Real-Time Driver Drowsiness Detection using an Embedded system

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Abstract:

Vehicle Accidents due to driver drowsiness are common in our country. Generally, Indian truck drivers disobey company policy on the maximum number of driving hours, due to which their lack of sleep results into drowsiness, fatigueness, and loss of concentration which eventually results into vehicle accidents. However, the lives of many such drivers could be saved, if their drowsiness can be detected early. To detect drowsiness, many methods exist, but not all of them are efficient as some methods require costly sensors or some are based upon inefficient algorithms. Through this project, we have implemented an efficient drowsiness detection algorithm using python, OpenCV,dlib models, and a metric EYE ASPECT RATIO(EAR). EAR is an efficient, easy to implement, fast-eye blink detection method as compared to other existing methods. Our proposed algorithm will significantly reduce the number of road accidents without requiring any physical contact with drivers. Also, we have used machine learning algorithms to test the effectiveness of our proposed algorithm.

Keywords: **Raspberry pi 4, buzzer, picamera, Eye aspect ratio, HOG,OpenCV,Dlib, facial landmarks detection.**

2. INTRODUCTION:

Advancement in technology enhances our standard of living. Each year about 1 lakh cases are reported involving vehicle accidents due to drowsiness which is 40% of total road accidents. In our country, generally, drivers don’t follow company policies and drive vehicles for more than the permitted time which results in drowsiness. Drowsiness is mainly caused due to fatigueness, loss of concentration, lack of sleep or brain disorder, etc. Driver drowsiness can result into vehicle accidents and loss of lives. So there is an urgent need to handle this drowsiness problem.

Although there does not exist any direct method for drowsiness detection but there are several indirect methods for its detection. Such as methods involving fingerprints, and behavioral or psychological measures for drowsiness detection. The fingerprint method is not efficient as it requires the driver's finger to be continuously placed on the fingerprint sensor, and in the physiological method, electrodes are required to be touched with the driver's body, thus making it inefficient. In this project, we have used raspberry pi to create a real-time application for drowsiness detection.

We have used a Raspberry pi board with some peripherals devices such as Picamera and buzzer. Many algorithms have been developed to encounter drowsiness problem which commonly involves face detection and eye feature extraction. But Existing algorithms involve less efficient approaches for eye blink detection, which is key to drowsiness detection. Traditional Eye blink detection methods such as finding the white area of the eye first and then detecting its disappearance for a certain time period is an inefficient method. Rather a new method -Eye aspect ratio(EAR)" introduced in the paper[11], can be used for efficient eye blink detection. We have used OpenCV and python to detect the driver's drowsiness and dlib to detect the facial landmarks. The model Shape_predictor_68_landmarks.dat is being used to train our dlib shape predictor method which is then used to detect and extract the facial landmarks.

Facial landmarks are determined to locate important parts of the face such as the eye, nose, ear, and lips. We have used 68 facial landmarks in our approach. Although for blink detection, we require eye localization only. The eye is identified by 6 coordinates(x,y), once the eye is detected using a facial landmark detection algorithm, the Eye aspect ratio is computed to determine whether the eye is closed or not. So by tracking eye movements we can detect the blinking of eyes and thus detect drowsiness. Whenever eyes are detected blinked, a buzzer will be sound to wake up the driver and disturb his sleep. To develop this real-time application, we require to fix the camera on the dashboard of the car. This camera will capture a live stream of the driver's face and continuously send it to our application. From these video frames, the trained Dlib facial landmark detector model would spot 68 facial landmarks, and thus eye would be detected after which the computed Eye aspect ratio would be compared to a constant on basis of which drowsiness will be detected and if drowsiness is detected then the driver will be alerted by an alarm/buzzer. We will expand our project by connecting our application with Spotify and telegram. A music from Spotify will be played and a call/text from telegram will raise upon drowsiness detection. Also, we will try to connect our prototype with an android app if time permits.

3. BACKGROUND WORK:

In this survey, we came to know about many technologies and research which are related to the topic of our project. Through this survey, we can understand better which aspect we should focus more on while developing this project. Current drowsiness detection technologies are for blink detection, and yawn detection. CNN, Computer vision, Behavioral measures, and machine learning are used which have different levels of accuracy advantages and challenges. Mainly when it comes to blinking detection and yawn detection, research is done on EAR-based technology and MAR-based technology. Rateb et al.(R. Jabbar, K. Al-Khalifa, M. Kharbeche, W. Alhajyaseen, M. Jafari, and S. Jiang) in 2018 detected drowsiness of a driver using neural networks and developed an android application to detect drowsiness of the driver. Tereza Soukupova et al. (T. Soukupova and J. Cech) 2016 used the eye-aspect ratio to detect the drowsiness of the driver. They also detailed active and passive systems which were used to detect the drowsiness of a driver active systems are reliable but use hardware that is intrusive and expensive such as infrared cameras and passive systems are inexpensive and rely on standard cameras. Vibin Varghese et.al (V. Varghese, A. Shenoy, S. Ks, and K. P. Remya) in 2018 detected landmarks for every frame to calculate the eye aspect ratio using landmark points on the face. After calculating, If the eye aspect ratio is less than the limit of 2 to 3 seconds then the driver is determined as drowsy because eye blink lasts up to 100-400ms.

