A Novel and Efficient Real Time Driver Fatigue and Yawn Detection-Alert System

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***Abstract*—Fatigue among drivers is a major cause of road accidents every year in India. Lack of sound sleep for six to eight hours is one of the primary reasons behind this fatigue. Drivers with sleep deprivation can imbalance the reaction time and decision making when behind the wheels and this can increase the cause of accidents. This type of accidents is more likely to result in death or severe injury as they tend to be in high speed and because of the fact that driver has fallen asleep cannot apply brake or skew to avoid or reduce the impact. Therefore, it is highly essential to create a smart system which can spot and alert the driver of his/her condition. Although there are few solutions proposed in this direction, most of them have not been implemented successfully and many of them only remain in theory. In this research paper, we propose an efficient driver fatigue detection and alert system using mainly open source technologies. We implement and test this system in real time and the results are highly encouraging compared to many existing systems.**

Keywords*— *Alert Systems; Driver Fatigue Detection; Real Time Solution; Smart Vehicular Systems; Yawn Detection

I. INTRODUCTION

Fatigue is an intense tiredness brought about by not having enough sleep over a specific period of time due to mental or physical strain or sickness. Each individual is required to have six to eight hours of good quality sleep each night. Many times people are unable to achieve this average time of sleep due to many activities. Many sensitive activities like driving requires good mental fitness and high level of alertness. Drivers with sleep deprivation can imbalance the reaction time and decision making when behind the wheels and this can increase the cause of accidents. At high speed, the crash is more likely to cause death or serious injury. Traffic surveys shows that 20% of road accidents are due to driver fatigue. So it is highly essential to have a smart and economically feasible system that can detect and alert the driver and prevent the damages.

The main purpose of this efficient and smart fatigue detection with alert system is to reduce the number of fatigue related road accidents. The first phase of this project is drowsiness detection module which is implemented using a camera placed near the driver. Detecting the eye region of the driver is very important for the project and is done in OpenCV. A 8 mega pixel camera is installed to receive the real time video of the driver. The captured video is handled by Raspberry pi. The algorithm is processed with Python. Closed eye and yawn is detected using Haar cascade classifier with Eye Aspect Ratio parameter and Mouth Aspect Ratio parameter respectively. Multiple checking with the database of positive and negative value of images is carried out and returns a white shade area around the eye region and mouth region on matching. Eye Aspect Ratio is calculated and if it jumps above a calculated threshold value for some predefined frames, then Raspberry pi produces a loud alarming noise which is used to wake up the sleeping driver. Similarly Mouth Aspect Ratio is calculated and if it crosses a predefined threshold for a predefined count, which indicates that there is a chance for the driver to fell asleep, then Raspberry pi sends an alert message to the car owner indicating the same.

Crashes caused by tired drivers are most 1ikely to happen around 2 am to 6 am. Most of the existing systems lacks proper detection of eye region at night time; proper detection of eye region is very necessary for fatigue detection or else the whole system is of no help. One of the major limitations with the existing system is with the mouth aspect ratio parameter which is used for detecting the yawn. The Mouth Aspect Ratio is calculated and if it crosses a predefined threshold for a predefined count, then Raspberry pi sends an alert message to the car owner. The camera mistakes speaking for yawn, this can also trouble the driver. In order to overcome these issues one efficient method is to use 4K ultra HD night vision cameras. This camera helps to properly calculate the eye aspect ratio even at night, which helps in proper fatigue detection.

The next section discusses few existing works in this research direction and highlight their limitations. Further the proposed system is discussed in detail in section 3 and the results are presented in section 4. In the last section we conclude and also put forward few future research directions in this area.

II. Related Works

This section discusses few of the related works done in this research area. The issues and limitations with the existing systems are highlighted in this section.

