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A Review on Driving Event Detection and Driving Style Classification

A. Syed Abrar[1], Dheeraj Kumar P.H[2], H.N Guru Shambhu[3], Swathi Somayaji .B[4]
Assistant Professor[4]
Department of Electronics and Communication Engineering
Atria Institute of Technology, Bengaluru, India

Abstract:
Driver behavior considered an important factor in vehicle driver-environment system. Real driving monitoring system has a big role in increasing driving safety. Several factors effect on the behavior of the driver like the fatigue, distraction, experience, environment condition, vehicle condition, and so on. Improper driver behavior will lead to increase the probability of accidents occurring. So detecting driver behavior is one of interested research area. By identifying and distinguishing between normal driving and aggressive driving, driving monitoring system alert the driver about his dangerous driving. The driver can enhance his driving style and decrease accident occurring probability. The important factor in driving monitoring system is the accuracy of it. Different techniques have been used to identify driver behavior based on the objectives of each system. Sensors are the key factor of driving monitoring systems. This paper deals with discussion of several methods which have been proposed for detecting driver behavior and identify the advantages and disadvantages of each method.

Index terms: Monitoring Driver Activities, Computer Vision, Gaze Direction, Image processing, Head movement estimation, Driver assistance system.

I. INTRODUCTION

Road accidents impose serious problems on society in terms of human, economic, medical and environmental costs. As the World Health Organization (WHO) announced, the total number of road fatalities was approximately 1.25 million in 2016. To understand the various factors associated with fatal and non-fatal road accidents is very crucial. Intensive efforts have been made to understand human driving styles and the classification of drivers' risk patterns [2]. For example, the relationship between the sensitivity of the driver to complex driving situations and the vehicle control has been acknowledged as a major contributing factor in accidents. Driving patterns and their influence on environment and fuel-use were also well studied. In industry, automotive insurance companies integrate pay-as-you-drive or pay-how-you-drive modes for pricing. Based on driving aggressiveness, prices can be adapted to the individuals [1]. Moreover, characterizing driving behavior can be particularly helpful for the development of vehicle automation. Many studies on road safety have primarily focused on investigating factors associated with fatal and serious injuries and so less effort has been made on slight injuries or pre-crash scenarios mainly due to underreporting. This fact may lead to biased conclusions in injury control and safety management. Although this topic has attracted great attention in the past, there is still much to be investigated, for example, the dimensions of driving patterns and their potential influence on road safety [2].The aim of this paper handles the characterization of the behavior of drivers using only the sensors in a smartphone, avoiding the installation of additional hardware and allowing the prediction of the energy consumption of the user considering the captured driving style. It is the purpose of this work to develop systems for monitoring both driver gaze direction and driver activities using vehicle-mounted cameras. Classification of driver behavior considered as a complex issue because it is a multi-dimensional problem and is subjected to several peculiarities of driver and traffic state [9]. The traffic state is derived by group of variables like road conditions, vehicle kinematic and driver behavior all these factors can be described by a set of vague driving rules developed through experience for different drivers and conditions. Therefore, driver behavior recognition in terms of manoeuvres and tactics must be obtained. Different factors have to be considered to evaluate and recognize driving style such as environmental factors, road states and vehicle [11], events classification and identification [12] and biological and physiological status [10]. Building an accurate and complete model based on all these factors is difficult and also impossible in practice. In the last 10 years different commercial and research systems have been proposed to analyze the driver behavior and present systems to evaluate driver performance and assist drivers [13]. A common infrastructure all these systems are shared which is the driving monitoring system. Driving Monitoring Systems generally are classified into In-Vehicle Data Recording Systems and Real-time Monitoring Systems [14]. The rest of the paper is divided as sections of various methods used to determine the driving event detection and style classification of a driver followed by the conclusion of the paper.

II. RESEARCH WORK

Section 1: DROWSINESS DETECTION

[1]Yuichi Saito, Makoto Itoh, Toshiyuki Inagaki have described an assistance system which effectively prevents sleep related

accidents. They presented a multilayered assistance with dual control scheme which can help in reducing sleep related accidents.

