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Arduino based Real Time Drowsiness and Fatigue Detection for Bikers using Helmet

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Abstract— Vehicle accidents are rapidly increasing in many countries. Among many other factors, drowsiness and fatigue are playing a major role in these accidents and systems which can monitor it are currently being developed. Among them, Electroencephalography (EEG) proved to be very reliable. The conventional vehicle and the vision based detection for drowsiness is very much essential only when the driver is about to sleep and every so often very late in preventing fatalities on road. This paper is specially developed to improve the safety of the bikers. The proposed system has EEG-sensors which are implemented within the helmet to detect the drowsy state of the driver. The biomedical signal from the driver's brain is sensed by a Brain-wave sensor. This system provides real-time drowsiness and fatigue detection for the bikers by making a helmet to play a vital part with warning platform as a miniaturized sensor and to provide mind machine interface (MMI) to address the challenges like drowsiness and fatigue. When the biker is detected to be in drowse state the system alerts the biker by an alarm and motor gets slow down and stopped.

Keywords— Drowsiness, Fatigue detection, EEG, Arduino, Mind Machine interface.

I. INTRODUCTION

Fatigue and drowsiness in human drivers are a serious cause of road accidents. About 10-20% of road accidents are caused by driver's ignorance. The administrators of the "national highway traffic safety" have evaluated the rate of crashes, injuries and fatalities to be 72,000.01, 44,000.02, and 800.03 respectively in 2013 due to the drowsiness [1].

Drowsy driving poses a major problem in road accidents as it is a violent combination of driving and sleepiness or fatigue. The risk and dangerous results of drowsy driving are alarming. There is a great requirement of real-time driver alertness monitoring in emerging intelligent transportation systems to prevent a huge number of accidents. Our proposed system detects the abnormal state of the driver and alerts him with high-frequency alarm placed near the helmet when the driver is detected to be drowsy and it also has the mechanism to stop the
Vehicle when the rider continues to stay in a drowsy state.

This proposed EEG-based MMI (Mind Machine interface) is equipped with the wireless module to acquire physiological signals and a processing unit for the same. The signal acquired from the microwave-electrodes are amplified, filtered, processed and analyzed to detect the drowsy states of the driver. It also triggers the alarm to the driver on if detects the driver's drowsiness and prevents the accidents.

II. RELATED WORK

Traditionally to prevent bike accidents Smart Helmet with Emergency Notification System is used to protect the head of the rider and alert the emergency service or an emergency contact when the rider has met with an accident [2]. Most people are aware of the various reasons for road accidents; it might be either the drowsy state, or due to the consumption of alcohol and drugs. Traditionally measures to monitor drowsiness are as follows.

A. Vehicle-based measures: sensor fixed to various components of vehicles enables to measure various metrics like wheel movement, standard deviations from lane position, speed of the vehicle, changes in gears, braking, etc. [3-6] which are constantly monitored for non-contact detection and any change beyond the specified threshold indicates a significantly increased probability of drowsy driving [7,8].but the constant framework owing to the experience of the driver and the circumstance of the road is quiet complex [3,7].

B. Behavioral measures: monitors the behavior of the drivers and detects the changes [9-11].

C. Physiological measures: The abnormal state of the driver that is the physiological signals are measured by EOG, ECG and EMG and their correlations are utilized to find the [12-15]. For automatic alertness state classification most currently existing approaches rely either on the signals acquired based on the behavior or the image sequences.

However, these measures detect the drowsy state of driver only after the driver crosses the specific threshold of attentiveness unlike automatic analysis of physiological signals. The paper puts forth an MMI to examine the EEG and raise alarm when it is needed.

III. Proposed Methodology

Drowsiness and fatigue detection system is the combination of brain wave sensor that is the electrode with an in-built copper plate that extracts the signal and amplifier that amplifies the signal for controlling the operations. This system has two modules, signal acquisition and signal processing as shown in Fig 1.

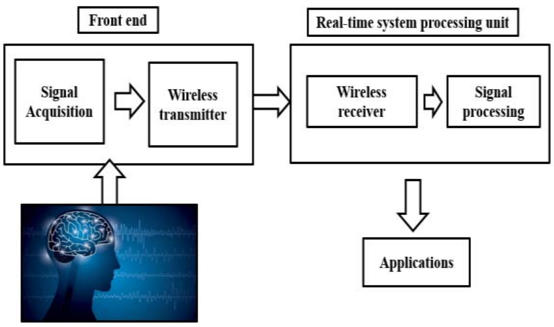

Fig .1. System design

A. *Signal Acquisition Module*:

The EEG usually records the activities of the brain in the form of electrical signals. About the sleeping brain EEG provides important and unique information. EEG is capable of providing a precise and a measurable taxation of the rate of alertness. EEG signals can be obtained from the Brain wave Sensor. EEG signal is quite small, ranges from 1Hz to 100Hz and amplitudes vary from 1µV to 100µV [16].