A. Fatigue detection using Partial Least Squares Regression-Based Fusion Model [1]

Fatigue detection system with multiple eyelid movement technique is proposed by Su and Zheng in 2008. The method uses Partial Least Squares Regression parameters to manage the issue of strong collinear connections among eyelid movement attributes. Thus, it predicts the propensity of drowsiness. The model provides a framework for integrating several sleepiness features together to predict the result.

B. Effective drowsiness identification with infrared illumination [2]

Automatic driver fatigue detection system with a module for an advanced driver assistance system helps to reduce the rate of fatalities. Artificial intelligent techniques are employed to summon the visual information to discover, trail and analyze both the drivers face and eye region to detect distraction and drowsiness. This system is also adapted to work in night also.

C. *A Dedicated System for Monitoring of Driver's Fatigue [3]*.

A new real time system was proposed by Spurjeon and Bahindwar in 2012 for monitoring video sequences of a driver and estimating his/her level of attention. The system deals with the calculation of Percent of Eyelid Closure (PERCLOS) for detecting drowsiness. Estimating the Driver's attention level, and issuing an alert alarm when the driver is not paying enough attention to the road is a good way to reduce the rate of road accident caused by driver factors. Visual information is received using specially designed CCD Camera with an IR illumination. The system is automatic and estimates eye position, eye closure and the gape of the eyes. It utilizes eye detection and face detection to locate the position of driver's eyes. An object locating method is used to track the position of the eyes. And finally we can estimate the fatigue state of the driver. Many video processing systems are available to assist these systems [4]

D. Fatigue detection system based on yawning estimation [5].

This fatigue detection system is based on the driver's level of attention and issues an alert if the fatigue of the driver is consequential. This assistive system was proposed in 2013. The system introduces different methods to detect fatigue based on yawning computation. Three approaches are adapted in the system that involves several steps, including the continuous identification of the driver's face, mouth and yawning. The proposed system can efficiently monitor the yawning state as a sign of driver's drowsiness.

E. Driver monitoring and event detection system [6].

This system works on 3-D information from a range camera is another system that was proposed by Peláez et. al in 2014. Here 2-D and 3-D techniques are combined to give head pose estimation and regions of interest detection. Based on the provided cloud of 3 dimensional points from the sensors and examining the 2-D projection, the marking with respect to the head position are estimated and extracted for additional analysis. Later, the head position analysis with three degrees of freedom known as Euler Angles is estimated based on the repetitive nearest points algorithm. Further, the important regions of the face are estimated and is utilized for additional evaluations. Many researches have been carried out in this direction in recent years [7-11]. Most of the existing systems suffered from few limitations especially in terms of accuracy of detection and delay in sending the alarm. Also many systems remaining as theoretical proofs and were not successful in practical implementation. Currently researches are conducted using the power of Internet of Things [12-13], Video Processing and Vehicular Fog computing [14-15] to bring out more efficient detection and alert systems. Our proposed system utilizes few of the advantages from the above mentioned areas and provide a real time implementation of fatigue and yawn detection and alert system that would help drivers avoid numerous accidents.

III. Proposed System

Fatigue detection of drivers, the most important factor is a smart monitoring to determine whether he/she is fatigued. In the proposed method, the image of the driver is acquired by the webcam for processing. The images are captured using the camera which is installed in front of the driver on the dashboard of the car.

We then use this input to determine how long the eyes have been shut for. If the eyes have been shut for a definite duration, we will presume that the driver is starting to drowse off and the system will issue an alarm to awake him/her up and to seize attention. We also have included yawn detection in the system. If the yawn count has crossed a certain threshold, our system sends an alert to the owner indicating the chances of the driver falling asleep.

Face detection is done by the Haar algorithm proposed by Viola and Jones in 2001. This is based on machine learning. A special function is conditioned using negative and positive images. Open CV holds several pre-trained classifiers for face, eyes, smiles, etc. For our system we have created an eye and mouth detector. When the face is detected, the facial landmark identification is employed to draw out the eye region and mouth region of the driver. As we have the eye regions, we calculate the Eye Aspect Ratio (EAR), which is the ratio of distance between the vertical and horizontal eye landmarks.

