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A Survey on Driver Cognitive Distraction Detection

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Abstract –

Road accidents is one of the major cause of death in today's generation. As there is an increasing number of vehicle manufacturing people tend to travel in vehicles rather than travelling by walk. Some of the factors that cause accidents due to drivers inattentiveness is drivers drowsiness. Drowsiness is determined by four different measures physiological measures, driving behavior based measures, visual measure and non visual measures. Some of these measures are intrusive to drivers and some are nonintrusive . Different techniques are used to evaluate the experimental results. The number of vehicle crashes is reduced by giving alert to the drivers on different measures of monitoring drowsiness. Alert can be in the form of either sound alert or vibration to the drivers in the car seat.

Keywords-

Sensor, Bluetooth, NFC, wearable, PERCLOS

I. Introduction

Road accidents is one of the major cause of death in leading generation. The cost for the loss due to vehicle crashes is more than $24,500 per vehicle crash, $150,000 per injury to the people in the vehicle , and $3.6 million per occurrence of death by accident according to the National Highway Traffic Safety Administration (NHTSA)and the Federal Motor Carrier Safety Administration. According to the statistical data more than 50 million people suffer due to vehicle crashes[1].Nowadays large number of vehicle crashes is due to drivers inattentiveness. Vehicle crash is one the main dominating factor that leads to death. The crashes occur due to the distractions of the driver. The crucial accidents leads to loss of people life and driving performance gets worse resulting in loss of control of the vehicle[22]. Most of the accidents occurs after midnight as the driver alertness level varies from high to very low depending on the amount of time taken to sleep. There are many reasons for drowsiness such as encephalitis which results in inflammation of brain tissues, hypovolemic shock which results in 20% loss of body's blood or fluid supply and concussion due traumatic brain injury. The effects of distraction is determined by the attentiveness state of driver in real time and by in-vehicle technologies[9]. The accident is caused by lorry drivers, call taxi drivers, travel bus drivers works in shift basis, drivers under medications, and drivers who regularly don't get enough sleep falls asleep while driving[26]. Any driver travelling to a long distance when they tired or in illness is the major reasons for sleep related vehicle crashes. The drivers vigilance is measured by six different parameters such as face position, frequency of nodding, frequency of blinks, gaze fixation , duration of eye closure and percentage of closure of eyelids(PERCLOS)[28]. The state of drowsiness can be define in three different stages such as a state between awake and asleep, moderate sleep and deep sleep[2].

II. Related Works

There are various measures used for determining the drowsiness of drivers. The distraction is classified into two types namely visual distraction and cognitive distraction. The visual distraction is that eye-off road and the cognitive distraction is that mind-off road[13]. The measures are physiological measure, driving behavior based measure, visual features and non visual features as shown in fig .1.. The physiological measure determines the vital signals such as activity of brain, muscle, tissues and heart . The driving behavior based measure determines the steering control, speed, frequencies of brakes applied and variations in lateral positions. The visual features measures the eye movement, facial expressions and yawning[7] .The non visual features measures the Galvanic skin response(GSR) and Heart rate variability(HRV).

An active IR illuminator is used to obtain driver's images for monitoring driver's visual behavior[28]. Drowsy driver's without changing the lateral positions of vehicle falls asleep only for a small seconds on a straight road. Lucas-Kanade optical flow method is used to keep track of changes in head position. For detecting changes in the physiological measures fast Fourier transform (FFT) is used to extract features in time and frequency domains. The wavelet packet transform (WPT) by Zhang *et al*.[3] is used because it can be employed to deal with different signals characteristics such as stationary, non stationary and transitory when there is any abrupt changes. For monitoring in real time , support vector machine (SVM) is used to detect cognitive distraction from drivers eye movement and driving behaviour data[4]. Observing the mental state of the driver is not feasible in detecting the cognitive distraction. In-vehicle information systems (IVISs) involves in monitoring drivers inattentiveness in real time. Distraction of drivers is monitored by using data mining methods in real time[29]. While driving , reaction of drivers is more slow in brake events when using cell phones as they get distracted from the road. Lateral positions of the drivers in getting deviated from the lane also detects that driver is mind off road.

