Driver Drowsiness Alert System

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***Abstract*—The research aims to detect the onset of drowsiness of drivers, while the vehicle is in motion. Detection is done by continuously looking out for symptoms of drowsiness, while considering physical signs. Physical cues including yawning, drooping eyelids, closed eyes and increased blink durations. Once the system detects that the driver is drowsy by using a combination of these factors, it alerts the driver across multiple stages depending on the severity of the symptoms.**

***Keywords*-drowsiness; yawning and eye recognition; alerting**

I.INTRODUCTION

The human body cycles between REM (Rapid Eye Movement) sleep and NREM (Non-Rapid Eye Movement) sleep. There are three phases of non-REM sleep. Each stage can last from 5 to 15 minutes. We generally go through all three phases before reaching REM sleep. Cases were found in vehicles, wherein the driver did not realize the onset of REM sleep and the subsequent loss of concentration in the drivers lasting for fractions of seconds, led to fatal accidents. The symptoms of fatigue are generally manifested during long distance continuous driving and infrequent breaks make the driver susceptible to feel drowsy. These symptoms can be physically observable such as yawning and drooping eyelids. The longer the driving session, more severe are the symptoms of fatigue and this fatigue sharply climbs with increasing hours behind the wheel.

Our system attempts to solve this problem by continuously monitoring the driver, once initial signs indicate that he is drowsy and this intense monitoring continues till the end of the driving session. Research has been going on to prevent such mishaps using various methods so far. Here, we attempt an approach where we take into consideration the physical factors of the person driving to determine the state of the driver. We intend to alert a fatigued driver in varied stages, depending on the level of drowsiness and provide him with an indication to pause his driving, till the symptoms of drowsiness subsides. The alerts are voice based and the gentleness and persuasion varies according to the stage of alert.

In order to accurately capture the symptoms, we capture the driver's face and analyse the eyes for closure or droopiness and monitor the mouth region for yawns. The system uses OpenCV along with the Haar-Cascade classifiers and Dlib to detect eyes and isolate the mouth region.

This approach was chosen as Haar-Cascade classifiers enable real-time face detection and thus enabling sampling of live media.

Section II deals with the related work done in the field till now and clarifies how our system addresses the existing pitfalls. In Section III, the architecture of the system used to study the drowsiness in drivers and the alerting and warning systems are described. The algorithm description, the methodology used to obtain Drowsiness is explained in Section IV. After that, experimental results obtained are depicted in Section V. Finally, the conclusion and future work is presented in Section VI.

II.RELATED WORK

Currently, there are existing systems which detect drowsiness based on physiological cues separately. For instance, an attempt was made to study the pressure of a driver's hand on the steering wheel in order to detect fatigue. This factor could vary for drivers, and this could yield wrong results. Many such approaches include monitoring of factors such as the eyes of the driver, their EEG readings, lane following pattern of the car etc. and the data obtained were subjected to pattern recognition and other such learning methods. However, since these factors were individually considered, the rate of accuracy was relatively low. Our system introduces a yawn detection mechanism so that all factors are considered in varied stages, before arriving at a conclusion that the driver is sleepy.

Volkswagen adopted a similar alert system to ours, but threat triggering mechanism triggers only when the car goes beyond 65 km/h. We intend to have a constantly running system because Drowsiness is known to cause accidents even in slow moving traffic. Fujitsu released a wearable sensor device that detects driver drowsiness based on pulse.

III.ARCHITECTURE

As shown in Fig. 1, the system is primarily composed of three components: External hardware, the data processing system and the alert module. The hardware communicates with the rest of the system over a USB port. The alert module and the data processing modules, though discrete, communicate with each other over function calls.

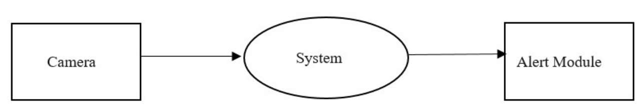


Figure 1. Architecture of the system

A. Alert Module

The system provides a different stages of alert depending on the severity of the parameters.