- They mainly used sensors and micro-controllers.
- Major detection is to demonstrate the process of drowsiness detection.
- Color conversion from RGB to HSV model.
- Blob detection is observed (detecting region in digital image that range in properties like brightness or color as compared to surroundings).

[2] Proposed the designing of a driver assistance framework which allowed switching between manual and autonomous driving on a simulated test-bed. They proposed a framework for monitoring driver's state. If a driver is non-drowsy then he/she can manually control the simulated car. Otherwise it is run along the predefined trajectory by switching to autonomous driving. [3] Presented a survey which includes the techniques for detecting driver drowsiness by monitoring the driving pattern. A number of measures like subjective, physiological, behavioral and vehicular were used in this model. Among various behavioral measures the most precise and effective is head movement measure. Aleksander, Oge and Borko[4] discussed the process of designing and implementing driver drowsiness detection system by combining off-the-shelf the algorithm with some suitable approaches. The system is dynamic, user specific. The models created are totally based on driver's current features. [5] Proposed a driver alertness detection system depending on fatigue detection at the given instant. They used image processing algorithms to identify the position of eyes. They obtained visual cues by observing eye blink rate using camera which characterize the alertness level of a driver. [6] Illustrated the process of locating the eyes of a person to decide whether they are open or not. The system utilized the data which is in binary form obtained for the image to locate driver's face and eyes. They developed an unob structive driver drowsiness detection system to concentrate on eyes of driver. [7] Proposed an algorithm to monitor eye blink which uses eye feature points to determine the state of driver's eyes and activate an alarm if the driver is drowsy. This technique gives correct results when the camera used is of high resolution. They proposed an algorithm which is less complex than the Flares algorithm and gives same accuracy.

LIMITATIONS- The above section described the use of various algorithms and techniques to detect drowsiness of the driver, which showed only an accuracy of 75% without use of high tech camera and SVM methods.

Section2:DRIVER FACE DETECTION USING SENSORS AND ALERTNESS SYSTEM

The study carried by Liang (2009) show, differences in visual behavior and driving performance associated with different types of distraction was found by using different sets of sensors and algorithms. The algorithms for distraction detection are mostly based either on eye measures or on driver performance measures [9]. The research demonstrated by Dong in (2010) show, a real time tracking kernel for stereo cameras to estimate face pose and face animation, including the movement of the eyelid, eyeball, eyebrow, and mouth, for driver inattention detection. The technique proposed by Smith in (2003) was to analysis global motion and color statistics to robustly track a driver's facial features [11]. The study performed by Liang in (2007), uses decision tree technique to estimate driver cognitive workload from eye glances, and driving performance measures using Support Vector Machines (SVMs) and Bayesian Networks (BNs) to successfully identified the presence of cognitive distraction from eye movements and driving performance but, glances were sensitive to task complexity and visual demand (1999). Similarly, Chad in (2005) developed an Advanced Driver Assistance (ADA) to prevent driver from getting distraction due to the cell phone using Bayesian Networks. They used sensors /actuators to collect context information of both driver and vehicle [13]. The technique developed by Yulanin (2007) used support vector machines (SVMs), a data mining method, to develop a real-time approach for detecting cognitive distraction using driver's eye movements and driving performance data. This approach assessed the discrete state of cognitive distraction, but did not predict the continuous level of distraction. The approach carried out by Pohl in (2007) makes use of the driver's face vector which in principle was the detection of direction of the driver's nose tip, and eyeball detection to prevent the distraction [15]. An educational car system proposed by Sharon in(2005) was based on generalized layered architecture.It used different sensors and inducers like temperature, humidity, pressure, stress, car gear state, GPS and many more attached inside the vehicle. Based on the sensors, stress was measured on a driving activity such as driving in reveres or performing maneuvers such as changing lanes, turning etc. [19]. The key points of these above mentioned papers are to detect and capture the driver's position, behavior and activities through sensors and to provide alertness to the driver in order to avoid accidents and this is done using AI and mobile application.