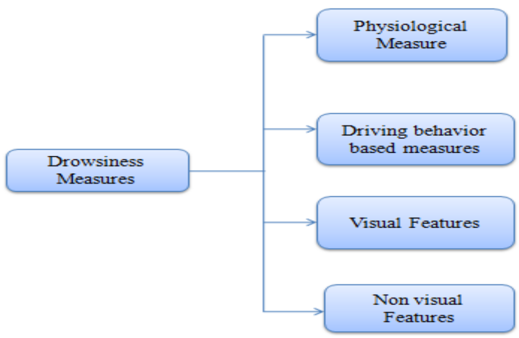

Fig.1.Different drowsiness measures

A. *Physiological measures*

In physiological measures ,the drivers drowsiness is measured by the physiological signs such as facial wrinkles which denotes brows and nasolabial fold, Electroencephalogram (EEG) which detects the heart's electrical activity, Electrocardiogram (ECG) which measures the electrical activity of muscles using flat metal discs, Electrooculogram (EOG) which records the eye movement[3].

I. Facial Wrinkles

In this physical sign ,the drowsiness of drivers is measured by the wrinkles in the faces which creates folds or ridges in the skin as shown in fig.2. As the drivers who don't get regular sleep gets wrinkles when they fall into drowsiness state[12]. Facial wrinkles includes inner brow rise and outer brow rise and nasolabial fold. For detection of facial expressions AdaBoost algorithm is used to detect face in real time. Detecting the facial wrinkles using face detection is categorised into two face features and face colours. Facial features includes the measure of distance between eyes, eyebrows, measure between eye and eyebrows[30].

Fig. 2. Facial Wrinkles due to drowsiness

II. Electroencephalogram(EEG)

In this the EEG detects the electrical activity of the brain or the scalp by using a flat metal discs that is attaching electrodes to the scalp[22]. It diagnosis the brain disorders which results in drowsiness as shown in fig.4. A high resolution results can also obtained for measuring the brains activity using MRI and CT. The brains electrical activity by four different rhythms namely Delta, Alpha, Beta and Theta. The frequency ranges differently for different rhythms for Delta the frequency ranges from 0.5 to 4 Hz ,which is the state between deep sleep and waking state. In case of Theta the frequency ranges from 4 to 8 Hz ,which is the state between unconsciousness and deep meditation. Alpha

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frequency ranges from 8 to 12 Hz for having relaxed awareness and Beta frequency ranges from 12 to 30 Hz for active busy and active concentrations[31]. Different drowsiness based technology is used for detecting drivers distraction such as Virtual Reality(VR) for driving environment , Independent Component Analysis (ICA), Power Spectrum Analysis and linear regression models.

Fig. 2. Electroencephalogram(EEG)

Fig.4. Brain activity measurement

III. Electrocardiogram(ECG)

In this the ECG records the heart's electrical activity by attaching electrodes to the surface of the skin as shown in fig.5.. It takes the dissemination of the cardiac muscles and the generates it into a wave form which is used to measure the regularity of the heart[23]. Using electrodes on the surface of the skin causes intrusiveness to the drivers while driving as shown in fig 6. Electrodes can be attached to the wheel and by using operational amplifier the signals can be measured.

Placing an electrode in the seats of the car or in the chest is intrusive to the drivers while driving. In such cases ECG sensors is used which is nonintrusive to drivers. Using electrodes on human body, the electrical signals acquired is affected by noise from the human body. The noise can be removed by using filters in which the noise is inverted using analog amplifier. As electrodes do not contact the skin of the drivers directly there is an high obstruction between electrodes and skin[32]. The noise in the ECG signals can be cancelled by using Adaptive Baseline Noise Cancellation method. The limitation on using ECG sensor is that it should be in contact with the drivers body constantly.

