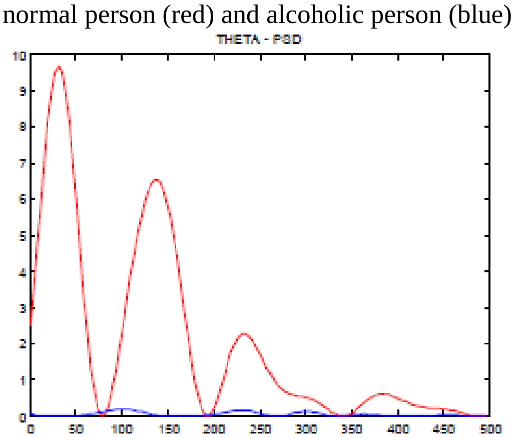

Figure 11: Power spectrum density of theta wave of ormal person (red) and alcoholic person (blue

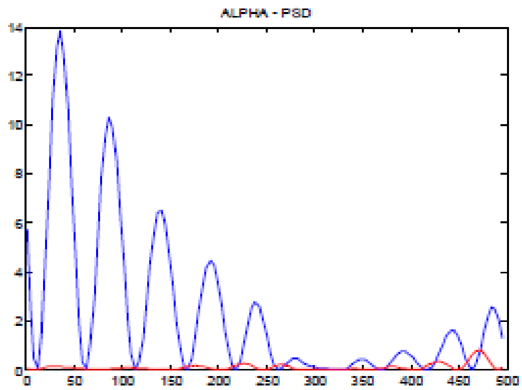

Fig 10: Power Spectrum Density of alpha wave of normal person (red) and alcoholic person (blue)

It is very much evident from the above plots that alpha activity is decreased in alcoholic person compared to normal person. Similarly theta activity is increased in alcoholic person compared to normal person. Going by these two facts normal person can be differentiated from alcoholics from their EEG.

7. Discussion:

From the above derived results, it is possible to devise a system to identify and prevent drunken driving. This technology will help in preventing such deaths (caused by drunken driving and drowsiness while driving) and it is a means to save thousands of priceless human lives. Therefore, we developed a novel BCI system which contains the advantages of small volume and low power consumption, and is suitable for practical driving applications. The proposed BCI system consists of a wireless physiological signal-acquisition module and an embedded signal-processing module. Here, the wireless physiological signal-acquisition module is used to collect EEG signals and transmit them to the embedded signal processing module wirelessly. It can be embedded into a headband as a wearable EEG device for long term EEG monitoring in daily life. The embedded signal processing module, which provides powerful computations and supports various peripheral interfaces, is used to real-time detect drowsiness and trigger a warning tone to prevent traffic accidents when drowsy state occurs. The basic scheme of our proposed EEG-based BCI system was shown in Fig. 12, [1]. The system hardware consists of a wireless physiological signal-acquisition module and an embedded signal-processing module. First, the EEG signal will be obtained by the EEG electrode, and then amplified and filtered by the EEG amplifier and acquisition unit in the physiological acquisition module. Next, the EEG signal will be preprocessed by the microprocessor unit and transmitted to the embedded signal processing module via a wireless transmission unit. After receiving the EEG signal, it will be monitored and analyzed by our drowsiness detection algorithm implemented in an embedded signal-processing unit. If the drowsy state of the driver is detected, a warning tone device unit will be triggered to alarm the driver.

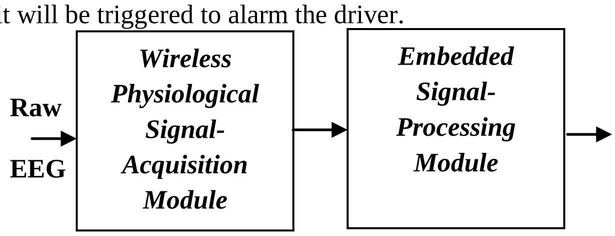

Figure 12: Basic structure for the proposed system with two modules

A. Wireless Physiological Signal-Acquisition Module: The wireless physiological signal-acquisition module mainly consists of the EEG amplifier and acquisition unit, microprocessor unit, and wireless transmission unit. Here, the EEG amplifier and acquisition unit, which includes a preamplifier, a band-pass filter, and an analog-to-digital converter (ADC), was designed to amplify and filter the EEG signal. The gain of the EEG amplifier and acquisition unit was set to about 5040 times with the frequency band of 0.1–100 Hz. Next, the amplified and filtered EEG signal will be digitized by a 12-b analog-to-digital converter (ADC) with a sampling rate of 512 Hz. The microprocessor unit (TI CC3200), which contains the advantages of ultra-low power consumption, 16-b reduced instruction set computing (RISC) architecture, 125-ns instruction cycle time, five power-saving modes, and the diversification of a peripheral communication interface, is used to control the ADC to obtain, preprocess, and send EEG data to the wireless transmission unit. In the microprocessor unit, EEG data caught from the ADC via a serial peripheral interface will be stored into the memory of the microprocessor unit, and then will pass through a moving average filter to remove power-line interference before wireless transmission. Here, the Bluetooth module is used as the wireless transmission unit.

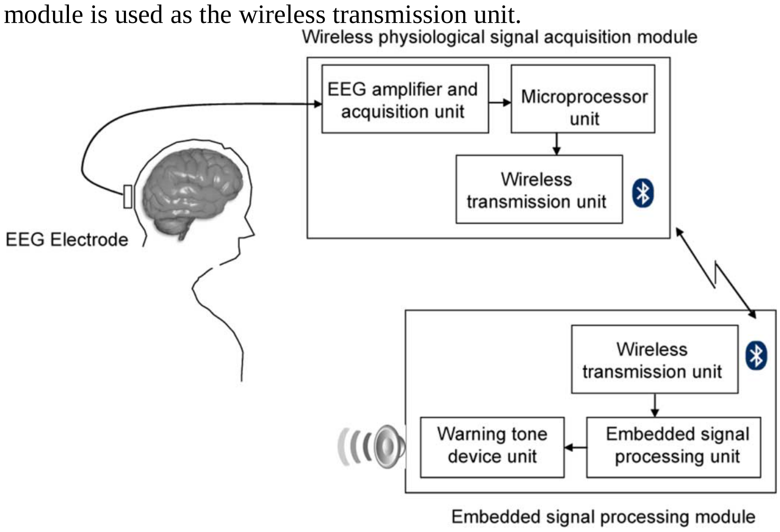

Figure 13: Basic scheme of Proposed EEG-based BCI system

B. Embedded Signal-Processing Module: The embedded signal-processing module was designed as a platform which performs a real-time EEG-based drowsiness detection algorithm. It contains powerful computations and can support various peripheral interfaces. The embedded module mainly consists of an embedded signal-processing unit, a wireless transmission unit, and a warning tone device unit. The received EEG data will be real time processed, analyzed, and displayed by the embedded signal-processing unit. When the drowsy state is detected, the warning tone device unit will be triggered to alarm the driver.

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