EEG signals are obtained from the EEG Electrode. The electrode is in the form of mobile headset and this EEG electrode is resting on the forehead above the eye. The headset transfers the signal to the circuit board. It analyses your brain waves to identify rhythms (repetitive patterns of neural activity) Fig 2 Shows the workflow of the proposed system.

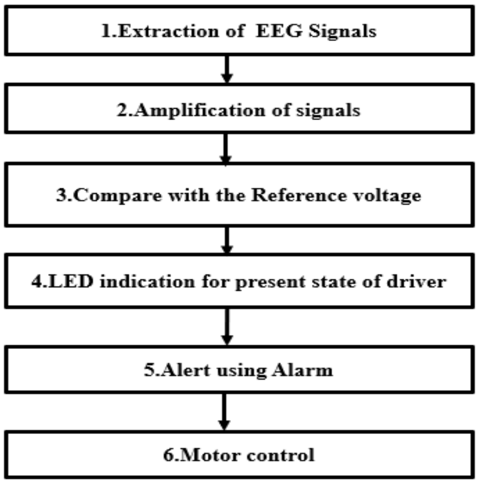

Fig .2. Workflow of the proposed system

The electrical signals generated from the EEG is classified into 4 categories as follows,

TABLE I. Classification of Signals [16]

S.NO	***SIGNALS***	***FREQUENCY***
1	Alpha	8.01 – 13.01Hz
2	Delta	0.312 – 4.001 Hz
3	Beta	Above 3.11 Hz
4	Theta	4.01 – 8.023Hz

B. *Wireless data Transmission and Signal processing Module*:

The four types of waves from the EEG electrode are sent to low and high pass filters in order to extract indications required and improved for further processing. Then output signals are transmitted to Arduino through the HC-05 Bluetooth module. These signals are processed using the algorithm mentioned below.

a) Algorithm Used: The proposed system employs logistic regression algorithm. Our proposed approach lowers the detection time, increases accuracy and finds probability of drowsiness (i.e., The algorithm determines the likelihood of drowsiness).

Logistic Regression is an algorithm for classifying and predicting the binary behavior from set of variables that are different. By fitting data to a logistic function, and forecasts the occurrences probability. Logistic regression is more powerful in distinguishing the active and drowsy state. It is considered that the mean of logistic regression is higher when the subjects are active than when they are drowsy. So, it can demonstrate that the complexity of brain activity in active state is high, but when the brain is drowsy, its activity is less complex than alertness [17].

b) Processing Unit:

The amplified EEG signals are transmitted to Arduino by Bluetooth where it is compared with the reference voltage. This reference voltage is obtained from prior training of a set of samples using Logistic Regression.

Thus, obtained output voltage denotes the various states of the driver that is depicted using LED.

There are four types of LED used, red indicating the drowsy state of the driver, blue indicating the normal state of the driver, yellow indicating the sleep state of the driver and green indicating the active state of the driver.

In the Arduino when the output voltage matches the reference voltage, a program sketch is written and dumped to control the operation of alarm and motor. Whenever the drowsiness or fatigue state is detected, the alarm in the helmet rings to alert the driver and if the driver continues to be in drowsy or fatigue state then the speed of the bike motor will be gradually reduced and stopped. The speed of the motor is controlled by a relay.

IV. Result & Discussions

This system delivers the most efficient and embedded drowsy driver detection system for bike riders using helmet. The outcome is targeted to help common people to overcome accidents due to drowsiness and fatigue. As soon as the drowsiness of the driver is detected alarm helps to wake up the driver, motor gets slow down to prevent major injuries.

If the driver's brain signals are in between 4-8Hz, that is the driver is in drowse state, the alarm will ring. If the driver continues to be in that state that is in our case if the alarm rings three times continuously then motor gets slow down and then stopped. Fig 3 shows the snapshot of the complete system.

For the observations made in Table II, a threshold value is used to distinguish the state of biker. From the training made using logistic regression in order to predict the threshold, it is found that the raw data below 49 and above 32 corresponds to the frequency between 4-8 Hz, if the bikers mind state is in this range then the alarm will ring else does not and red LED glows to show that the biker is not in the condition to drive. If this happens more than three times using relay the speed of the bike motor is controlled and further stopped. Thus, in this way, this system provides real-time drowsiness and fatigue detection system for bikers. Table II indicates EEG signal observations where the Arduino readings (Raw) in microvolts are converted to Signal frequency (Hertz) by using FFT (Fast Fourier Transform) [18].