Fig.5.Measuring heart activity

Fig .6. Electrodes attached to the seat of the drivers

IV. Electrooculogram(EOG)

In this the EOG records the eye movement by measuring the potential of the retina eye[18] . A pair of electrodes is placed either below or above the eyes to measure the eye movement as shown in fig .7. When eye moves from its center location to the one of the electrodes, the positive and the negative side of the retina is measured. EOG is used to monitor the lane deviation with the highest possible correlation[33] . EOG measures the potential in the surrounding tissues of the eye by placing the electrodes in forehead and near the surface of

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cornea. The EOG has two different channels namely vertical and horizontal based on low frequency and high frequency. The eye movement is monitored and the number of blinks for a fraction of seconds is measured and stored in the database so that if there is any reduced number of blinks and variations in the eye closure alerts the driver immediately[35].

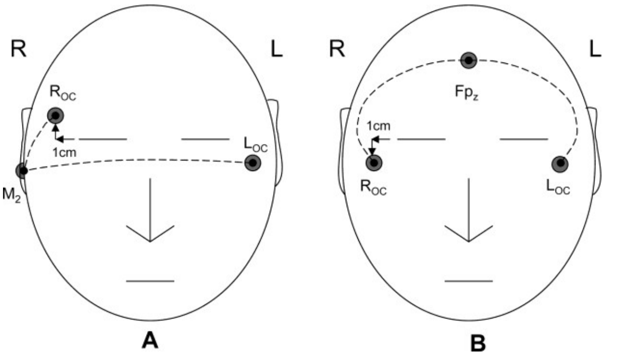

Fig .7. Eye movement measured by retina

B. Driving behavior based measures

In this measures the drivers driving behavior is measured based on the steering control, speed , variations in lateral positions and frequencies of brakes applied as shown in fig.8. When the driver gets distracted they take eye off road and loses the control over the steering which leads to rotation of wheels in different angles. The speed for driving in a certain speed limit road is also measured. Sitting positions of the driver shows that whether the drivers are in attentive state or not. By measuring the frequencies of brakes applied at every measurable distance on the road also provides a result of drivers drowsiness[4].

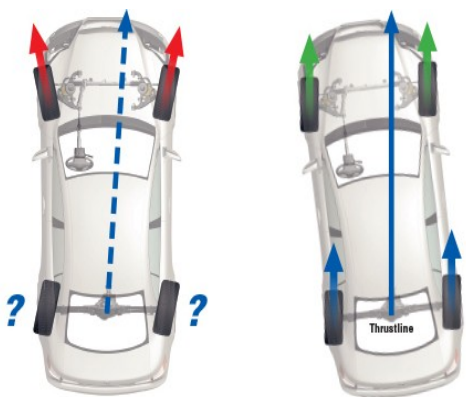

Fig.8. Steering wheel angle positions

C. Visual Features

The visual features for monitoring drivers drowsiness state includes measuring the eye movement , detecting the yawns [25], change of head pose and facial expressions as shown in fig .9. The movement of eye is monitored by measuring the eye pupil width and height and by the percentage of closure of eyelids (PERCLOS).The change of head pose is measured by three Euler's angle of head pose nodding, tilting and shaking[16]. The Facial expressions while driving in a drowsiness state is measured by taking the left and right pupil, left and right eye corner both inner and outer left and right nostril root and tip[10].

The drivers vigilance is monitored by placing an active IR illuminator in the car along with a camera on the dash board. Using fuzzy classifier different visual parameters is combined in one camera and then it is analyzed[28].To monitor visual features in daytime and night time a CCD camera is used for image acquisition. The visual characteristics gives reduced alertness level from the drivers image acquired from monitoring the duration of blinks as longer, eyelid movement to be slower, posture of drooping, gaze fixation areas, yawning frequently, expressions from the face and nodding frequency. To provide alert to the drivers, the number of blinks per second is noted. If there is no notable blinks for fraction of seconds then an immediate alert is given to the drivers to keep them in awake state.

