A Survey on Brainwave Stimulated Accident Prevention Systems

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Abstract - Anomalous accidents are happening nowadays due to subject's fatigue, drowsiness and carelessness. Predominant accidents occurred during night time due to subject's psychological behavior. To avoid such occurrences, a system has to be designed to detect the subject's consciousness continuously and guide them throughout their journey. In this paper, a survey on various methods of analyzing both the physiological and psychological behaviors of subjects at various stages and accident prevention systems are discussed here. Then, a novel system is proposed which is wireless and will be implemented with the help of embedded processor. It monitors the brain waves of the subject regularly and transmits the signal through wireless transmitter module. The brain waves of the human at various stages can be simulated and updated as the new application software to generate the prototype of brainwaves. Then the waves are categorized based on different fatigue levels of the subject, by the microcontroller and the corresponding actions for vehicle like reducing the speed, alarm, halt and emergency contacts intimation can be provided. Thus this proposed prototype will be an effective solution for fatigue based accidents.

**Keywords: accidents, psychological behavior, physiological behavior, embedded processor,
brainwaves, application software, microcontroller and control actions.**

I. INTRODUCTION

For years, the most commonly used protection materials against accidents are seat belts and air-bags. Seat belts are not intended to provide safety whereas it is highly essential to save money. When persons wearing seat belts driving at high speed, are about to stop; the belt goes just below your neck, meaning your head (and therefore your spine) continue at full speed until jerking to a sudden stop. If you crash at a low speed it will prevent you getting a bump on your head, but if you crash on the open road it will snap your neck and kill you instantly. In order to avoid such injuries air bags are evolved, which also further results in injuries to the subjects and also to all the passengers. Then arrives the accident preventing methods, which also provides with several limitations. Such methods include: Vehicle based measures, Behavioral measures, Physiological measures. A vehicle based measures provide number of metrics, including deviations from lane position, movement of the steering wheel, Pressure on the acceleration pedal due to the need of immediate action even when the subjects are alert. A Behavioral measure provides the behavior of the driver, including yawning, eye closure, eye blinking, head pose; which occurs even when the subject is completely alert. A Physiological measure provides the correlation between physiological signals Electrocardiogram (ECG), Electromyogram (EMG), Electrooculogram (EOG) and Electroencephalogram (EEG)) and driver drowsiness. Among the above mentioned measures Electroencephalogram (EEG) is the best approach to monitor the brain waves which can produces the exact result. Here we are going to demonstrate the simulated accident prevention system by means of Visual Basic software in the PC, which contains the different frequency ranges similar to the frequencies extracted from the EEG sensors. The frequency ranges are classified as: Beta (12-30Hz), Alpha(8-12Hz), Theta (4-8Hz), Delta(0.1-3Hz) and Gamma(40Hz). The following section includes: Literature Survey, Proposed Methodology, Conclusion and future works.

II. LITERATURE SURVEY

[1] " The link between fatigue and safety", Ann Williamson, David A.Lombardi, Simon Folkard, Jane Stutts, 2011.

The objective of this reviewwasto examine the evidence for the link between fatigue and safety, especially in transport and occupational settings. For the purposes of this review fatigue was defined as 'a biological drive for recuperative rest'. The review examined the relationship between three major causes of fatigue – sleep homeostasis factors, circadian influences and nature of task effects – and safety outcomes, first looking at accidents and injury and then at adverse effects on performance. The review demonstrated clear evidence for sleep homeostatic effects producing impaired performance and accidents. Nature of task effects, especially tasks requiring sustained attention and monotony, also produced significant performance decrements, but the effects on accidents and/or injury were unresolved because of a lack of studies. The evidence did not support a direct link between circadian-related fatigue influences and performance or safety outcomes and further research is needed to clarify the link. Undoubtedly, circadian variation plays some role in safety outcomes, but the evidence suggests that these effects reflect a combination of time of day and sleep-related factors. Similarly, although some measures of performance show a direct circadian component, others would appear to only do so in combination with sleep-related factors. The review highlighted gaps in the literature and opportunities for further research.

