

Intelligent Driver Safety System Using Fatigue Detection

Samra Naz*, Aneeqa Ahmed*, Qurat ul ain Mubarak*, Irum Noshin†

*Department of Computer Engineering, National University of Sciences and Technology, Islamabad, Pakistan.

samranaz81@ce.ceme.edu.pk, aneeqa.ahmed81@ce.ceme.edu.pk, qurat.ulain85@ce.ceme.edu.pk

†International Islamic University Islamabad.

irum.nausheen@iiu.edu.pk

Abstract—Driver safety systems protect driver from accidents by sensing signs of drowsiness. The main aim of this paper is to propose such technique that can detect the signs of drowsiness and make corresponding decisions to make him alert. This paper presents a technique in which the driver will be continuously monitored by a camera and his eyes, head and mouth movements will be observed. If the drowsiness signs are detected on the basis of these three movements under the predefined criteria, driver will be declared as sleepy and he will get alert with the help of alarms. Three robust techniques of drowsiness detection are combined together to make a robust system that can prevent form accident.

Keywords: drowsiness, fatigue detection, eye closure, yawn detection.

I. INTRODUCTION

Driver's Fatigue is a phenomenon that results in reduction of level of attentiveness of a driver [1]. It is very difficult in general to measure fatigue level with some direct methods but it can be measured indirectly using some features that give the signs of drowsiness. The methods include visual techniques so that they can be monitored by some camera or methods may include non-visual techniques like some physiological changes that can be monitored to check the driver's drowsiness level. Many accidents and car crashes have been occurred so far and are increasingly becoming very common day by day. Nowadays people are getting so much involved in work that they get exhausted and while driving this fatigue may lead drivers to unconscious sleep resulting into severe accidents. Such accidents are more dangerous because the driver is no more in his senses to reduce the speed or apply the brakes prior to collision. There are specific group of people that are at higher risk of causing an accident due to fatigue. It includes the young drivers, the shift workers and the drivers with sleep disorders. The drivers of heavy vehicles have also seen to be involved in such kind of accidents at very high rate [2]. Research shows that generally about 20% of the road accidents are caused due to fatigue and 30% resulted in fatal accidents due to drowsiness [3]. The accidents rate in which heavy vehicles are crashed due to increased level of fatigue is reported as 50% [4]. It has been reported in literature that many efforts have been made to devise such methods that can be helpful in reducing this cause of accidents. Many researchers have contributed by proposing methods of monitoring that can alert the driver on time thus prevent the accident due to his reduced

vigilance. Different approaches have been employed to analyze the driver's state of alertness. In [5]–[8] EEG based drowsiness monitoring has been done and similarly in [9] and [10] another physiological parameter i.e. ECG is has been used to track the driver's alertness. These techniques are very accurate and exact but they are not realistic because the sensors needs to be attached to the driver's body directly thus proving to be disturbing and annoying. Also using these sensors for long may decrease their ability of accurate monitoring. Driver's operation is another property that can be used in order to detect the drowsiness. In [10] steering wheel grip pressure is also monitored to track the driver's condition. Another method of monitoring the fatigue level of driver is to keep tracking the internal environment of the vehicle. When concentration of Carbon (30 ppm) and oxygen level reaches below 19.5% then alarm should be generated to make the driver alert [11]. In [10], [11] temperature difference of the vehicle is tracked to detect the alarming situation. The best opportunity that can be provided to a driver is to design a non-intrusive monitoring system that can work without interrupting the person during driving. Driver operation and vehicle behavior tracking are two non-intrusive techniques that can be used for this fatigue detection purpose but their limitation to vehicle type and driver condition does not make them a good parameter for measuring. Monitoring the response of the driver is considered to be the best applicable technique. It involves a periodic response of driver being sent to that analyzing system to indicate the level of alertness. One technique is to design such system that can monitor the driver continuously via camera and keep tracking the open eyes, if the eyes found close for a certain time then it would generate the alarm to make him awake [11]. Depending on the head movement of the driver, he can also be warned if an abnormal motion is detected [12]. Yawn is another parameter that is considered as an initial sign of drowsiness. Sever accidents can prevented if warning is generated at initial stage. In this paper, for the first time a fusion of three very robust techniques is implemented. The driver is monitored continuously and different level of drowsiness is observed. Initially if the driver yawns then by tracking his mouth it will be detected and an alarm will be turned on to make him attentive towards driving. The other type of fatigue is short burst of naps in which the driver's eyes remains close for few seconds. This eye closure can be very harmful. Sometimes