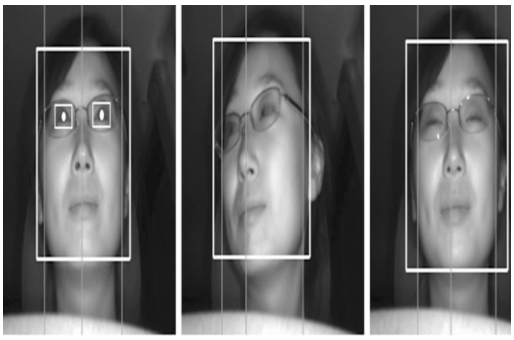

Fig.9.Eye movement and head pose lateral variations

D. Non Visual Features

The non visual features includes two main physiological signals such as Heart Rate Variability(HRV) and Galvanic Skin Response(GSR) as shown in fig.10. The HRV is measured by monitoring the heart rate of the driver using some sensors and frequently updated if there

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is any variations in the heart rate[6]. The Galvanic Skin Response measures the change in electrical properties of the skin. It is used to examine the nervous system while driving. The change of skin color during drowsiness is also monitored by GSR.

The methods used to determine the different measures of drowsiness state uses Kalman filters to track the pupil. The skin color changes when the driver is in drowsiness state. The heart rate varies due to stress, emotions , health disorders , fatigue and drowsiness. The HRV can be monitored in two different state of environment such as simulated driving state and real time driving state[34].

Fig .10. Galvanic Skin Response (GSR)

III. Results and Discussions

From the above discussed drowsiness monitoring measures, certain measures are intrusive to drivers and certain measures are not intrusive too drivers. Based on the survey measuring the brains activity using electrodes causes damages to the brains. The developed mobile application aims at monitoring the drivers drowsiness and alerting the driver to reduce the number of deaths due to vehicle crashes in day to day life[27]. Monitoring of pulse rate is carried out to measure the variations in the drivers pulse rate in normal state and in inattentive state or the state of drowsiness. Using pulse sensor the heart pulse is measured continuously for alertness of vehicle driver[14].

The proposed scheme extracts the physiological features from wrist ,chest , neck of the driver in real outdoor driving condition. A drowsy driving alerting system is proposed by analyzing the driving patterns and pulse rate . From the table inferred, by taking different parameters into the considerations detection performance percentage is calculated[28]. The main aim of this project is to continuously monitor the driver's pulse rate variations. Then the sensor data is fetched from microcontroller and the information is sent to Android device by using Bluetooth modem . By using java code the Graphical user interface form displays the sensor values continuously and monitors the driver's state.

IV. CONCLUSIONS

The driver's drowsiness is monitored using different features. After reviewing different measures some are difficult to be observable in real time .In such cases sensors can be used to detect fatigue which is low cost and affordable to the drivers. In future the drowsiness can be measured by using a mobile app which can be integrated in smart phones .The sensing of data from the detection measures can be monitored by using a wearable devices such as watches, chest belt. The data can also be fetched using NFC tags or bluetooth.

Compared to different driving measures driving performance measures is very effective , non intrusive and user friendly in real time for detecting drivers drowsiness. Different people have different salient features that are based on physiological , their style of driving also varies in case of holding the steering and establishing the brake events. Therefore the information should be collected when the driver is in alert state.

REFERENCES

[1] Global Status Report on Road Safety 2009. World Health Organisation (WHO); Geneva, Switzerland: 2009.

[2] Brodbeck V., Kuhn A., von Wegner F., Morzelewski A., Tagliazucchi E., Borisov S., Michel C.M., Laufs H. EEG microstates of wakefulness and NREM sleep. NeuroImage. 2012;62:2129–2139.

[3] R. N. Khushaba, S. Kodagoda, S. Lal, and G. Dissanayake, “Driver drowsiness classification using fuzzy wavelet-packet-based feature

extraction algorithm," *IEEE Trans. Biomed. Eng.*, vol. 58, no. 1, pp. 121– 131, Jan. 2011.

[4] Y. Liang, M. L. Reyes, and J. D. Lee, "Real-time detection of driver cognitive distraction using support vector machines," *IEEE Trans. Transp. Syst.*, vol. 8, no. 2, pp. 340–350, Jun. 2007.

