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A PROFICIENT SYSTEM FOR PREVENTING AND ACKNOWLEDGING ABOUT THE DRUNKEN DRIVE BY ANALYSING THE NEURONAL - ACTIVITIY OF THE BRAIN

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ABSTRACT

As it is regardless to say, majority of accidents occur due to drunken driving. Driving while intoxicated (DWI) (drunken driving, which means operating under the influence of alcohol, drinking and driving, impaired driving) is the act of driving a motor vehicle with blood levels of alcohol in excess of a legal limit. Though drunken driving is considered to be a criminal offense in most countries, it still remains to be a serious, unavoidable problem. Therefore, a highly efficient system that provides early prevention of drunken drive to protect the public from drunken drive male facts is the current need to society. In this paper, we intend to propose the designed mechanical system that prevents drunken drive and its subsequent catastrophes by monitoring the EEG of the driver. The power of the EEG signal in frontal region (alpha waves) decreases with the increase in the amount of alcohol intake, and the power of the EEG signal in central, occipital region (delta, beta) increases. Therefore, in this paper, we make use of threshold values of alpha, beta and theta waves to differentiate EEG of alcoholic from non-alcoholic. The continuous EEG monitoring of the driver makes our system highly reliable to prevent drunken drive accidents. Further, in our proposed system, we make use of special indicators called prevention indicator to avoid inconvenience to other drivers and prevent the accidents due to collision of vehicles. Once any evidence of drunk driving is present, SMS which contains the current location of the driver by means of GPS is sent via a GSM module to the police control room. Thus our exemplary system emerges to be a highly efficient and cost effective solution to prevent drunken drive accidents.

Keywords: drunken drive detection, electroencephalography, alpha wave, theta wave, PSD, threshold value, GPS, GSM.

1. INTRODUCTION

Drunken drive, apart from being a great threat to public safety and health, also imposes a heavy financial burden on the whole society, especially on the healthcare sector. It is one of the major problems that law enforcement is striving to prevent and control. In most jurisdictions a measurement such as blood alcohol content in excess of a defined level, such as 0.05% or 0.08% defines the offense. Excessive drinking that can raise the BAC (Blood Level Concentrate) to 0.08 and above is becoming one of the nation's greatest problems (Slawecki *et al*., 2000). Statistics show millions of people die every year and over 1 billion dollars of property damage occurs yearly as a result of alcohol abuse. These statistics show the deadly effects of drunken driving. The graph below indicates the worst effect of increase in the Blood Alcohol content.

Table-1. Drunk and drive accident statistics.

Year	Total fatalities	Alcohol - related fatalities	
	Number	Number	Percentage
1997	42, 013	16, 711	40
1998	41, 501	16, 673	40
1999	41, 717	16, 572	40
2000	41, 945	17, 380	41
2001	42, 196	17, 400	41
2002	43, 005	17, 524	41
2003	42, 643	17, 013	40
2004	42, 518	16, 919	39
2005	43, 443	16, 885	39
2006	42, 532	15, 829	37
2007	41, 059	15, 387	37
2008	37, 261	13, 846	37

A recent statistical data provided by the US Government in 2009 provides the following information (Desai and Haque, 2006):

- In 2009, there were 10, 839 fatalities in crashes involving a driver with a BAC of 0.8 or higher.
- An average of one alcohol-impaired-driving fatality occurred every 48 minutes in 2009.
- Of the 10, 839 people who died in alcohol-impaired-driving crashes in 2009, 7, 281(67%) were drivers with a BAC of .08 or higher. The remaining fatalities consisted of 2, 891(27%) motor vehicle occupants and 667(6%) non occupants.
- The rate of alcohol impairment among drivers involved in fatal crashes in 2009 was four times higher at night than during the day (37% versus 9%).
- In 2009, 6, 685(56%) of the drivers involved in fatal crashes who had been drinking had a BAC of 15 or greater.

