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DRIVER DROWSINESS DETECTION TECHNIQUES: A REVIEW

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ABSTRACT. Drowsy Driving is the chief cause for road accidents and bears a significant relation to road safety. Around one quarter of all serious motorway accidents are ascribable to sleepy drivers in need of rest, which implies that drowsiness causes more road accidents than drunk-driving. It occurs when a person driving a motor vehicle is too tired to remain alert and eventually falls asleep behind the wheel due to slow reaction time, reduced vigilance and debilitated thinking. This paper presents an extensive review of the state of the art techniques, research and development as well as advances in the field of drowsiness detection. This paper classifies and compares the existing techniques into three categories: Behavioral based techniques, Vehicular based techniques and Physiological parameters-based techniques.

1. INTRODUCTION

Fatigue has always taken a toll on the safety, health, and quality of life. Lack of alertness, generated by the unconscious transition from wakefulness to sleep, leads to several serious road accidents crashes. Hence, the use of aiding systems that examine a driver's level of vigilance is necessary to avoid road accidents. In simple words, Driver drowsiness detection is a car safety technology which prevents accidents when the driver is getting drowsy. These systems continuously analyze the drivers' attention level and alert the driver before the arrival of any fatal threat to life.

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2. Factors Causing Drowsiness

Drowsy Driving is one of the pressing issues in the research field. The harbingers of driver fatigue are driving hastily, yawning, feeling stiff, heavy eyes and reacting unsteadily. It is often caused by four main factors namely Sleepiness, Work, Time, and other Physical Factors. Torpor is induced by persistent working hours, medication side-effects or certain sleep disorders. This lack of sleep piles up and the person ends up sleeping. Time of the day affects the way our brain functions. When tumultuous timetables are extended the person eventually dozes off. A person's physical condition also plays a major role in determining whether a person is bound to be drowsy or not.

3. Drowsiness Detection Techniques

Various drowsiness detection techniques (DDT) are mentioned in this section along with their pros and cons. These methods are generally classified into three main categories:

(A) Behavioral based Drowsiness Detection Methods;
(B) Vehicular based Drowsiness Detection Methods;
(C) Physiological based Drowsiness Detection Methods.

3.1. **Behavioral Based Drowsiness Detection Methods.**

Behavioral parameters are non-invasive measures of drowsiness detection. These techniques calculate drivers' fatigue based on driver's behavioral parameters such as eye aspect ratio (EAR), eye blinking, facial expressions, etc. Yawning based detection is another time of image processing technique that helps to determine the variations in the geometric shape of the mouth of drowsy driver. Following behavioral methods are used for calculating the driver's drowsiness:

3.1.1. *Facial Expressions Method.*

The authors of [1], deciphered a hardware-based Drowsiness Detection system derived from facial expressions which is an important application for machine vision. This technique is a derivative of the Finite Element Analysis used by researchers which contains a complex system that holds the record of facial expression and detects the drowsiness on the basis

of the results from the saved record. Facial expressions are obtained by using horizontal projection and matching the dynamic template from the record.

3.1.2. *Yawning Extraction and Analysis.* The authors of [2], proposed a DDT based on mouth and yawning analysis. The system identifies the driver's mouth using cascade of classifiers and performs mouth detection from the predictor images. The classifier that was used to train these images was the Support Vector Machine so that it could carry out a binary or a multiclass classification and alert the driver. The authors collected some videos for this experiment and selected twenty images of a yawning person and over hundred normal videos.

3.1.3. *Eye Tracking System.* The authors of [3], put forward a system known as Percent of Eye Closure (PERCLOS) in order to track the eye. A top down model is used to identify the face and the eyes with a web camera connected to a GUI software on a laptop. The system continues to take the images from the webcam until the face is located. The eye region is extracted using Viola-Jones algorithm along with Adaptive Boosting (Ada-Boost). In this method, the fatigue level of the driver S is calculated as $S = \frac{H}{L}$, where H corresponds to the height and L is the length of drivers' eye. Each frame of input video is arranged using the measured value of S. When the level of drowsiness approaches 0.15 which is severe, the system turns on the alarm to wary the driver.

3.1.4. *Eye Blink Detection and Monitoring Method.* The authors of [4], devised a DDT based on non-intrusive machine-based concepts. The system's hardware consists of a web camera for recording the facial expressions and head movements mounted in front of the driver. Viola-Jones algorithm and Haar Cascade classifier is used to detect the face and extract features like eyes and mouth. The indication of drowsiness in this method is given by eyes blinking that varies from 12 to 19 blinks per minute normally. If the frequency level is lesser than the required range, then drowsiness is implied. If the eye is closed, the value of the attribute is zero, otherwise the value of the attribute is a non-zero number in case of open or partially opened eyes. This system showed an efficiency of 90%.

3.2. **Vehicular Based Drowsiness Detection Methods.** Vehicular based methods for Drowsiness Detection are those methods that detect driver fatigue based

on various vehicular metrics such as lane changing patterns, accelerator movement, vehicle speed variability, angle of steering wheel, grip force and so on. These techniques endeavor to observe and record the driving patterns and detect plummeting driving performance due to tiredness. We cannot do much for measuring driver fatigue, in accordance to the vehicle movement because these measurement values are subjected to change by external factors such as the state of the road and weather conditions, [7]. The methods for various Vehicular Techniques are described below:

3.2.1. *Real Time Lane Detection System.* The authors of [5], described a method for drowsiness detection which works in low lightning conditions. The system works in two phases: In the first phase, the system detects lane based on Hough transform. In the second phase, the system detects the driver's eyes and face using Viola Jones Algorithm. To process the images, Segmentation is done following which Otsu's Threshold method is carried out.