[5] Murphy-Chutorian, E.; Trivedi, M.M. "Head Pose Estimation in Computer Vision: A Survey", *Pattern Analysis and Machine Intelligence, IEEE Transactions on,* On page(s): 607 - 626 Volume: 31, Issue: 4, April 2009

[6] Jeen-ShinWang ,Pau-Choo Chung ; Wei-Hsin Wang ; Che-Wei Lin," Driving Conditions Recognition Using Heart Rate Variability Indexes " 15-17 Oct. 2010; 978-0-7695-4222-5.

[7] R. O. Mbouna, S. G. Kong, and M. G. Chun, "Visual analysis of eye state and head pose for driver alertness monitoring," IEEE Transactions on Intelligent Transportation Systems, vol. 14, no. 3, pp. 1462–1469, 2013.

[8] Q. N. Niu, L. S. Jin, H. J. Hou, H. C. Xian, and Y. G. Qin, "Driver fatigue detection system based on eye movements," in ICTIS, pp. 657–663, 2013.

[9] T. Akerstedt, D. Hallvig, A. Anund, C. Fors, J. Schwarz, and G. Kecklund, "Having to stop driving at night because of dangerous sleepiness-awareness, physiology and behavior," Journal of Sleep Research, vol. 22, no. 4, pp. 380–388, 2013.

[10] J. Q. Wang, L. Zhang, D. Z. Zhang, and K. Q. Li, "An adaptive longitudinal driving assistance system based on driver characteristics," IEEE Transactions on Intelligent Transportation Systems, vol. 14, no. 1, pp. 1–12, 2013.

[11] A. A. Lenskiy and J. S. Lee, "Driver's eye blinking detection using novel color and texture segmentation algorithms," International Journal of Control, Automation, and Systems, vol. 10, no. 2, pp. 317–327, 2012.

[12] A. Picot, S. Charbonnier, and A. Caplier, "On-line detection of drowsiness using brain and visual information," IEEE Transactions on Systems, Man, and Cybernetics A, vol. 42, no. 3, pp. 764–775, 2012.

[13] L. S. Jin, Q. N. Niu, H. J. Hou, H. C. Xian, Y. L. Wang, and D. D. Shi, "Driver cognitive distraction detection using driving performance measures," Discrete Dynamics in Nature and Society, vol. 2012, Article ID 432634, 12 pages, 2012.

[14] A. Sahayadhas, K. Sundaraj, and M. Murugappan, "Detecting driver drowsiness based on sensors: a review," Sensors, vol. 12, pp. 16937–16953, 2012.

[15] R. C. Coetzer and G. P. Hancke, "Eye detection for a real-time vehicle driver fatigue monitoring system," in Proceedings of the IEEE Intelligent Vehicles Symposium, pp. 66–71, Baden-Baden, Germany, June 2011.

[16] S. J. Lee, J. Jo, H. G. Jung, K. R. Park, and J. Kim, "Real-time gaze estimator based on driver's head orientation for forward collision warning system," IEEE Transactions on Intelligent Transportation Systems, vol. 12, no. 1, pp. 254–267, 2011.

[17] Y. Dong, Z. Hu, K. Uchimura, and N. Murayama, "Driver inattention monitoring system for intelligent vehicles: a review," IEEE Transactions on Intelligent Transportation Systems, vol. 12, no. 2, pp. 596–614, 2011.

[18] F. Friedrichs and B. Yang, "Camera-based drowsiness reference for driver state classification under real driving conditions," in Proceedings of the IEEE Intelligent Vehicles Symposium, pp. 101–106, June 2010.

[19] Z. T. Zhang and J. S. Zhang, "A new real-time eye tracking based on nonlinear unscented Kalman filter for monitoring driver fatigue," Journal of Control Theory and Applications, vol. 8, no. 2, pp. 181–188, 2010.