driver's head also starts leaning in extreme fatigue condition. Both conditions of eye closure and head movement are being monitored continuously and upon detection a vibrator under driver's seat will be turned on to make him awake. To make the technique more robust parallel monitoring of all the three parameters is taken into consideration. There exist total eight combinations of conditions using three parameters which are checked all the time using opencv in order to decide whether a driver is sleepy or not. If the driver is found sleepy, signal is sent to the hardware module for generation of required alarm in accordance with the detected drowsiness level. Figure 1 shows that how the proposed system works.

II. METHODOLOGY

This paper implements a technique in which drowsiness detection has been done by continuously monitoring driver's mouth, head and eyes at a time in order to implement a driver safety system.

A. Yawn Detection

Yawning is the mild stage of fatigue. A person yawns when he feels sleepy. To detect this state the driver is monitored all the time by a camera and his face is located in the frame continuously using haarclassifier in opencv. In each frame, face is extracted and then thresholding is applied to have a black and white image. For this conversion the best value for threshold was found empirically to be the minimum value as 24 and maximum as 255. In this frame there are mainly three black blobs. Two of the blobs represent the eyes and one at lower position is mouth area. To narrow down the computations for processing and keeping in view that the mouth is located in the lower portion of the face extracted area, the image is cropped and lower portion is extracted out having a black blob showing the lips of the driver. To check whether the mouth is open or closed the black pixels are counted. Figure 2 shows the pictures of mouth.



Fig. 2. Cropped mouth images (a)Closed Mouth (b)Open Mouth.

As it can be seen from the image that if the mouth is open then the size of black blob is increased thus giving large value of black pixels otherwise the value will be lower than the threshold. To increase the accuracy further another check is added at this stage that is if the value of black pixels which is found greater than threshold stays greater for some consecutive frames then it is declared as yawn. The block diagram in Fig. 3 shows the necessary steps that are required for yawn detection.

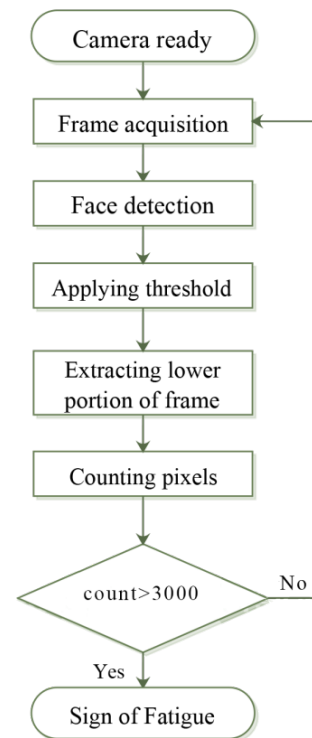


Fig. 3. Flow Chart for Yawn Detection

B. Eye closure detection

It is a natural phenomenon that when any individual feels sleepy his eyes start closing. In order to detect the drowsy state this important parameter can be detected. The technique proposes that while monitoring the driver continuously, the eyes of the driver are being detected and extracted. Haarclassifier is applied that detects the open eyes and highlight them by a rectangle. This rectangle is then extracted containing the eye portion. Figure 4 shows both the conditions.