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Although the proportion of crashes that are alcohol-related has dropped dramatically in recent decades, there are still far too many such preventable accidents. Unfortunately, inspite of great progress, alcohol-impaired driving remains a serious national problem that tragically effects many victims annually.

Drunk drivers are more liable to make errors and more liable to get into a range and drive rashly. Drunk drivers become more reckless, unable to see the consequences of their actions. The risk of collision for high BAC drivers is dramatically higher than for a non-driving driver. When drunk, within one hour, a person can become so disoriented that they can cause a terrible crash if they drive. The causes and effects of drinking and driving are staggering: Poor coordination, disorientation, blackouts, poor self-esteem and double vision that not only cause horrible accidents but also pose a serious threat to the innocent public (Zhang *et al*., 1997).

Despite the fact that drunk driving is a serious problem, its detection has been so far relying on visual observations by patrol officers. Drivers under the influence of alcohol show a marked decline of perception, recognition, and vehicle control, so they tend to make certain types of dangerous maneuvers. Therefore, relying on visual observation of patrol officers to prevent drunk driving is insufficient (U.S.NHTSA). So it is essential to develop systems that actively monitor drivers' operating situations and alert if any insecure conditions occurs to prevent accident. It is convincing that the designed mechanical system provides active monitoring of driver's operating situation a real time monitoring of driver's EEG with quick response thus providing a highly reliable system.

2. OVERVIEW OF EXISTING DRUNKEN DRIVE DETECTION METHODS

The conventional method used for the detection of blood-alcohol content is the use of Breath analyzers. Breath analyzers measure the Breath-alcohol content by measuring the amount of alcohol exhaled from the lungs and convert it into the corresponding blood-alcohol content. However, due to their limitations and demerits, Breath analyzers are being expelled from their practical implementation. The functioning of Breath analyzers is based on the odor and the level of alcoholic ions present in the breath (Lukas *et al*., 1986; Ehlers *et al*., 1989). Thus, it is possible for the drunken driver to take in spices or other smell attenuators to cheat the patrol officers. Sensors are found to be inaccurate and less sensitive in measuring the OH-(alcohol) ions (Liewhiran *et al*., 2007; Liewhiran and Phanichphant, 2008). Further the use of pulse oxymeter is found to be inappropriate because it is a time-consuming approach, to detect OH-ions. Another conventional method to detect drunk driving is the use of orientation and accelerometer sensors. It is based on analysis of drunken driving related behaviors like weaving, drifting, turning with a radius etc. In this method, the probability of fault messages is more (Lee *et al*., 2006; Ramanath *et al*., 2010). Thus, it is an unreliable method to function as an automated system for detecting drunk driving.

3. PROPOSED METHOD

Our proposed technology will keep impaired drivers off the road by detecting any abnormality in the EEG of the driver (Malar *et al*., 2011). Our analysis 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 (Vadim *et al*., 2005). The acquired EEG signal is preprocessed and analyzed for alcoholic activity. The result of EEG analysis is fed into a microprocessor which in turn controls the Electromechanical Fuel Valve. In case, if any abnormality is detected during EEG analysis, our proposed system prevents further driving to prevent the accidents due to drunken driving.

4. EEG

The electro encephalogram (EEG) is a recording of electrical activity originating from the brain along the scalp. EEG measures voltage fluctuations resulting from ionic current which flows within the neurons of the brain (Zhong and Ghosh, 2002). It is recorded on the surface of the scalp using electrodes, thus the signal is retrievable non-invasively. The brain consists of billions of neurons making up a large complex neural network. Thus, EEG is the electrical field potential that results from the spike train of many neurons. The brain waves illustrate the activity as it is taking place in various areas inside the brain. The rhythmic activity of EEG is divided into various 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 7Hz. 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 12Hz 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 30Hz. 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 (Pollck *et al*., 1992).

Table-2. Wave types found in EEG signals (adapted from neurosky Inc. 2009 brain wave signal (EEG) of NeuroSky. Inc) (Makeig and Inlow, 1993).