LIMITATIONS- The above section even though it used the SVM and other algorithms could only detect driver's facial or visual features and report the problem and not both at the same time. Hence, the required hardware was more and less accuracy.

Section3: DRIVING GAZE DETECTION USING ML& EXTRACTION ALGORITHMS

Author Kamalpreet Kaur proposed gaze detection using visual information which are face tracking and face detection; both based on head movements and using Voila Jones algorithm based on ML is used to provide 90% accuracy. The object recognition and tracking with Eye state analysis is done using LBP operator and SVM method respectively [12].

Similarly, eyeball tracking was carried out through Block matching algorithm and Gabor ordinal measures images obtained from continuous streaming of the camera.

Face extraction is done in two steps—

- Cropping the detected face of the driver.
- Crop the region where the eyes are most likely located.
- Adaptive boosting algorithm is used for constructing a strong image.

Other proposed methods are using visual C++ and an application called Framework for processing video (FPV). Then, gaze classification using CNN, facial landmarks detectionby Dlib facial features tracker and PCCR vector calculation of left & right eye (comparison method).[14] Authors Paul Smith, Mubarak Shah, and N. da Vitoria Lobo[20] introduced an algorithm for initializing eye, skin, lip and head occlusion.

Figure.1. Lip tracking using NIR camera.

Figure.3. Eye and head tracking using camera.

Figure.4. Face tracker

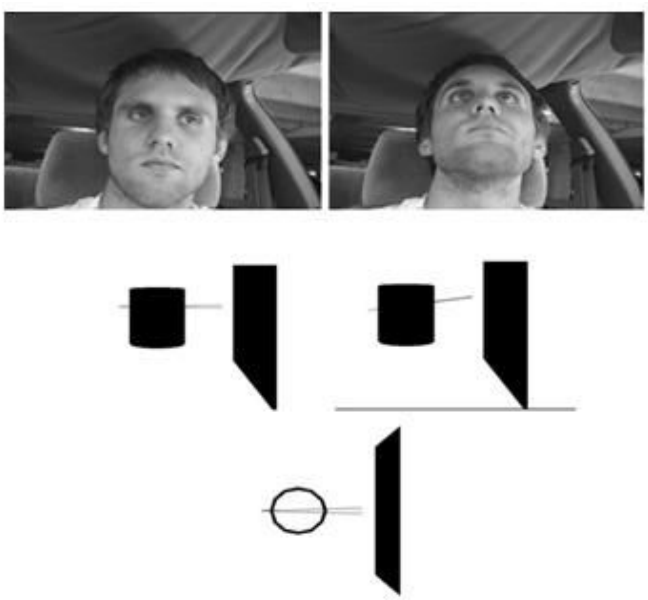


Figure.5. Eye blink tracker and acquiring 3D info.

Here the standard methods are used and the usage of color predicates, usage of single webcam or camera and reconstruction of 3D gaze using constant projection assumptions [22]. The above section describes the use of algorithms, which is a very efficient technique as errors are very low in number.

LIMITATIONS- The above section deals with usage of machine learning with other extraction algorithms which only gave 90% output with regard to characterization of driver's behavior and styles. Placing sensors to record particular parts of the driver wasn't working out and hence it gave rise to the idea of MEMS sensors.

Section4:DRIVING EVENT AND STYLE CLASSIFICATION

The application developed for this project [24] successfully finds the gaze direction of a driver 85% of the time. When errors did occur, the system never failed to find the gaze direction again and continue on. The software reports a history of the driver's gaze in real-time.

The Matlab tool could easily be used for a driver warning system similar to those in most fatigue detection systems. Whenever a driver's gaze seems fixated on a position other than the road, the system could warn the driver to pay attention [24]. Data recorders captured 5,675 events in the study1, of which 3,332 or 58.7% indicated unsafe driving with either an unsafe event or behavior. The study2 captured 6,671 events of which 5,448 or 81.7% indicated unsafe driving. The following table summarizes the event coding.