Fig. 4. (a)Eye Detection and (b) Extraction from the frame

When the eyes are being detected continuously it simply means that eyes are open but for the consecutive frames of 4 seconds if the eyes are not being detected then it is an alarming situation and driver needs to get alert to avoid any hazardous situation. If this situation happens an indicator needs to be turned on. To do this a signal is transferred to the controller via serial communication that turns on the vibrator present on seat belt of the driver to make him awake. Following block diagram shows the important steps that are implemented for eye closure detection.

C. Head Movement Detection

Another sign of drowsiness is the leaning of head towards front side or the window side. When the eyes of the driver get

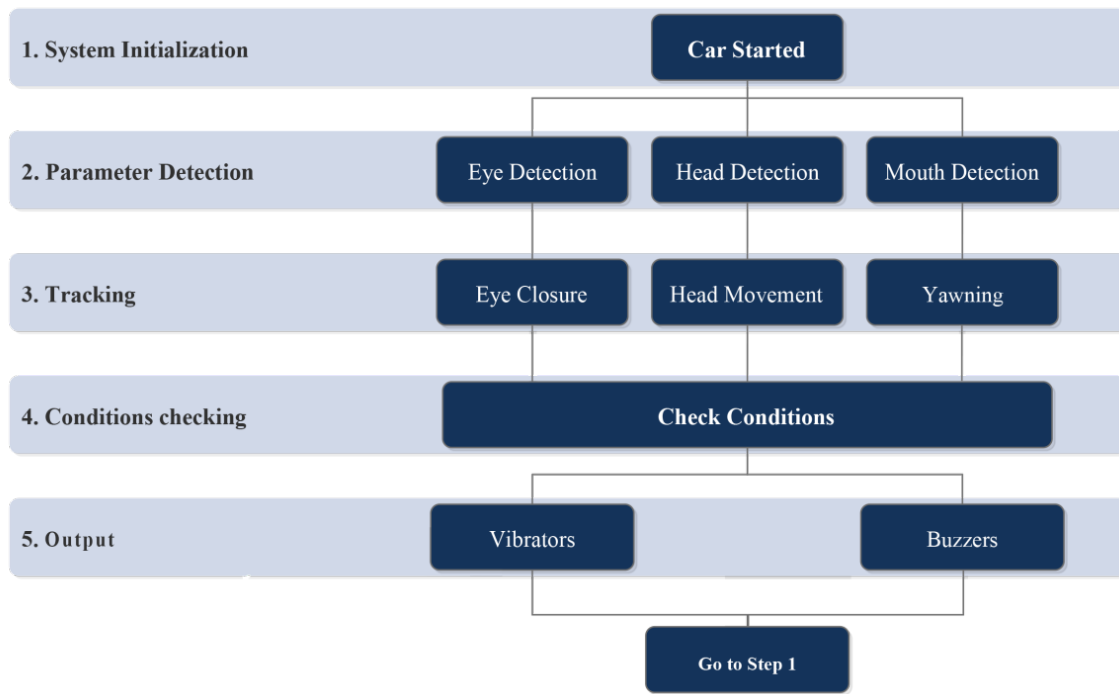


Fig. 1. Flow diagram of proposed methodology.

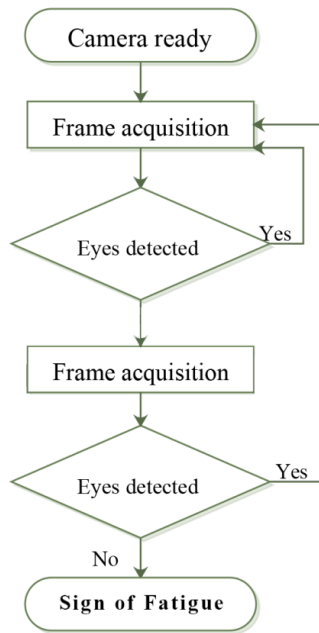


Fig. 5. Flow Chart for Eye Closure Detection

closed then it is observed that most of the time his head starts leaning down which is very dangerous situation. An alarm is badly needed in this case to make him alert. In this paper to cater this issue, first of all this state is detected by extracting the frame and then converting that into binary form. If any movement is done by the driver then this will be shown as the

white pixels on the black background as shown in the Figure 6.