EEG bands	**Frequency** (Hz)	**Conditions**
Delta (δ)	0.5-4	Deep, dreamless sleep, non-REM sleep, unconscious
Theta (θ)	4-8	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha (α)	8-13	Relaxed, but not drowsy, tranquil, conscious
Beta (β)	13-30	Formerly SMR, relaxed yet focused, integrated, thinking, aware of self and surroundings, alertness, agitation
Gamma (γ)	30-100	Motor functions, higher mental activity

5. DECOMPOSITION OF EEG USING WAVELET TRANSFORM

In order to detect the presence of alcohol in EEG, it is necessary to analyze the temporal and spectral features of EEG. Stationary wavelet transform applies high and low pass filters to the data at each level without carrying out the process of decimation (Tompkins, 1993; Welch, 1967). 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)).

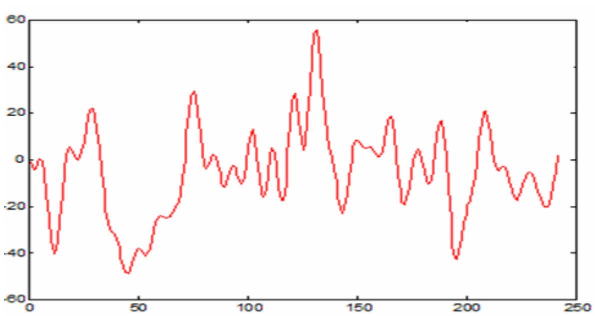

Figure-1. EEG wave.

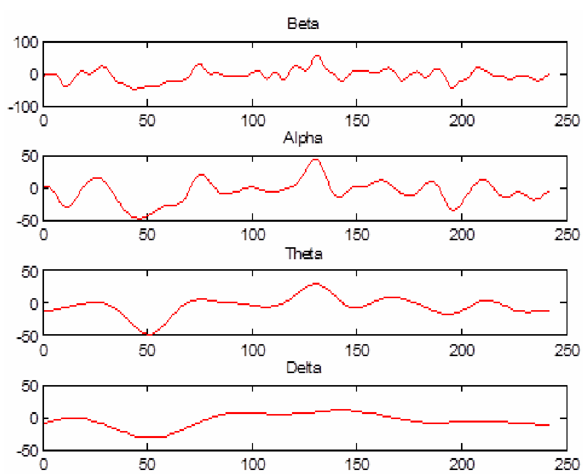

Figure-2. Beta, alpha, theta and delta bands of EEG wave decomposed using stationary wavelet tranform.

6. POWER SPECTRAL DENSITY AND THRESHOLD VALUE ANALYSIS

Researches on EEG waves have revealed the fact that with the increase in alcohol intake, the power of the EEG signal in the frontal region decreases and that of central and occipital region increases (Davis *et al*., 1941). Thus, our proposed technique necessitates Power Spectral Density Analysis and Threshold value analysis to differentiate the EEG waves of an alcoholic person from that of a normal person. The results of our analysis indicate that

- **Alpha waves**
  The region of alpha wave decreases with the increase in alcohol intake. So, the power and threshold value of alpha wave decreases for a drunken person (Lukas *et al*., 1986).
- **Theta waves**
  Consumption of alcohol causes theta waves to appear and gradually enhance. These waves drive the drivers into a state of sleepiness as the central nervous system of the drivers is inhibited. This causes the power and threshold value of theta waves to increase for a drunken person than that of a normal person (Beatty *et al*., 1974).
- **Beta waves**
  Once alcohol is consumed, the cerebral cortex remains in an excitable condition. Therefore, the power and threshold value of beta waves gradually increase for an alcoholic person (Rangasamy *et al*., 1944).