Methods:

This survey paper follows the framework of

1) Link between fatigue and safety outcomes
2) Link between the cause of fatigue and performance outcomes
3) Link between performance and safety outcomes

From this survey, we can also form the table for statistics of fatigue, time on task and slept for hours

S.NO	FATIGUE (Time of Day)	Time on Task	Slept hrs for last 48 hours
1	9 A.M to 11A.M	Working in a plant	15 (safe)
2		Cross - country	12(not risk)
3		Truck driver	<9 (risk increases)
4		Continuous driver	>21 (risk increases
5		Air traffic controller	<5 (very high)

Table 1: Statistics of fatigue

INFERENCE: This review provides evidence of a link between fatigue and safety outcomes. Factors that cause fatigue have been demonstrated to have adverse effects on performance as well as safety outcomes. This review was restricted to three main input types that are thought to cause fatigue: circadian, sleep homeostasis and task-related influences. Across multiple studies, sleep-related factors, including sleep deprivation and time since waking, show impairments in performance and increased accidents and injuries. Furthermore, performance effects correlate well with neurological evidence of changes in cortical function, providing converging evidence to reinforce the link between sleep homeostasis factors and performance. As the accidents increases linearly with the fatigue level of drivers, the specific system has to be designed for the avoidance of accidents.

[2] "EEG signal analysis for the assessment and quantification of driver's fatigue", Sibsambhu Kar, Mayank Bhagat, Aurobinda Routray, 2010.

Fatigue in human drivers is a serious cause of road accidents. Hence, it is important to devise methods to detect and quantify the fatigue. This paper presents a method based on a class of entropy measures on the recorded Electroencephalogram (EEG) signals of human subjects for relative quantification of fatigue during driving. These entropy values have been evaluated in the wavelet domain and have been validated using standard subjective measures. Five types of entropies i.e. Shannon's entropy, Rényi entropy of order 2 and 3, Tsallis wavelet entropy and Generalized Escort-Tsallis entropy, have been considered as possible indicators of fatigue. These entropies along with alpha band relative energy and (a+b)/d1 relative energy ratio have been used to develop a method for estimation of unknown fatigue level. Experiments have been designed to test the subjects under simulated driving and actual driving. The EEG signals have been recorded along with subjective assessment of their fatigue levels through standard questionnaire during these experiments. The signal analysis steps involve preprocessing, artifact removal, entropy calculation and validation against the subjective assessment. The results show definite patterns of these entropies during different stages of fatigue.

Technology used:

The technology used in this survey includes: Preprocessing, Artifact Removal, Wavelet relative energy and ratios, Wavelet entropy, Subjective assessment and Fatigue scale. The following procedure is followed to establish the proposed entropy measures as the indicator of fatigue:

Step 1: Selection of important EEG parameters those are most coherent with the self assessed fatigue at different levels.

Step 2: For every subject, plot each parameter value with respect to self-estimated fatigue levels and fit a polynomial.

Step 3: Estimate the unknown fatigue level from each of the above curves.

Step 4: Compute the mean and variance of the estimated values.

Step 5: Eliminate those estimations which cross a predefined threshold value. Find the mean estimation of all other measurements.

Inference: This paper have investigated a number of fatigue indicating parameters based on higher order entropy measures of EEG signals in the wavelet domain. These parameters indicate the state of fatigue with more clarity. This method can be used on board to quantify the level of fatigue in human drivers or human operators in safety critical human–machine interactions.

[3]"Real-Time EEG based detection of fatigue Driving Danger for Accident Prediction", Hong Wang, Chi Zhang , Tianwei Shi, Fuwang Wang & Shujun Ma,2014.