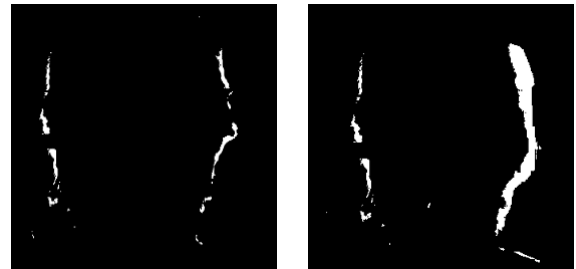


Fig. 6. Head Movement Indication

By taking the difference of two adjacent frames and the counting up the white pixels that appears due to movement can make us judge how much movement has been done. Counting up the white pixels helps us to measure that motion of the driver. A range of count of white pixels have been set, if the count of white pixels lies within the range of the threshold it indicates the driver is sleepy. Hence the signal is sent to the controller and vibrators installed under the seat are turned on to make him awake. Figure 7 shows a complete flow diagram for detection of head movement of the driver.

The threshold is kept so to avoid any kind of false detection. If the driver is just looking into the back view mirror, his movement will be slightly slow and it does not come under defined threshold. Also if he turns back, that abrupt movement will be so intense that also couldn't lie in our defined threshold. So our range will cater only those conditions that will be a true drowsiness state.

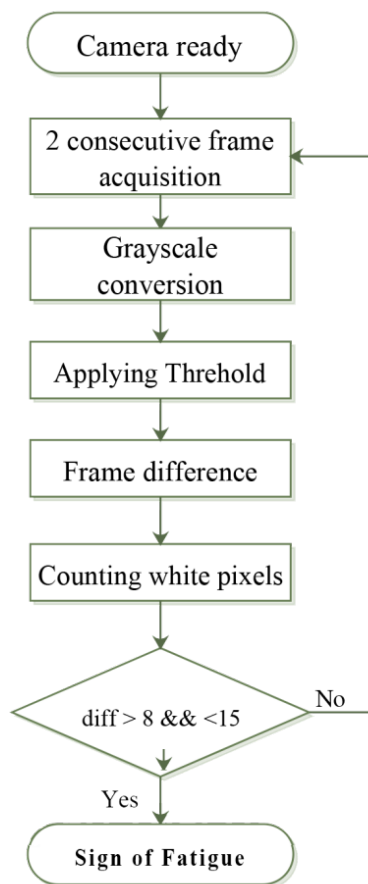


Fig. 7. Flow Chart of Head Movement

III. RESULTS AND DISCUSSION

For precise drowsiness detection all the possible conditions of three used parameters are determined every time and level of drowsiness is detected on the basis of combined results. Following table shows all the possible combinations and their corresponding outputs.

TABLE I
RESULT SUMMARY

Sign of Fatigue			Drowsiness Level	Output
Eye	Head	Mouth		
0	0	0	No Fatigue	No Alarm
0	0	1	Low	Turn on Buzzer
0	1	0	Invalid	No Alarm
0	1	1	Invalid	No Alarm
1	0	0	Mild	Turn on Vibrator
1	0	1	Low	Turn on Buzzer
1	1	0	High	Turn on Vibrator
1	1	1	Invalid	No Alarm