7. HARDWARE DESCRIPTION

In our proposed technique, we have designed a mechanical system which is used to prevent drunken drive accidents. It basically functions on the basis of presence or absence of abnormality in the EEG of the driver. The real time implementation of this system is practically trustworthy as the drunken driver himself cannot impose any changes on the EEG signals (Desai and Hakue, 2006; Ramanath *et al*., 2010). The functioning of designed mechanical system is elaborated in the flowchart below:

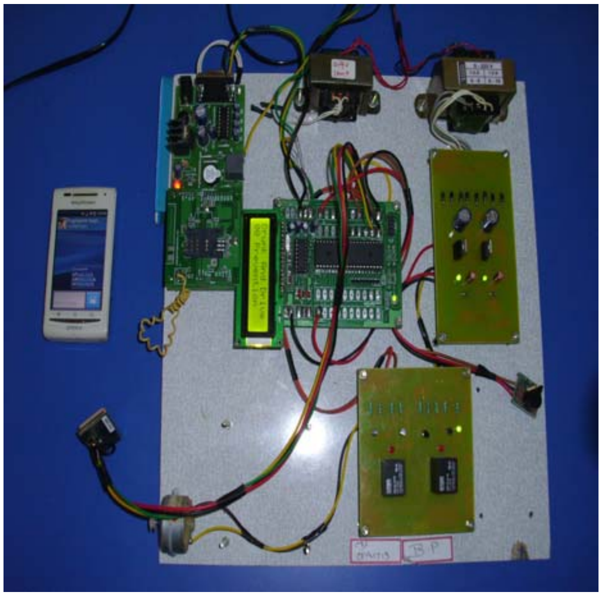

Figure-3. Hardware kit.

7.1. Flow chart

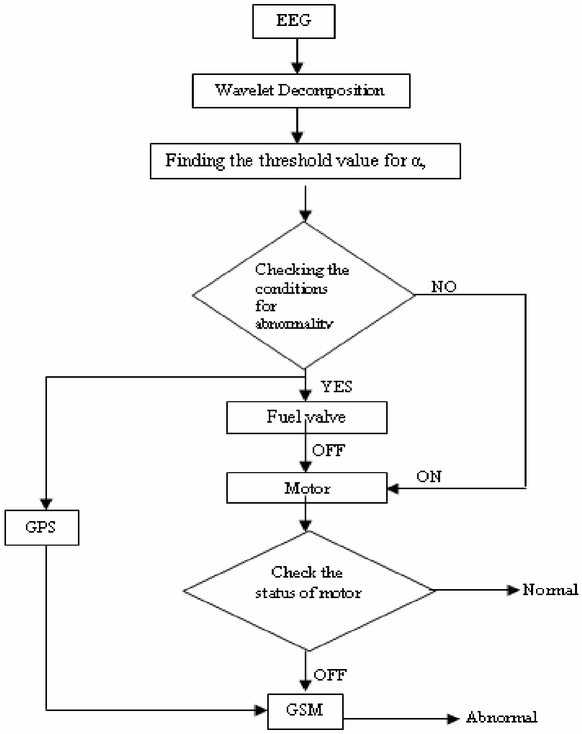

Figure-4. Flow chart for the proposed methodology.

A mechanical system is designed using our proposed technology. This system consists of the following units:

- EEG abnormality detection unit
- Processing unit
- Vehicle control unit
- Vehicle location tracking unit