This paper proposes a real-time Electroencephalogram (EEG) –based detection method of the potential danger during fatigue driving. To determine driver fatigue in real time wavelet entropy with a sliding window and Pulse Coupled Neural Network (PCNN) were used to process the EEG signals in the visual area (the main information input route) to detect the fatigue danger, the neural mechanism of driver's fatigue was analyzed. The functional brain network the functional brain networks were employed to the track the fatigue impact on processing capacity of the brain. The results show the overall functional connectivity of the Subjects is weakened after long time driving tasks. The Regularity is summarized as the fatigue convergence Phenomenon. Based on the fatigue convergence Phenomenon, we combined both the input and global Synchronizations of brain together to calculate the residual amount of the information capacity of brain to obtain the dangerous points in real time. Finally the dangerous detection system of the driver's fatigue based on the neural mechanism was validated using accident EEG. The time distributions of the output danger points of the system have a good agreement with those of the real accident points.

Technology used:

The technology used here includes: PCNN, Dangerous point detection and Fatigue pattern recognition.

Results: Through the analysis of functional brain networks, the averaged global synchronization energy of the driver's decreases linearly and standard deviation of the global synchronization energy becomes smaller and smaller with the accumulation of driving fatigue. This system can detect real dangers corresponding to the accidents and thus can predict the accidents when the detected danger time is prior to the accident time.

III PROPOSED METHODOLOGY

The basic scheme of the proposed accident prevention system is as shown in the figure (1).

Our system consists of four main blocks: PC, Transmitter-Microcontroller, RF module and the receiver microcontroller for control actions. The prototypes of brainwaves can be obtain from the PC. The Visual Basics software helps to access the prototypes of brain waves conveniently.

Table2. Frequency ranges of brainwaves

Subject's behavior	Brainwave	Actions to be taken
Concentrated	Beta	normal
Conscious but relaxed	Alpha	Speed reduces by 50%
Imagery, Switching thoughts, drowsy	Theta	Buzzer alert
Unconscious, Drunk & Drive	Delta	Stop the vehicle
Integrated thoughts	Gamma	Buzzer alert

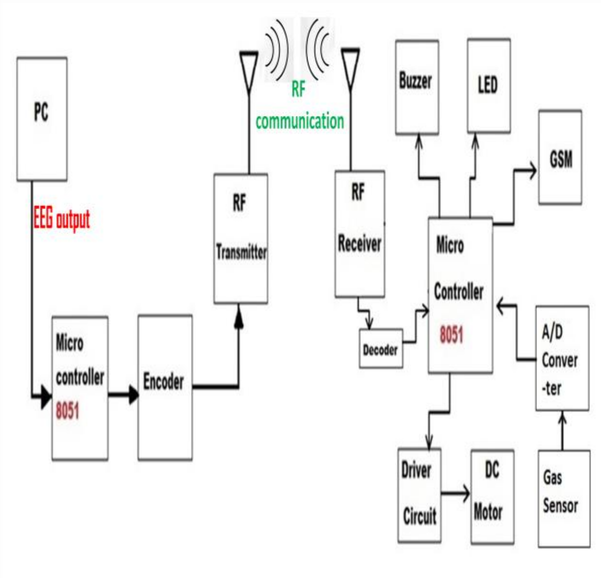


Figure1 EEG based accident prevention system

The selected prototypes of brain waves i.e) particular frequency range can be observed and transmitted to the wireless RF module through encoder. The encoder is used to achieve serial communication for the effective transmission of data without any loss. It is then transmitter to the RF receiver module. The receiver microcontroller module is used to analyze the data and to take necessary actions for the prevention of accidents. Based upon the analyzed range of brain wave

Brainwaves	Frequency Range
Beta	12-30Hz
Alpha	8-12Hz
Theta	4-8Hz
Delta	0.1-3Hz
Gamma	40Hz

Table 3 Relationship between brainwave signal and the subject's level of fatigue & the actions to be taken

frequency, different levels of fatigue can be classified and the required actions for the corresponding level of subject's fatigue frequency range can be given as

The actions to be taken are processed by the microcontroller and it can be implemented by means of buzzer alert, LED, GSM module. In the receiver side, we are having another input device is the Gas Sensor, which is used to sense the excess level of LPG gas leakage. This can be intimated to the microcontroller by means of an A/D Converter in order to perform the necessary actions.