3.2.2. *Time Series Analysis of Steering Wheel Angular Velocity.* The authors of [6], worked on a fatigue detection method using time series analysis of steering wheel angular velocity of the car. The behavior of the steering wheel and a detection window is made into used as the detection feature to compute the angular velocity of steering wheel so that it can be used for the time series analysis. The proposed method outperforms the previous methods and proves to be very advantageous in real world setting. [7] also came up with a real-time online detection to monitor the fatigue level of drivers under real conditions using Steering Wheel Angles (SWA). This system showed an accuracy of 78.01%.

3.3. **Physiological Parameters Based Drowsiness Detection Methods.** The Physiological Parameters based Drowsiness methods are those which are used to detect drowsiness based on drivers' physical conditions and environmental conditions such as heart rate, body temperature, pulse rate, rate of response etc. Following are the Physiological based DDT Methods:

3.3.1. *EEG-Based Driver Fatigue Detection.* EEG stands for Electroencephalogram. For this system, the driver has to wear an electrode helmet while he is behind the wheel, [9]. The proposed method uses FastICA algorithm to find the drowsiness index. Dataset for simulated car driver under the various levels of drowsiness was collected locally for evaluation of this method. It had two states sober and

drowsy. This method can be used to detect the drowsiness from all kinds of setting.

3.3.2. *Pulse Sensor Method.* The authors of [10], presented a study to detect drowsy drivers using infrared heart-rate pulse sensors which measure the heart pulse rate from drivers' wrist. The sensor determines the amount of blood flowing through the hand and oxygen measured causes the infrared light to reflect off to the transmitter. Arduino is used as a microcontroller which receives the fluctuation of oxygen sent by the sensor. The heart pulse rate is visualized by the software processing of HRV frequency. It was observed that low to high frequency ratio decreases as drivers go from the state of being awake to the drowsy.

4. Comparasion of Various Drowsiness Detection Methods

Every drowsiness detection method has a disadvantage as well as an advantage. Table 1. presents comparative study of these DDT, [8].

Table 1. Comparison of Various Drowsiness Detection Methods

TECHNIQUE	PARAMETERS	PROS	CONS
Behavioral Parameters-based DDT	Eye blinking, Eye closeness ratio, Head movement, Yawning	Non- intrusive, Easy to use	Effected by illumination, lightening conditions
Vehicle Parameters-based DDT	Steering wheel, lane changing pattern	Non- intrusive	Effected by geometric characteristic of roads, Unreliable
Physiological Parameters-based DDT	Heart Rate, Pulse Rate, Brain Activity	Effective, Realiable	Intrusive

5. CONCLUSION

As highlighted this paper, various advancements exist to identify driver exhaustion. This paper tries to elucidate the developing advances and determine

the ideal methodologies in attempting to save drivers from lethal attacks. Various techniques have been proposed by researchers from time to time which use different kinds of input. However, these techniques are constrained to a great degree and are not exceptionally compelling. The present market and innovations is in its embryonic mode. New innovations keep developing utilizing numerous new and efficient procedures.

REFERENCES

[1] M. A. ASSARI, M. RAHMATI: *Driver drowsiness detection using face expression recognition*, Proc. 2011 IEEE International Conference on Signal and Image Processing Applications (ICSIPA) IEEE, (2011), 337–341.

[2] M. SARADADEVI, P. BAJAJ: *Driver fatigue detection using mouth and yawning analysis*, International journal of Computer science and network security, **8**(6) (2008), 183–188.

[3] W. B. HORNG, C. Y. CHEN, Y. CHANG, C. H. FAN: *Driver fatigue detection based on eye tracking and dynamic template matching*, Proc. IEEE International Conference on Networking, Sensing and Control, **8** (2004), 7–12.

[4] R. AHMAD, J. N. BOROLE: *Drowsy driver identification using eye blink detection*, Int. J. Comput. Sci. Inf. Technol., **6**(1) (2015), 270–274.

[5] Y. KATYAL, S. ALUR, S. DWIVEDI: *Safe driving by detecting lane discipline and driver drowsiness*, Proc. IEEE Int. Conf. Adv. Commun. Control Comput. Tech., (2014), 1008–1012.

[6] G. ZHENHAI, L. DINHDAT, H. HONGYU, Y. ZIWEN, W. XINYU: *Driver drowsiness detection based on time series analysis of steering wheel angular velocity*, Proc. 9th Int. Conf. Measuring Technol. Mechatron. Automat. (ICMTMA), (2017), 99–101.

[7] Z. LI, S. E. LI, R. LI, B. CHENG, J. SHI: *Online detection of driver fatigue using steering wheel angles for real driving conditions*, Sensors, **17**(1) (2017), 495–507.

[8] M. RAMZAN, H. U. KHAN, S. M. AWAN, A. ISMAIL, M. ILYAS, A. MAHMOOD: *A Survey on State-of-the-Art Drowsiness Detection Techniques*, IEEE Access, **7** (2019), 61904–61919.

[9] M. LI, C. ZHANG, J. F. YANG: *An EEG-based Method for Detecting Drowsy Driving State*, Proc. 17th Fuzzy Systems and Knowledge Discovery (FSKD), (2010), 2164–2167.

[10] H. A. RAHIM, A. DALIMI, H. JAAFAR: *Detecting drowsy driver using pulse sensor*, J. Technol., **73**(3) (2015), 5–8.

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