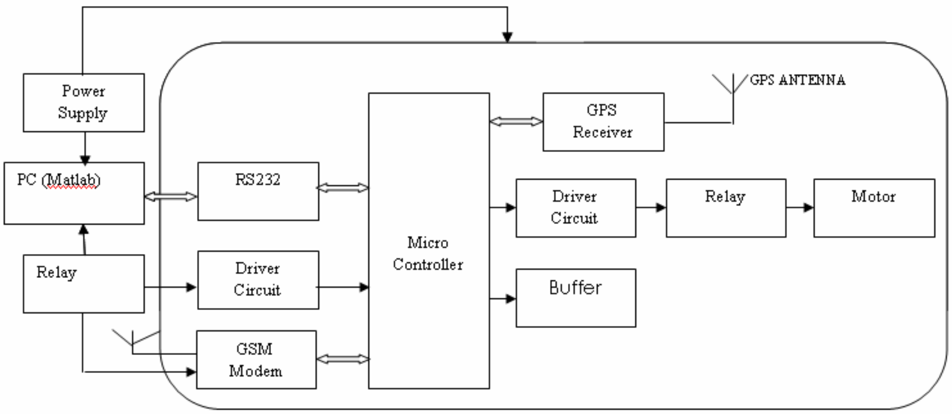

Figure-5. Block diagram.

7.1.1. EEG abnormality detection unit

On the basis of Threshold value analysis, the EEG Abnormality Detection Unit differentiates the EEG wave of a normal person from that of a drunken person (Borisov *et al*., 2005). In case, if any abnormality is detected, then this unit produces a digital output “1”. If the EEG wave is found to be normal, then “0” is produced as output.

7.1.2. Processing unit

The processing unit consists of a microcontroller which controls the vehicle on the basis of output generated

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from the EEG Abnormality Detection Unit. Incase if any abnormality is detected the microcontroller generates a control signal which in turn controls the fuel mechanical valve. Our proposed technique makes use of "Renesas 16-Bit Single -Chip Microcomputer M16CFamily" which turns our system to be cost effective.

7.1.3. Vehicle control unit

The fuel mechanical valve functions is in two states- either "OPEN" or "CLOSED" on the basis of control signal generated from the processing unit. If the driver is found to be drunk, the processing unit generates the control signal. The fuel mechanical valve cuts off the fuel supply and prevents further driving of the vehicle. Only if the driver is found to be normal, the fuel mechanical valve functions in the "open" state. An important point to be taken into consideration is that the vehicle does not stop immediately.

Once the vehicle slows down, the precautionary indicators namely buzzers at the back will provide an alarm signal notification to the drivers at the back. This will prevent even a minute chance of accident due to collision of the vehicles (Ramanath *et al*., 2010). This makes our system not only reliable but also extremely safe to prevent drunken drive accidents.

7.1.4. Vehicle location tracking unit

The GPS module in the vehicle location tracking unit tracks the physical co-ordinates of the location of the vehicle. Once a drunken drive is detected, the GPS module tracks the latitudinal and longitudinal position of the vehicle. The GSM module sends information regarding the location of the vehicle accompanied with an alert message "DRUNKEN DRIVE" to the nearby control room to alert the police (Lee *et al*., 2006).

8. RESULT AND DISCUSSIONS

Based on the methodology discussed above, this section describes the results and their interpretation (Su Jinming and Zhang Lianhualiu Bo, 2004). EEG signals of alcoholic person and normal person were used for analysis and the required threshold values of Alpha, beta, theta waves were calculated (Akay, 1998; Engel and Rosenbaum, 1944).

In our analysis, we make use of a reference signal i.e., EEG wave of a normal person. The following results were obtained based on the analysis of reference signal and EEG wave of a non-drunken person using MATLAB:

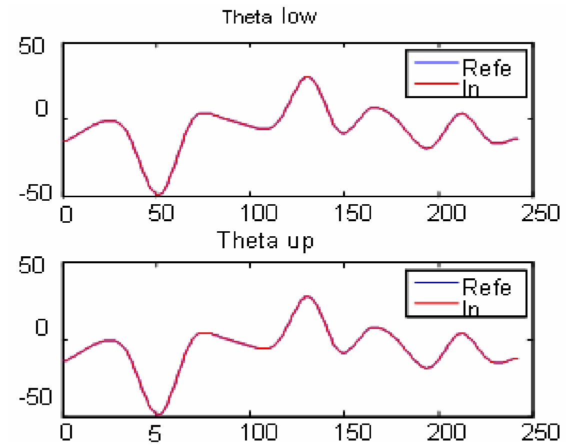

Figure-6. Theta band of EEG wave of reference signal vs. non-drunken person.