In the above table it can be seen that there are a total of eight combinations. Out of which three combinations are invalid because those conditions are not realistically possible. In drowsiness state a person's head get tilted but his eyes are not open then. Also while yawning the person is in conscious

state so head will remain straight. And the last condition is invalid because all the three parameters are not possible to occur at the same time. Among the valid states, the first condition continues to exist as long as the driver is awake so no alarm is generated in that case. There are four valid conditions for those the driver needs to get up by overcoming his sleepy condition to drive safely. From the table it can be seen that there are three levels of fatigue. When a person yawns, it is the initial stage of fatigue. A person can yawn whether his eyes are closed or open so when both of these conditions are detected a signal is communicated and a buzzer is turned on in the car to make the driver alert and concentrate on the driving. The mild stage of fatigue occurs when the driver's eye tends to close. If such condition is detected then the vibrator present on the seat belt of the driver is turned on to make him awake. If the driver's eyes are detected to be closed and his head tends tilt slowly then this is declared to be the most severe level of fatigue. For this alarming situation the vibrator on the seat belt is turned on to make the driver awake and also the back lights of the vehicle are turned on to alert other drivers on the road.

The three parameters including eye closure, head tilt and yawn along with all the possible conditions are monitored and checked for every likelihood. The required alarm is then generated on the basis of the severity of the fatigue level. Following plot is generated on the basis of all possible conditions and level of fatigue is determined.

In this plot the horizontal axis shows the possible combinations of eye, head and mouth movement. The vertical axis shows the level of fatigue. We have divided it into three levels low, mild and high. The yellow bars show the initial or low level of drowsiness detected when a person yawns. The magenta color bar is for mild fatigue and that is when the driver's eye tends remain close for few seconds. And for the severe condition that is when eyes are closed and head is tilted the bar is shown in the red color.

IV. CONCLUSION

Driver fatigue is one of the severe reasons due to which the rate of traffic accidents is increasing annually. We are proposing the technique of accident prevention that is caused due to driver's fatigue. Most of the research in this area that was carried out previously focuses only on one parameter at a time. Detecting fatigue with single parameter is not very efficient and accurate. This is a specialized technique because it is providing fusion of three different techniques for fatigue detection i.e. Head Moment, Eye Closure Detection and Yawning. It uses all of these parameters simultaneously to decide whether the driver is drowsy or not and hence draws conclusions on the bases of all of the three parameters. This precise technique continuously monitors driver for fatigue signs and alarm him if fatigue is detected in order to reduce the risk and danger of accidents for drivers. Further this technique can be enhanced to allow different light intensities backgrounds as a workable range and automatic parking feature can also be incorporated with the help of automated

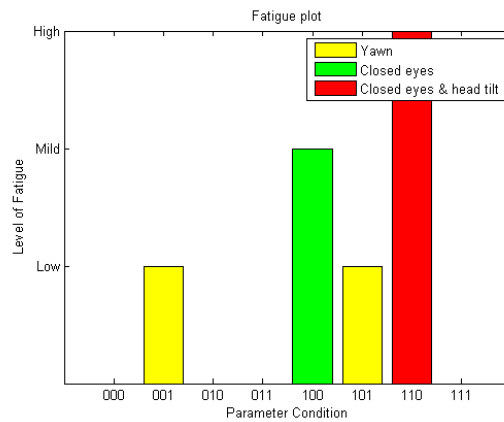


Fig. 8. Fatigue Plot.

braking system which will control speed of cars in case of danger and hence reduces risk of accidents.