1) When the video camera detects yawning, the system warns the driver that he is drowsy by playing a pre-recorded warning.

2) When the camera detects drooping eyelids, eye closure etc., and the driver is warned insistently and the warning is continued till the driver is alert again. The video camera is used to ensure that the alert continues till the driver is aware.

B. Graph

The values of EAR and MAR are represented in a graphical form and displayed to the user at the end of the driving session.

IV. METHODOLOGY

The system uses a physical factor to gauge if the driver is drowsy.

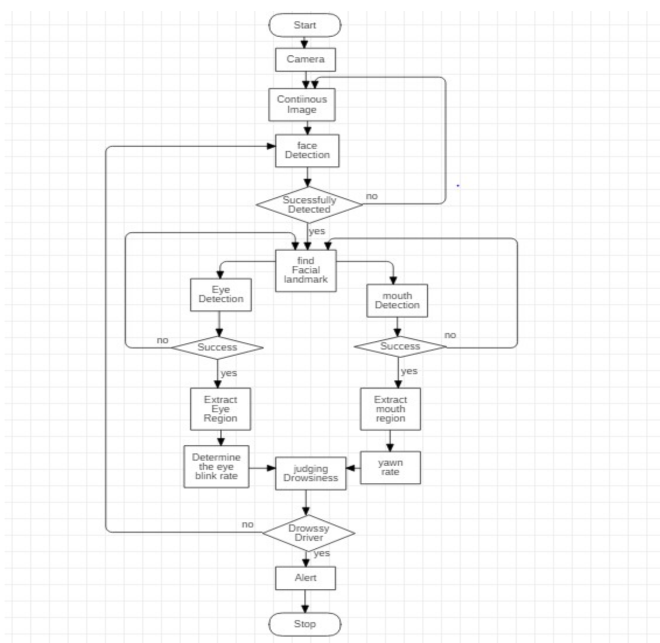


Figure 2. Overview of the driver Drowsiness Alert system

The system employs anomaly detection to detect if the values are deviating from the established norm for the driver. Depending on the severity of the symptoms, the system uses a staged alert to warn the user. The data obtained are used to plot a graph at the end of the driving session

B. Physical Monitoring

i) Blink detection

In a life critical system such as the one being described here, minimal latency is desired. Taking this requirement into consideration, we have chosen the Viola and Jones algorithm to detect the face. This algorithm was chosen because it enables face detection in real time and is highly robust. Once the face is detected, the region of interest is extracted where the eyes would approximately lie. The system then uses Haar-Cascades and Dlibto detect the presence of eyes in the region isolated. This is a tried and tested model and rather than implement our own model, a decision was made to use it. Detection is done by dividing the image into several sub windows and scanning each window for potential features of a face. To find Blink Detection EAR(Eye Aspect Ratio) is calculated, If EAR is Less then threshold then consider as eye is closed else open. Thus knowing whether the eye is open at any given point of time, allows us to identify blinks.

Additionally, the driver might frequently move his head and thus situations can arise where we are unable to detect the face or only one eye, under illumination, is detected while the other eye is not. In this case, the system issues a spoken warning that the face is not detected. This warning is sounded every three seconds and stops as soon as the driver's face is detected again.

As for the scenario where there is minimal lighting within the vehicle due to tinted windows etc. or driving during the night, we can instead use a night vision camera, thus enabling the system to function optimally.

ii) Yawn detection

The algorithm to detect yawning is as follows:

1. First Histogram-equalize the image obtained so that it works with any skin tone and then detect the driver's face using the Viola-Jones face detecting algorithm.
2. Select a region of interest (ROI) within the detected face, within which the mouth is likely to be located and Then Calculated MAR(Mouth Aspect Ratio)
3. Check MAR with Threshold Value if MAR is Greater than the threshold value for a particular time help us to find yawn detection. If it's large, then the mouth is open. If it's small, then the mouth is closed.