[20] D. W. Hansen and Q. Ji, "In the eye of the beholder: a survey of models for eyes and gaze," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 32, no. 3, pp. 478–500, 2010.

[21] C. Liu and R. Subramanian, "Factors related to fatal single-vehicle run-off-road crashes," DOT HS 811 232, U.S. Department

of Transportation, American National Highway Traffic Safety Administration, Washington, DC, USA, 2009.

[22] B.C. Yin, X. Fan, and Y.-F. Sun, “Multiscale dynamic features based driver fatigue detection,” International Journal of Pattern Recognition and Artificial Intelligence, vol. 23, no. 3, pp. 575–589, 2009.

[23] X. Fan, B.-C. Yin, and Y.-F. Sun, “Yawning detection for monitoring driver fatigue,” in Proceedings of the 6th International Conference on Machine Learning and Cybernetics (ICMLC '07), pp. 664–668, August 2007.

[24] T. D'Orazio, M. Leo, C. Guaragnella, and A. Distante, “A visual approach for driver inattention detection,” Pattern Recognition, vol. 40, no. 8, pp. 2341–2355, 2007.

[25] H. Eren, U. Çelik, and M. Poyraz, “Stereo vision and statistical based behavior prediction of driver,” in Proceedings of the IEEE Intelligent Vehicles Symposium, pp. 657–662, June 2007.

[26] M. Ingre, T. Akerstedt, B. Peters, A. Anund, and G. Kecklund, “Subjective sleepiness, simulated driving performance and blink duration: examining individual differences,” Journal of Sleep Research, vol. 15, no. 1, pp. 47–53, 2006.

[27] Building your first app,https://developer.android.com/training/basics/
firstapp/index.html.

[28] Luis M. Bergasa, Miguel A. Sotelo, Member IEEE, “Real-Time System for Monitoring Driver Vigilance”, Vol.7,pp. 63-77 IEEE Transactions on Intelligent Transporation Sytems, March 2006.

[29] Yulan Liang, John D. Lee, and Michelle L. Reyes," Nonintrusive Detection of Driver Cognitive Distraction in Real Time Using Bayesian Networks", Transportation Research Record: Journal of the Transportation Research Board,No. 2018,D.C., 2007, pp. 1–8.

[30] Saeid. Fazli, and Parisa. Esfehani." Tracking Eye State for Fatigue Detection", International Conference on Advances in Computer and Electrical Engineering (ICACEE'2012) Nov. 17-18, 2012.

[31] Howida A. Shedeed, Ahmed G. El-deeb," Vigilance Monitoring System Using Brain EEG Signal Processing",Recent Advances in Information Science ISBN: 978-960-474-344-5.

[32] Xun Yu," Real-time Nonintrusive Detection of Driver Drowsiness",Intelligent Transportation Systems Institute Center for Transportation Studies may 2009.

[33] Tsuyoshi NAKAGAWA Taiji KAWACHI Satori ARIMITSU Masayuki KANNO," Drowsiness Detection Using Spectrum Analysis of Eye Movements and Effective Stimuli to Keep Drivers Awake",Proceedings of smart systems 2006 and ICMA 2006.

[34] José Vicente, Pablo Laguna, Ariadna Bartra, Raquel Bailón," Detection of Driver’s Drowsiness by Means of HRV Analysis",Computing in Cardiology 2011;38:89−92 SSN 0276−6574.

[35] Xuemin Zhu, Wei-Long Zheng, Bao-Liang Lu, Xiaoping Chen , Shanguang Chen, and Chunhui Wang," EOG-based Drowsiness Detection Using Convolutional Neural Networks",International joint conference on neural network,IJCNN july 2014.

[36] Chuang-Wen You, Nicholas D. Lanet, Fanglin Chen, "CarSafe App: Alerting Drowsy and Distracted Drivers usng Dual Cameras on Smartphones", june 2013 ACM 978-1-4503-1672-9/13/06.

[37] Singh Himani Parmar, Mehul Jjal, Yadav Priyanka Brijbham", Drowsy Driver Warning System using Image Processing, ISSN:2321-9939.