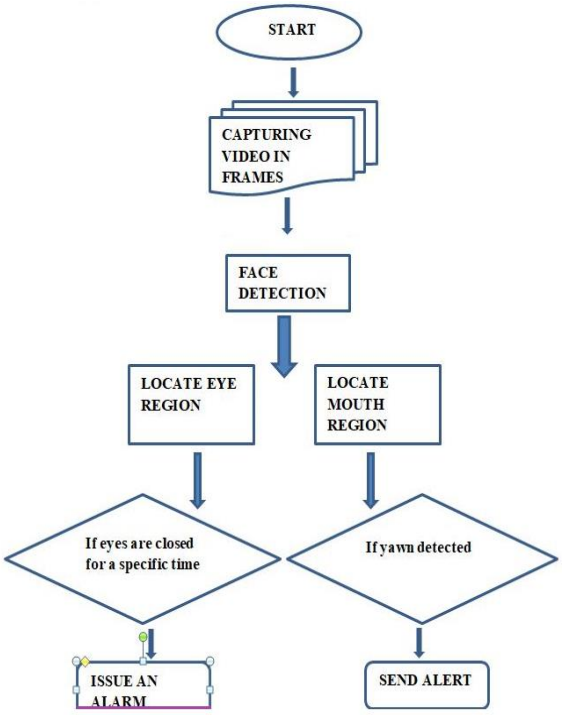

Fig. 1. Architecture of the proposed system.

Figure 1 illustrates the architecture of the presented system Figure 2 and 3 depicts the Eye Aspect Ratio, that is employed to determine the ratio of vertical and horizontal eye landmarks; if constant indicates that the eye is open, if it changes rapidly and then to a zero value, this indicates that a blink has occurred. The presented system identifies the Eye Aspect Ratio to observe if the value drops to zero and does not increases again, confirming that the person has closed their eyes and fatigue is being detected.

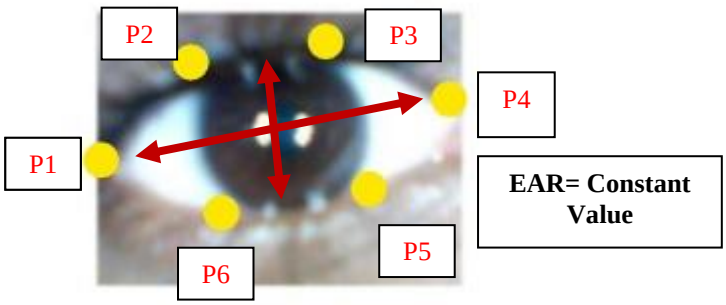

Fig. 2. EAR estimated on open eye.

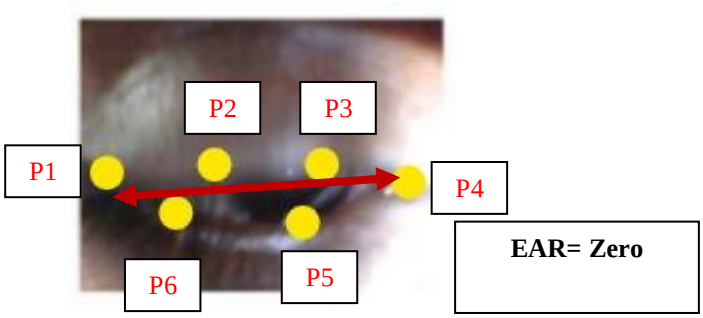

Fig. 3. EAR estimated on closed eye.

In the presented system, if the EAR goes under the predefined value, the number of frames the person had closed their eyes for is counted. If this value exceeds a predefined frame count, our program sends an alarm to alert the driver. In our proposed system, the consecutive frame count we have set is 48, that is, if the person has closed their eyes for 48 consecutive frames, the system will play an alarm.