Since there is a possibility that the driver talking might also be inaccurately classified as a yawn due to the open mouth, the algorithm also monitors the time duration the mouth stays open. Studies have shown that the average duration of a yawn lies between 3 to 6 seconds and we have chosen 4 seconds as the threshold to indicate a yawn.

C. Alerting

The alerts are classified into following categories depending on the severity of the symptoms. A multi-stage alert is in place because if we were to trigger the highest level of alert upon a false positive like a slightly longer duration blink, the driver might get disturbed and deactivate the system.

1) *Stage I alert:* This alert is triggered when mild symptoms indicate that the driver is potentially sleepy. These symptoms include yawning detection returning true. This will produce an output audio as “sir! please take some rest”.
2) *Stage II alert:* Stage II alert is a more severe form of alert. It is triggered when the system, while continuously monitoring the driver’s eyes detects that the eyelids are drooping, or the blink duration of the driver exceeds the threshold. These alerts are triggered every time the system senses the aforementioned symptoms. This will give an output audio as “sir! please stop the car, your eyelid drops has crossed the threshold value”.
3) Stage *III alert:* alert is triggered as soon as a long dropping of eyelids is detected. This will alert give an audio output audio as “sir! Wake up”.
4) Stage *IV alert:* alert is triggered as soon as a long nap is detected. It will give an audio alert as an output as “Head position is not stable”.
5) *Stage V alert:* Stage V alert is the most severe form of alert. It is triggered when the system, passes through all the Alerts.If the driver does not stop driving, then a harsh alarm is triggeredalong with a message sent to their family members.

V.RESULTS

Significant amount of usability testing and experimentation was done on the prototype under different conditions.

The prototype, by the end of each trial run, was able to read detect and process blinks, detect and process yawn The performance of the system was satisfactory with the alarm being sounded within a second, when the system detected drowsiness. Drowsiness detection was also nearly instantaneous as the system returned a positive signal as soon the blink duration exceeded the threshold value set .

The completely connected circuit shown in Fig. 3 was responsible for evaluating

Figure 3. Connected circuit

The prototype detected blinks accurately as shown in Fig. 4, using a custom-built blink detector on top of the Viola and Jones algorithm to detect the face.

Using the yawn detector algorithm described, the system was successful in detecting yawns as seen in Fig. 5.