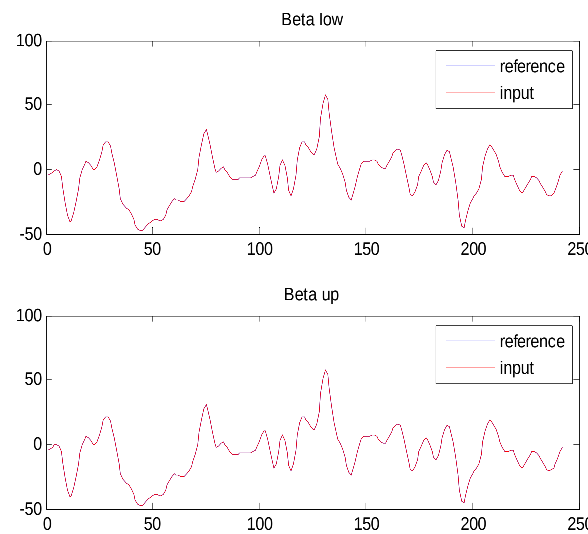

Figure-7. Beta band of EEG wave of reference signal vs. Non-drunken person.

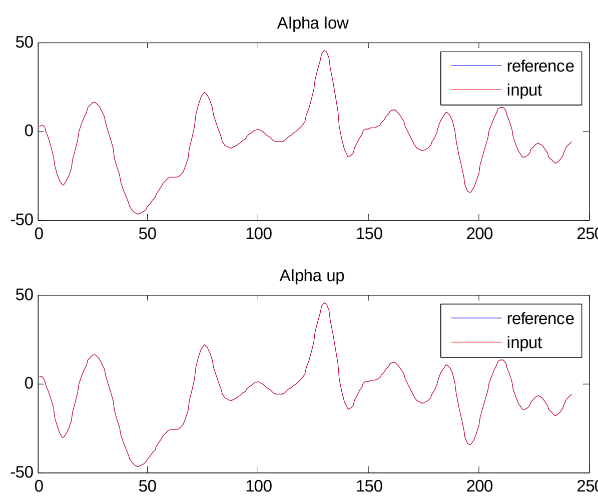

Figure-8. Alpha band of EEG wave of reference signal vs. non-drunken person.

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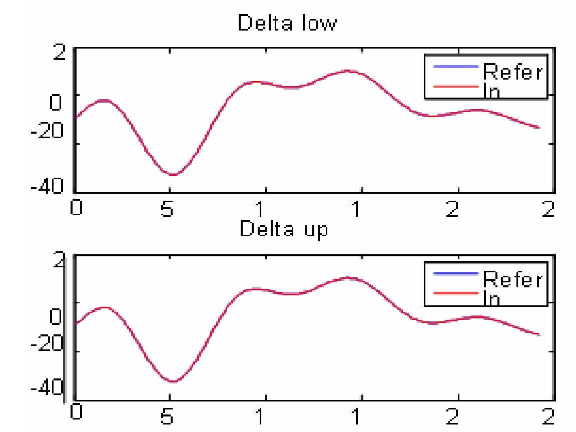

Figure-9. Delta band of an EEG wave of reference signal vs. non-drunken person.

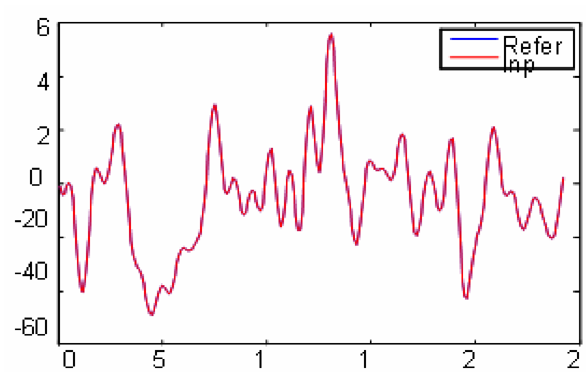

Figure-10. Power spectrum density of reference signal vs. drunken person

EEG signals of reference wave and alcoholic person were analyzed and decomposed into Alpha, Beta and Theta bands. The following results were obtained using MATLAB:

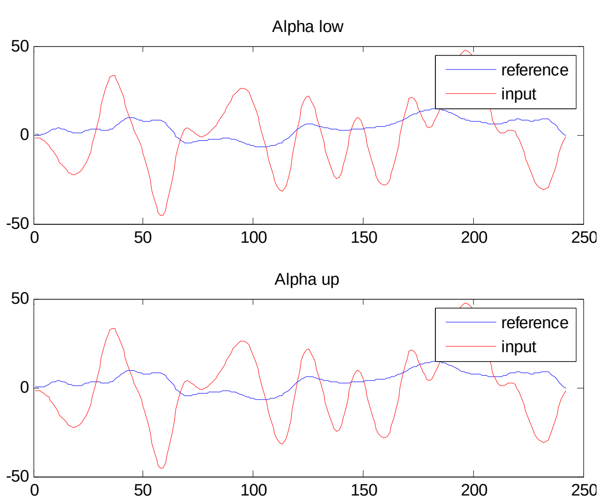

Figure-11. Alpha band of EEG wave of reference signal vs. drunken person.

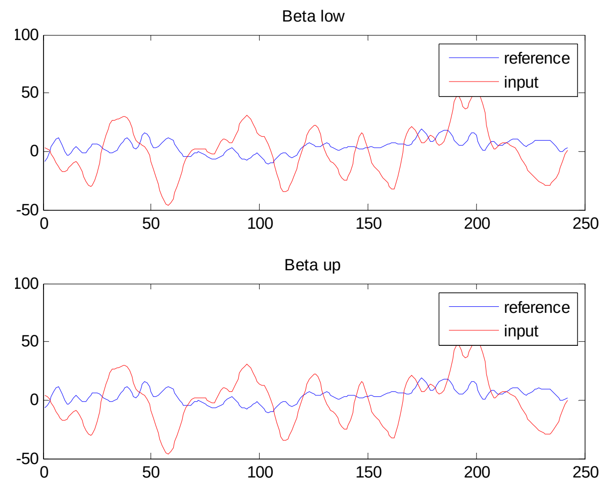

Figure-12. Beta band of EEG wave of reference signal vs. drunken person.

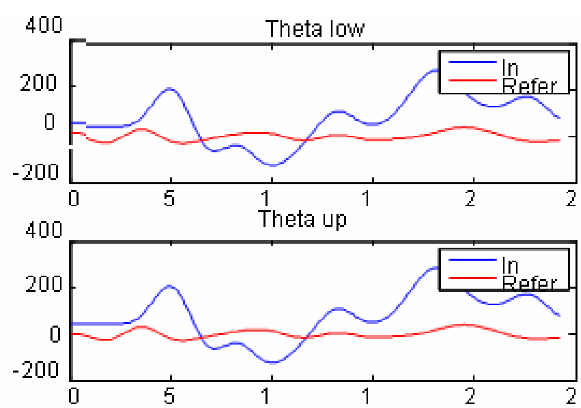

Figure-13. Theta band of EEG wave of reference signal vs. drunken person.

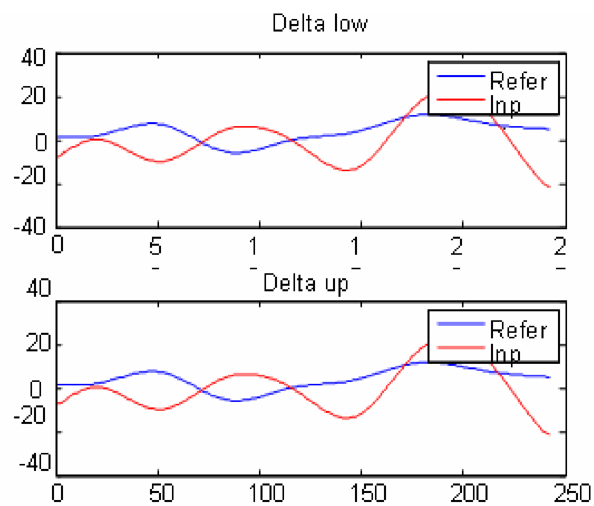

Figure-14. Delta band of EEG wave of reference signal vs. drunken person.