REFERENCES

- [1] Ernest B Perry, Eric Oberhart, Steven Wagner, and Mid-America Freight Coalition. Truck parking management systems. 2015.
- [2] Qiang Ji, Zhiwei Zhu, and Peilin Lan. Real-time nonintrusive monitoring and prediction of driver fatigue. *IEEE transactions on vehicular technology*, 53(4):1052–1068, 2004.
- [3] Mohamad-Hoseyn Sigari, Muhammad-Reza Pourshahabi, Mohsen Soryani, and Mahmood Fathy. A review on driver face monitoring systems for fatigue and distraction detection. 2014.
- [4] Megan Bayly, Brian Fildes, Michael Regan, and Kristie Young. Review of crash effectiveness of intelligent transport systems. *Emergency*, 3:14, 2006.
- [5] Vandana Reddy. Eeg based drowsiness detection using mobile device for intelligent vehicular system.
- [6] Chin-Teng Lin, Ruei-Cheng Wu, Sheng-Fu Liang, Wen-Hung Chao, Yu-Jie Chen, and Tzzy-Ping Jung. Eeg-based drowsiness estimation for safety driving using independent component analysis. *IEEE Transactions on Circuits and Systems I: Regular Papers*, 52(12):2726–2738, 2005.
- [7] Zahra Mardi, Seyedeh Naghmeh Miri Ashtiani, and Mohammad Mikaili. Eeg-based drowsiness detection for safe driving using chaotic features and statistical tests. *Journal of medical signals and sensors*, 1(2):130, 2011.
- [8] Muhammad Awais, Nasreen Badruddin, and Micheal Drieberg. Driver drowsiness detection using eeg power spectrum analysis. In *Region 10 Symposium, 2014 IEEE*, pages 244–247. IEEE, 2014.
- [9] Aihua Zhang and Fenghua Liu. Drowsiness detection based on wavelet analysis of eeg and pulse signals. In *Biomedical Engineering and Informatics (BMEI), 2012 5th International Conference on*, pages 491–495. IEEE, 2012.
- [10] Elena Rogado, José Luis García, Rafael Barea, Luis Miguel Bergasa, and Elena López. Driver fatigue detection system. In *Robotics and Biomimetics, 2008. ROBIO 2008. IEEE International Conference on*, pages 1105–1110. IEEE, 2009.
- [11] K Galatsis, W Wlodarski, YX Li, and K Kalantar-Zadeh. Vehicle cabin air quality monitor using gas sensors for improved safety. In *Optoelectronic and Microelectronic Materials and Devices, 2000. COMMAD 2000. Proceedings Conference on*, pages 65–68. IEEE, 2000.
- [12] Abhi R Varma, Seema V Arote, Chetna Bharti, and Kuldeep Singh. Accident prevention using eye blinking and head movement. *IJCA Proceedings on Emerging Trends in Computer Science and Information Technology-2012 (ETCSIT2012) etcsit1001*, (4):31–35, 2012.



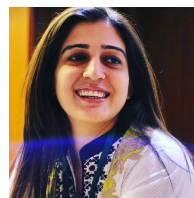
Samra Naz was born in Talagang, Pakistan. She received her BS degree in the field of Electronic Engineering from International Islamic University in 2014. She is currently enrolled in MS program in the field of Computer Engineering at National University of Sciences and Technology Islamabad, Pakistan. Her area of interest is Image Processing specifically Medical Imaging. Currently she is working as a Lab Engineer at Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan.



Aneeqa Ahmed was born in Wah Cantt, Pakistan. She received her BS degree in the field of Electronic Engineering from International Islamic University in 2014. She is currently enrolled in MS program in the field of Computer Engineering at National University of Sciences and Technology Islamabad, Pakistan. Her area of interest is Image Processing.



Qurat-ul-ain was born in Wah Cantt, Pakistan. She received her BS degree in the field of Electronic Engineering from International Islamic University in 2014. She is currently enrolled in MS program in the field of Computer Engineering at National University of Sciences and Technology Islamabad, Pakistan. Her area of interest is Image Processing.



Ms. Irum Noshin was born in Rawalpindi Pakistan. She received her BS degree in the field of Software Engineering from Fatima Jinnah Women University Rawalpindi, Pakistan in 2006. She has received her MS degree in the field of Computer Engineering from University of Engineering and Technology Taxila, Pakistan. She is currently pursuing her PhD degree in the field of Computer Engineering. She is in research phase. Her main areas of interests include image processing, mobile ad hoc networks and tactical networks. She is currently working as a

Lecturer in Department of Electronic Engineering, Faculty of Engineering and Technology, International Islamic university, Islamabad, Pakistan from 2009 to date.