Mouth Aspect Ratio is calculated to identify whether the driver is yawning. The facial landmark detection is used to extract the mouth region of the driver. Mouth Aspect Ratio (MAR) is the ratio of distance between the vertical and horizontal mouth landmarks, using which we can detect whether the driver is yawning. If the yawn has crossed a predefined count, our program sends an alert message indicating the chances of the driver falling asleep. Figure 4 and 5 shows the estimated Mouth Aspect Ratio for closed and open mouth

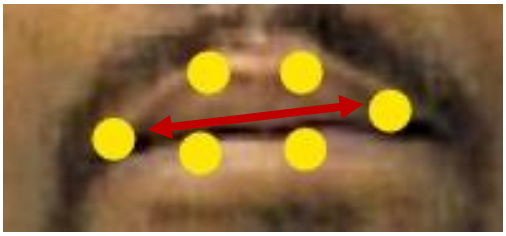

Fig. 4. MAR estimated on closed mouth.

Fig. 5. MAR estimated on open mouth(yawn).

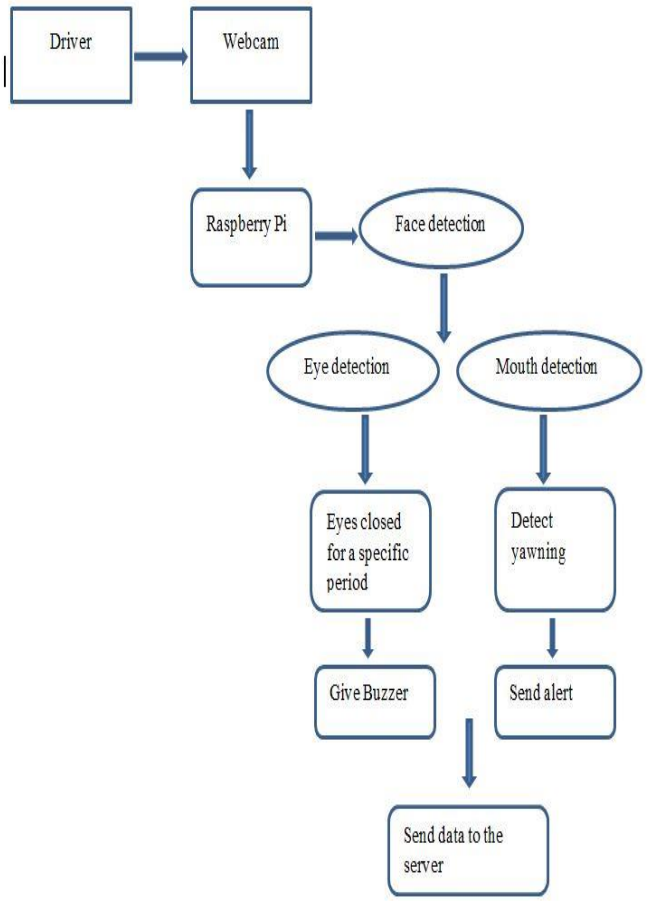

Fig. 6. Driver Alert System

Figure 6 depicts the overall working of the driver alert system. and Figure 7 depicts the hardware set up of the proposed system. The entire drowsiness detection program starts to run when the driver starts the vehicle and it can be stopped with the command line interfaces in Raspberry Pi 3 or when the system is switched off. On the detection of drowsiness, the system cautious the driver by issuing an alarm to ensure vigilance.