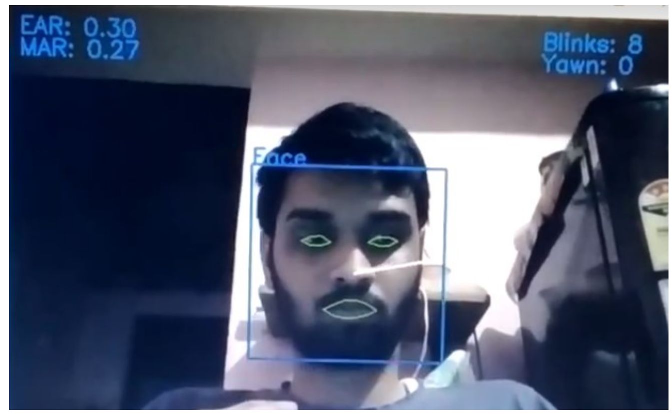


Figure 4. Eye monitoring

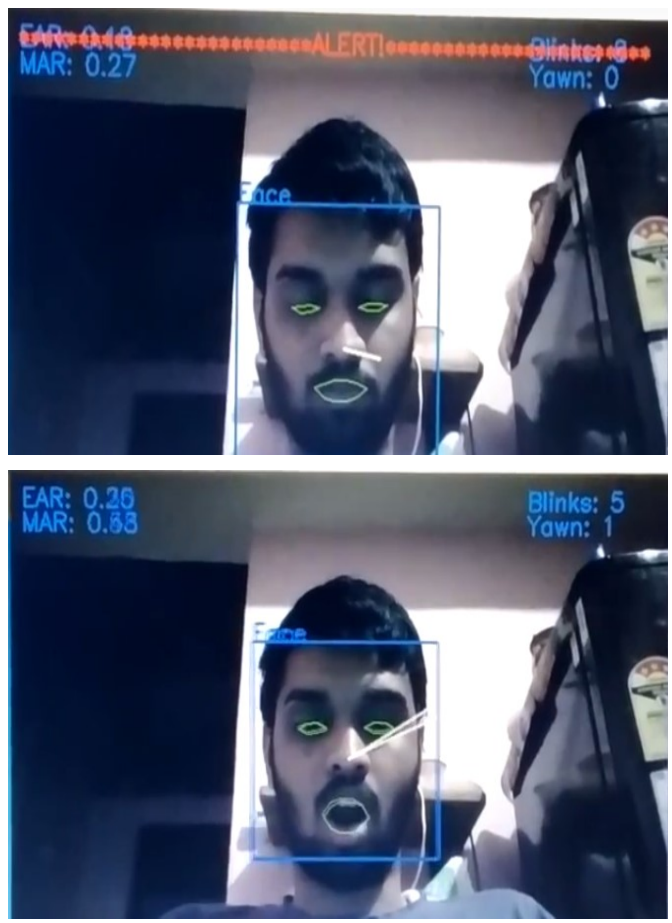


Figure 5. Yawn detection

After a driving session, the system shows a driving report with a graph plot.

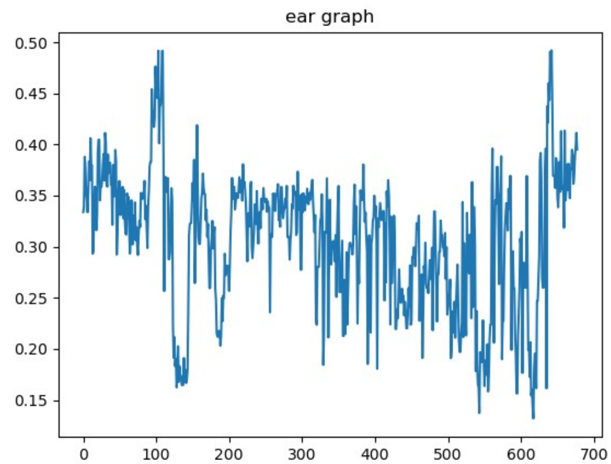
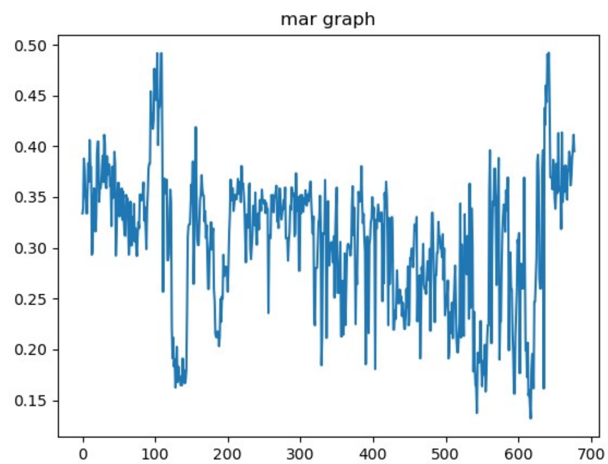


Figure 8. Statistics obtained at the end of driving session.



A car driver overcome by fatigue does not realize the onset of sleep and it has been observed that this has been a major cause in road accidents. Non-REM sleep is the first stage of sleep which occurs during this onset.

This prototype is an attempt to make the driver realize that he's tending to fall asleep by giving him an alert, which wakes him up very easily, according to the studies of Non-REM sleep.

Current solutions for this involve only approached based on eye-movement or the pressure applied by the driver on the steering wheel. Sound alert to wake the driver up, is another unique feature adopted by the system. Also, compared to other solutions, our system can be developed into an easy-to-use wearable.

VI. FUTURE ENHANCEMENTS

As demonstrated by the system, it is capable of detecting drowsiness in real time and provides a range of alerts depending on the severity of the detection, capable of collecting data for statistics and provide an integrated experience of monitoring physical and in a nonintrusive manner. However, there exists scope for improvement of the system and make it even more accurate.

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