TABLE II. EEG Signal Observations [18]

S. No	*Frequency of the Signals (Hertz)*	*Arduino Readings (microvolts)*	*Alarm Ring*	*LED*	*state*
1	1.4	16	No	Yellow	Sleep
2	2.7	24	No	Yellow	Sleep
3	3.7	29	No	Yellow	Sleep
4	8.3	76	No	Blue	Normal
5	8.4	79	No	Blue	Normal
6	9.3	97	No	Blue	Normal
7	13.5	112	No	Green	Active
8	5.2	43	Yes	Red	Drowse
9	4.9	39	Yes	Red	Drowse
10	5.7	46	Yes	Red	Drowse

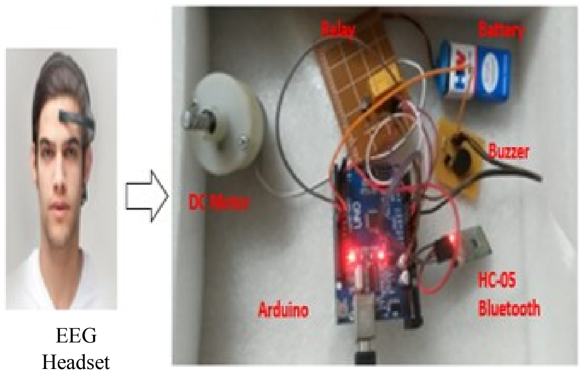

Fig .3. Output Snapshot of the proposed system

Initially, training is done to predict the threshold that is used to compare with the input voltage. Brain wave visualizer shown in Fig 4 shows a graphical representation of brain's activity is used to visualize the bio medicals signals of the driver and record values for visualized signals.

After necessary training, threshold value is predicted. Then the EEG headset and Arduino are paired using AT-commands. According to the coding written, the input is processed and act based on the standard values. Whenever the drowsiness is detected, the alarms rings and speed of the motor will be reduced and then the message will be displayed on the LCD.

The EEG signals are given to Arduino. The Arduino compares the acquired voltage with the reference voltage. The output voltage denotes the various state of the driver that is depicted using LED.

For each and every variation in the state of the driver, different colors of LED begin to glow. Red indicating the drowsy state of the driver, blue indicating the normal state of the driver, yellow indicating the sleep state of the driver and green indicating the active state of the driver.

Whenever the drowsy state is detected the Arduino connected with a relay will enable the motor to slow down. At the same time using the buzzer, an alert is given to the driver to make him awake.

The hardware components shown in Fig 5 are chosen on the basis of specifications, accuracy, features and cost.

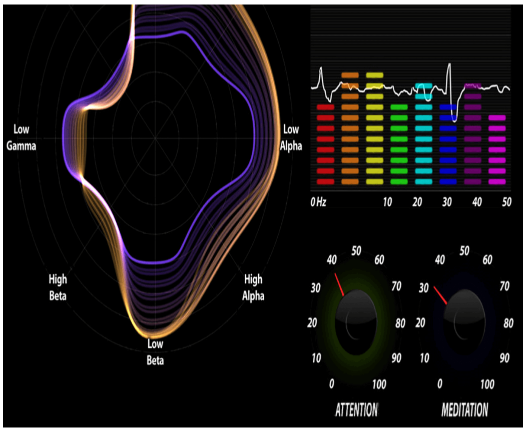

Fig .4. Brainwave visualization

Fig .5. Hardware/Software Requirements

V. CONCLUSION

In this proposed system the activity of brain is taken as input through EEG sensors. These sensors are aided with low cost and high reliability. The normal and abnormal rate of acquired input is differentiated according to the authentic and preferred standards available. A software module is employed in Arduino to control the motor and alarm. It is the most efficient and embedded drowsy driver detection system for bike riders by enhancing the safety of the biker by making a helmet to play a vital part with warning platform as a miniaturized sensor and flexible designs with the ability of real-time detection of drowsiness and providing real time control providing instantaneous alert motivating the practice of wearing a helmet while riding in order to stay safe even during accidents.

VI. FUTURE ENCHANCEMENTS

The drowsiness detection with the online warning feedback in real time is instigated. An alternative approach parametric autoregressive (AR) modeling engaged in extracting features in the categorization of EEG and must be equipped with the capability of examining the convenience and efficiency in various frequency bands utilizing the entropies for the real time identification [18-20]. Its inherent capacity to model the peak spectra and all-pole model resolves sharp changes in the spectra and helps to achieve high accuracy in estimation of threshold. Nanotechnology can be used to incorporate most of the hardware can be include in helmet by eliminating the interference and using digital twin more controls can be added to the bike motor which prevents the driver from accident.

REFERENCES

[1] The National Highway Traffic Safety Administration, “Research on Drowsy Driving external icon”. Accessed October 20, 2015.

[2] S Sasirekha, I Joe Louis Paul, S Swamynathan, Y Gokul, P Kirthana, “Smart Helmet with Emergency Notification System-A Prototype ”, 3rd International Conference on Wireless Communication and Sensor Network, 2017.