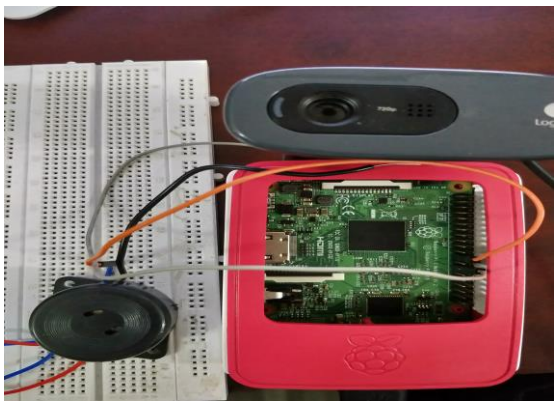

Fig. 7. Hardware set up of the system

IV. Results and Discussion

Fatigue is calculated by detecting Eye and Face Haar Cascade Classifier and also using facial landmarks and Eye Aspect Ratio which is estimated with the Euclidean distance between the eyes. When Eye Aspect Ratio crosses a predefined threshold, our program will issue an alarm to awake the driver from sleeping state. Figure 8 and 9 shows the EAR and MAR detection on open eye and closed eye respectively.

Fig. 8. EAR and MAR detection on open eye.

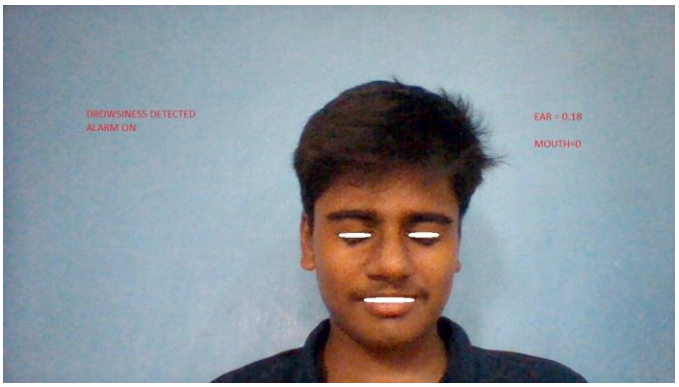

Fig. 9. EAR and MAR detection on closed eye.

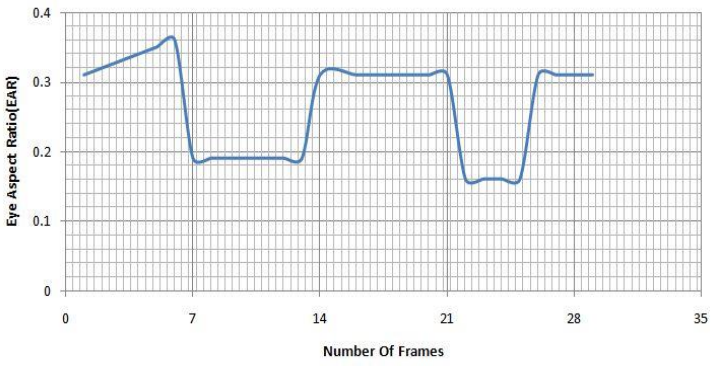

Fig. 10. Graphical representation of EAR.

Figure 10 shows the graphical representation of EAR estimation. The bottom steep denotes blink state of the driver, and if the driver's eye is closed for some consecutive frames, then our program issues an alarm to awake the sleeping driver. In the proposed system Mouth Aspect Ratio is calculated in order to detect yawn. If the Mouth Aspect Ratio crosses a threshold value of then the yawn is detected. If the driver is found to yawn for a count of 4, our system issues an alert message to the owner of the car indicating the chances of the driver falling asleep.

V. CONCLUSIONS

This paper presented the design and analysis of an efficient and smart driver fatigue detection system. The proposed system is used to avoid road accidents created by human factors such as drowsy driving. It also helps the driver to stay awake during driving by generating an alert as soon as the driver is feeling sleepy. The Raspberry Pi module along with Camera is used to monitor the drowsiness of the driver in real time. Fatigue is detected with face, eye and mouth using Haar Cascade Classifier, and also with the use of facial landmarks and Eye Aspect Ratio by estimating the Euclidean Distance between the eyes and mouth. During the monitoring, the system is able to detect if the eyes are closed or open. When the eyes have been closed for a specified period of time, the system issues an alarm. Our system also implements the detection of yawn. If the yawn count has crossed a predefined number, the system sends an alert message to the owner of the car indicating the chances of the driver falling asleep. The system implemented in real time gave highly accurate results and promises a reliable fatigue detection.