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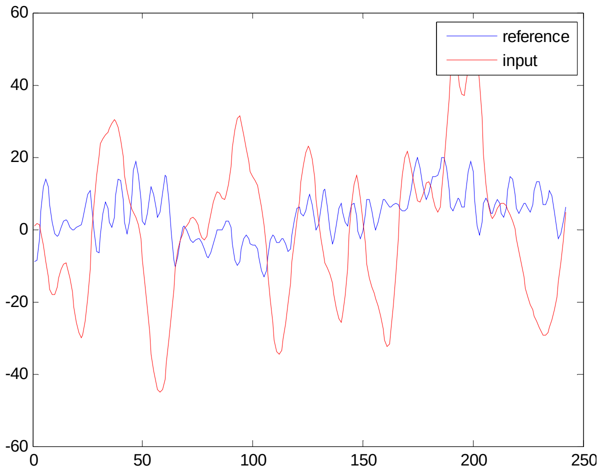

Figure-15. Power spectrum density of reference signal vs. drunken person.

Using MATLAB, the threshold values of alpha, beta, theta, delta waves were calculated and tabulated as below:

Table-3. Threshold values of various bands of EEG for reference and alcoholic signal.

Parameters	Threshold value of reference signal	Threshold value of alcoholic signal
Beta	53.3113 (th_1)	247.6211 (th_{11})
Alpha	247.0692 (th_2)	36.4820 (th_{22})
Theta	31.2546 (th_3)	249.9273 (th_{33})
Delta	24.6678 (th_4)	224.2978 (th_{44})

From the above tabulation, it is clear that alpha activity of alcoholic person decreases and beta, theta, delta activity of alcoholic person increases when compared to that of normal person.

Condition

If the value of th_{22} is less than (for e.g.: $th_2 > th_{22}$) and if the value of th_{33} is greater than (for e.g.: $th_3 < th_{33}$), then the EEG is conformed to be alcoholic. From the above results, it is determined that the driver is drunk.

9. CONCLUSIONS

In this paper, we present a highly efficient drunken driving detection system. The EEG cap, which is placed on the head of the driver, will continuously monitors the EEG signal. The acquired EEG signal is preprocessed and analyzed for alcoholic activity. On the basis of threshold value analysis, the EEG Abnormality Detection Unit differentiates the EEG wave of a normal person from that of a drunken person based on the condition i.e., the alpha activity is decreased and theta activity is increased for an alcoholic person. In case, if any abnormality is detected, then this unit produces a digital output "1". If the EEG wave is found to be normal, then "0" is produced as output. The result of EEG analysis is fed into a processor which in turn controls the Electromechanical Fuel Valve. In case, if any abnormality is detected during EEG analysis, our proposed system will cut off the fuel valve. When the fuel valve is closed, further motion of the vehicle is terminated. Prevention indicator in the detection system will give warning signal to the public to reveal about the status of the vehicle. This will prevent even a minute chance of accident due to collision of the vehicles. This makes our system not only reliable but also extremely safe to prevent drunken driving accidents. Global positioning system will give the current location which is sent to control room by means of GSM as a SMS. This SMS contain the information about latitude and longitude of location of vehicle which prevent the accidents. Since this method deals with biological signals to identify the presence of alcohol, it is more efficient than the previous techniques. Previously mentioned statistics shows that 40 % of accident is due to drunken drive. Hence it will surely yield much greater benefits of saving thousands of human lives on roads every year.

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