[3] C. C. Liu, S. G. Hosking, M. G. Lenne, "Predicting driver drowsiness using vehicle measures: Recent insights and future challenges", *Journal of Safety Research*, vol. 40, no. 4, pp. 239-245, 2009.

[4] Z. L. Zhang, D.; Rasim, Y.; Li, Y.; Meng, G.; Xu, J.; Wang, C., "A vehicle active safety model: Vehicle speed control based on driver vigilance detection using wearable EEG and sparse representation," Sensors (Switzerland), vol. 16, 2016.

[5] A. D. McDonald, J. D. Lee, C. Schwarz, and T. L. Brown, "Steering in a random forest: Ensemble learning for detecting drowsiness-related lane departures," Human Factors, vol. 56, pp. 986-998, 2014.

[6] X. Zhang, J. Li, Y. Liu, Z. Zhang, Z. Wang, D. Luo, et al., "Design of a Fatigue Detection System for High-Speed Trains Based on Driver Vigilance Using a Wireless Wearable EEG," Sensors (Basel), vol. 17, Mar 01 2017.

[7] R. N. K. Khushaba, S.; Lal, S.; Dissanayake, G., "Uncorrelated fuzzy neighborhood preserving analysis based feature projection for driver drowsiness recognition," Fuzzy Sets and Systems, vol. 221, pp. 90-111, 2013.

[8] P. Li, W. Jiang, and F. Su, "Single-channel EEG-based mental fatigue detection based on deep belief network," in Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, 2016, pp. 367-370.

[9] C. Ahlstrom, M. Nyström, K. Holmqvist, C. Fors, D. Sandberg, A.Anund, et al., "Fit-for-duty test for estimation of drivers' sleepiness level: Eye movements improve the sleep/wake predictor", Transportation Research Part C: Emerging Technologies, vol. 26, pp. 20-32, 2013.

[10] T. Vesselenyi, S. Moca, A. Rus, T. Mitran, and B. Tătaru, "Driver drowsiness detection using ANN image processing," 2017.

[11] A. M. Rumagit, I. A. Akbar, and T. Igasaki, "Gazing time analysis for drowsiness assessment using eye gaze tracker," Telkomnika (Telecommunication Computing Electronics and Control), vol. 15, pp. 919-925, 2017.

[12] D. Sandberg, T. Åkerstedt, A. Anund, G. Kecklund, and M. Wahde, "Detecting driver sleepiness using optimized nonlinear combinations of sleepiness indicators," IEEE Transactions on Intelligent Transportation Systems, vol. 12, pp. 97-108, 2011.

[13] F. Abtahi, A. Anund, C. Fors, F. Seoane, and K. Lindecrantz, "Association of drivers' sleepiness with heart rate variability: A pilot study with drivers on real roads," 2017, pp. 149-152.

[14] M. Awais, N. Badruddin, and M. Drieberg, "A hybrid approach to detect driver drowsiness utilizing physiological signals to improve system performance and Wearability," Sensors (Switzerland), vol. 17, 2017.

[15] K. T. Chui, K. F. Tsang, H. R. Chi, B. W. K. Ling, and C. K. Wu, "An Accurate ECG-Based Transportation Safety Drowsiness Detection Scheme," IEEE Transactions on Industrial Informatics, vol. 12, pp. 1438-1452, 2016.

[16] Murugan Ezhumalai, Venkat Subramanian, Venkatraman Pitchaikannu,"Drowsy Driver Detection and Accident Prevention System using Bio-Medical Electronics",International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 11, November 2015

[17] Mohsen Babaeian, Nitish Bhardwaj, Bianca Esquivel, Mohammad Mozumdar, "Real time driver drowsiness detection using a logistic-regression-based machine learning algorithm", IEEE Green Energy and Systems Conference (IGSEC), 2016

[18] Viraj Yadav, Pradeep Shinde, Nilima Patil, Akshaya Thorat, "Human Emotions Detection using Brain Wave Signals", International Research Journal of Engineering and Technology (IRJET), 2018

[19] Chin- Teng Lin, Fellow, IEEE, Che-Jui Chang, Bor-Shyh Lin, Mem- ber, IEEE, Shao-Hang Hung, Chih-Feng Chao, and I-Jan Wang, "A Real- Time Wireless Brain–Computer Interface System for Drowsiness Detec- tion", IEEE Transactions on Biomedical Circuits And Systems, Vol. 4, No. 4, August 2010

[20] J. A. Horne and L. A. Reyner, "Sleep related vehicle accidents," Brit. Med. J., vol. 310, pp. 565–567, 1995.

[21] Liu C.C., Hosking S.G., Lenné M.G. Predicting driver drowsiness using vehicle measures: Recent insights and future challenges. J. Saf. Res. 2009;40:239–245.