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REFERENCES

[1] Hong Su and Gangtie Zheng, "A Partial Least Squares Regression-Based Fusion Model for Predicting the Trend in Drowsiness", IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, vol. 38, no. 5, pp. 1085-1092, 2008.

[2] M. Flores, J. Armingol and A. de la Escalera, "Driver drowsiness detection system under infrared illumination for an intelligent vehicle", IET Intelligent Transport Systems, vol. 5, no. 4, pp. 241-251, 2011.

[3] A K.Subhashini Spurjeon and A Yogesh Bahindwar, "A Dedicated System for Monitoring of Drivers Fatigue", International Journal of Innovative Research in Science, Engineering and Technology, 2013.

[4] J. Alzubi, S. Jacob, V. G. Menon, S. Joseph and P. G. Vinoj, "A Top-Up Design for PAL to VGA Conversion in Real Time Video Processing System," 2018 International Symposium on Advanced Electrical and Communication Technologies (ISAECT), Morocco, 2018, pp. 1-5.

[5] S. Abtahi, B. Hariri and S. Shirmohammadi, "Driver drowsiness monitoring based on yawning detection," 2011 IEEE International Instrumentation and Measurement Technology Conference, Binjiang, 2011, pp. 1-4.

[6] G. A. Peláez C., F. García, A. de la Escalera and J. M. Armingol, "Driver Monitoring Based on Low-Cost 3-D Sensors," in IEEE Transactions on Intelligent Transportation Systems, vol. 15, no. 4, pp. 1855-1860, Aug. 2014.

[7] W. Zhao, R. Chellappa, P. J. Phillips, and A. Rosenfeld. 2003. Face recognition: A literature survey. ACM Comput. Surv. 35, 4 (December 2003), 399-458

[8] C. Scharfenberger, S. Chakraborty, J. Zelek and D. Clausi, "Anti-trap protection for an intelligent smart car door system," 2012 15th International IEEE Conference on Intelligent Transportation Systems, Anchorage, AK, 2012, pp. 1734-1740.

[9] Nan-Ning Zheng, Shuming Tang, Hong Cheng, Qing Li, G. Lai and F. -. Wang, "Toward intelligent driver-assistance and safety warning system," in IEEE Intelligent Systems, vol. 19, no. 2, pp. 8-11, March-April 2004.

[10] Sukanesh, R & Vijayprasath, S. (2013). Certain Investigations on Drowsiness Alert system based on Heart Rate Variability using LabVIEW. Transactions on Information Science and Applications. 10. 368-379.

[11] A. M. Malla, P. R. Davidson, P. J. Bones, R. Green and R. D. Jones, "Automated video-based measurement of eye closure for detecting behavioral microsleep," 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology, Buenos Aires, 2010, pp. 6741-6744.

[12] Philip V, Suman VK, Menon VG, Dhanya KA. A Review on latest Internet of Things based Healthcare Applications. International Journal of Computer Science and Information Security. 2017;15(1):248.

[13] Rajesh S, Paul V, Menon VG, Khosravi MR. A Secure and Efficient Lightweight Symmetric Encryption Scheme for Transfer of Text Files between Embedded IoT Devices. Symmetry. 2019 Feb;11(2):293.

[14] V. G. Menon, "Moving from Vehicular Cloud Computing to Vehicular Fog Computing: Issues and Challenges", International Journal on Computer Science and Engineering, vol. 9, no. 2, pp. 14-18, 2017.

[15] V. G. Menon and Joe Prathap. "Vehicular Fog Computing: Challenges Applications and Future Directions." In Fog Computing: Breakthroughs in Research and Practice, pp. 220-229. IGI Global, 2018.