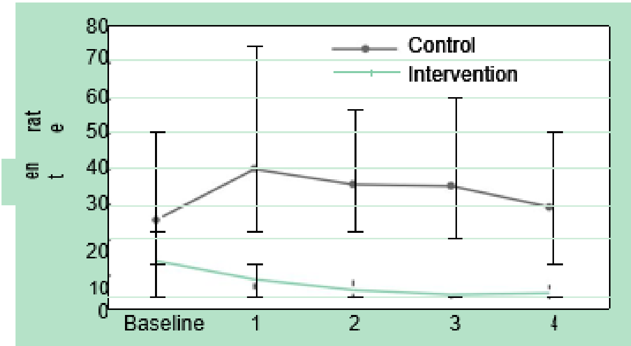
Summary of Previous Events by Event Type

Table.1. Driver event classification

	Study 1		**Study 2**	
	Events	**Percent**	**Events**	**Percent**
Unsafe event including crash and near-crash	2,542	44.8%	5,233	78.5%
Invalid event with unsafe Behavior	790	13.9%	215	3.2%
Appropriate response	69	1.2%	60	0.9%
Other invalid events	2,274	40.1%	1,163	17.4%
Total	**5,675**	**100%**	**6,671**	**100%**

Study 1

Relative to the baseline phase (first 4-week segment), the event rate for teens receiving feedback decreased over time. The average event rate during intervention segment 1 was lower than the baseline rate ($p< 0.05$), and segments 2, 3, and 4 were significantly lower than the rates during baseline and segment 1 ($p< 0.01$). During the intervention phase, teens receiving feedback had significantly fewer unsafe driving events than those in the control condition with an average of 6.1 unsafe events per 1000 miles driven versus 35.3 ($p<0.01$). Event rates for the video and non-video feedback groups did not differ significantly.



Study 2
The event rate for teens receiving feedback significantly decreased relative to the baseline for the two groups of drivers 16 and older (p<0.05), but there was not a significant difference for the group with the special minor's license. During the intervention phase, teens receiving feedback had significantly fewer unsafe driving events than those in the control condition across all three participant groups [24].

Table .2. Driver's style classification

Participant Group	Event Rate (Intervention)	Event Rate (Control)	P-Value for Difference
School	6.4	35.4	<0.01
Inexperienced	11.3	45.7	<0.01
Experienced	8.4	20.3	<0.05

III. CONCLUSION

The approach is to indulge a proposal that will overcome all the limitations of previous methods adopted and will provide us with an accuracy of 96% and many new additions to the driving style classifications and event detections. Each one of these techniques has its own strength and weakness points. The techniques of non-real time system are very important in training and feedback to the driver but it is not good in alert driver through his driving. In other hand, real driving monitoring systems need to several hardware devices with long processing time and high memory capacity. However, these systems have its own disadvantages like signal losing, large memory needed, and long-time processing. The development of smartphone, availability and cheap cost helped in enhancing and improving driver behavior monitoring systems by overcome all the obstacles faced in previous systems. With regard to a solution to the above limitations, a low cost sensor based low power driving style system based on image processing which is used as an instrument to measure the characteristics of the driver. The usage of Voila Jones algorithm along with the SVM methods for acquiring the characteristics of the driver and create a database using Machine Learning which keeps record of the detected information and is found more efficient and more suitable for the project. The database is saved in the cloud platform for futuristic references. Therefore the use of MEMS sensor as the main hardware and usage a high tech camera to perform continuous surveillance which helps in categorizing the style and characteristics of the driver using image processing techniques. For this purpose consideration of sample images of different driving styles and driver placement scenarios. After tracking and observing the positions of the driver hence it's possible to classify the drivers in various categories. For this purpose MATLAB software is most preferable and some algorithms along with machine language for creating the database were used. In addition to it, a proposal of system that identifies emergency vehicles and priority is given for such vehicles. As the whole prototype is connected to the cloud services an immediate notification can be sent to the respective authorities through a mobile application facility in case of an emergency situation as an indication of danger and alert.

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