III. MODULE DESCRIPTION

A. Microcontroller transmitter module

The transmitter module microcontroller is used to fetch the input prototypes of brain waves from the PC. The PC can able to generate different prototypes of brain waves by means of Visual Basics Software. The selected prototype of brainwaves can be passed to the RF transmitter module via microcontroller transmitter module. The transmitter side microcontroller will act as the interface between PC and the RF transmitter module, since these two devices can't be connected directly. It acts as the analyzing device which in turn produces the digital signal.

B. RF Module

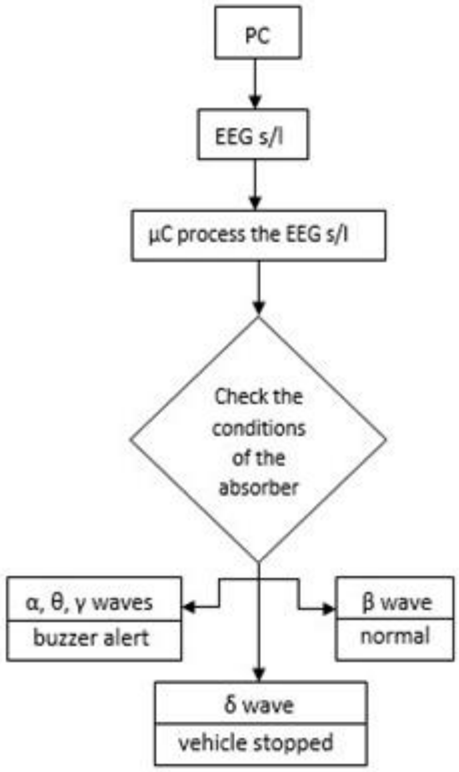
The RF transmitter module used to receive the serial data by means of an encoder HT12E IC, which is highly essential for long distance transmission. The secured data can then be transmitted via RF transmitter module, by means of converting the incoming signal into the RF frequency range via ASK modulation technique.

The modulated signal can then be demodulated in the RF receiver module by means of an ASK demodulation technique for the effective control of the motor in the case of any critical situations. The RF module used to provide the digital parallel data to the receiver microcontroller.

C. Microcontroller Receiver Module

The Receiver microcontroller module is used to achieve the necessary control actions based upon the level of driver's fatigue as mentioned in the figure 2. The receiver module will analyze the frequency range and classify according to the different levels of fatigue. Based upon the level of fatigue, different actions can be performed: when the incoming signal is the beta wave then the motor proceeds its function normally. For the successive level of fatigue the motor's speed reduces gradually in order to avoid accidents in the fraction of seconds. When the incoming signals are the alpha, theta and gamma den the buzzer alerts are provided to alert the subjects. When the incoming signal is delta, then it means that the subject is drunken and unconscious which leads to the stopping of the vehicle by also intimating to the following vehicles in order to avoid inconvenience. Once the vehicle is stopped then the intimation will be given to the emergency contacts by means of the GSM module.

IV. FLOW CHART



V. IMPLEMENTATION

This system can be effectively implemented by means of analyzing the frequency range of the brainwaves and matching it with the levels of subject's fatigue, corresponding actions can be taken. Each frequency range is initially correlated with the levels of subject's fatigue. Based upon its result, the actions to be taken are decided and implemented. In the earlier stage of the subject's fatigue, they will be provided with multiple alert systems. If they are in/ the ultimate critical stage of the fatigue, then the vehicle must stop. When the vehicle is stopped, immediately the emergency contacts such as police station, ambulances, subject's close relations can be intimated by means of GSM module.

VI. CONCLUSION AND FUTURE WORKS

In this system, the simulated accident prevention system was proposed. The modular approach applied in hardware and software design enables this system to be configurable for different application scenarios. This system is feasible for further extensions. For example, this system can be effectively applicable for non-transport disasters (Nuclear Power Plants, Chemical Industries). It can also be applicable in the medical field, in the research of a new medicine and its reactions with the brain. Thus our simulated system can be altered as the real time accident prevention system by the usage of EEG sensor for the continuous monitoring of the brain waves of the subjects, and the warning tone would be triggered to prevent traffic accidents when the drowsiness conditions occurred.

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