In [1] authors discussed the drowsiness system which is based on computer vision for vehicles with web push notifications and buzzer sounds. This system uses an eye-aspect ratio to know whether the driver is sleeping or not. Buzzer sounds are used to alert drivers and web push notifications show nearby coffee shops in order to alert drivers. The trail run system detected the driver's drowsiness and a buzzer was generated and a web notification was sent to the driver about nearby coffee shops. The limitations of this paper are that they used raspberry pi which does not work at nighttime. Instead, we can use night vision camera

In [2] "the authors discussed how they used DMS (driver monitoring system) to detect the drowsiness of the driver along with different kinds of sensors. Results obtained from the system showed that the system could successfully classify drivers' drowsiness into low, moderate, and severe levels of drowsiness. The limitations of this paper are that the system could not classify drowsiness into moderate and severe levels of drowsiness.

In [3] authors discussed about the system which detects drivers' drowsiness by analyzing the eye blinks of humans using facial landmark detection and making use of eye aspect ratio (EAR). eye aspect ratio is used for fast, easy, and efficient blink detection. The results of this detector showed that the system effectively detected the driver's drowsiness by providing a precise enough estimation of the level of eye openness. As performance cost is very low in this system we can use this system in real-time.

In [4] authors discussed about a driver detection system in which the driver's eye movements and mouth movements are tracked using Haar cascade classifiers. By tracking eye and mouth movements we can detect the drowsiness of the driver. After the driver's drowsiness is detected then a buzzer sounds to alert the driver. Results of this driver drowsiness detection system showed that in 85 % of the cases the system detected faces and facial features accurately which is required. The Limitation of this paper is that system accuracy decreases in bad lighting conditions.

4. PROBLEM STATEMENT:

To encounter the problem of drowsiness many solutions exist, Although there are no direct methods for measuring drowsiness but indirect methods exist. Such as methods involving fingerprints, behavioral and physiological measures for drowsiness detection. But fingerprint method and physiological methods are inefficient, also require continuous physical contact with the driver's body, and are costly. So there is a need of a drowsiness detection method that does not require physical contact with the driver and is cost-effective. Through this project, we have developed a real time prototype for drowsiness detection. Which is based upon a metric *Eye aspect ratio*, and utilizes dlib, OpenCV. Dlib is a popular library and more accurate than OpenCV for face detection and facial landmarks detection. To detect drowsiness, we need to determine certain eye movements such as eye blinking, which will ensure that driver is sleepy. Eye blinking detection is key to drowsiness detection. So we need to efficiently detect eye blinking of a driver. From related work, we can see that by calculating the *eye aspect ratio* for every frame we can successfully detect eye blinking and thus driver's drowsiness, also the performance cost is very low and it is detected in real-time.
In our project "Real-time Driver Drowsiness Detection using Embedded system," we will detect the driver's drowsiness by calculating *eye aspect ratio* (EAR) for every frame in real-time. We need to alert the driver whenever he is detected as drowsy, we can use an alarm for this. So Whenever a driver is detected as drowsy then the buzzer sounds to alert the driver and then the music starts playing in order to energize the driver and reduce drowsiness.

5. Work Completed/Results :

At First, We covered the Raspberry Pi board basics to understand its functioning. Also explored some of the ways to use the board effectively. Some of the ways to protect the board and increase its efficiency are- by attaching the heat sinks and temperature controlled fans so that they can regulate the temperature according to the usage.

Also, gathering all the wired elements for this project was very challenging, so we researched a lot and found a very efficient way to connect the pi board wirelessly. We have used VNC Viewer software which is a graphical desktop sharing system that allows a user to remotely control the desktop of a raspberry pi board from our laptop, and it works as usual like a normal computer with all accessibility

For this drowsiness detection project, we have used Opencv and python3. Opencv is very useful for image processing additionally, There are many methods for face detection but we used the dlib library for face detection using the HOG (Histogram of Oriented Gradients)algorithm as the Dlib library is more accurate than OpenCV for face detection.

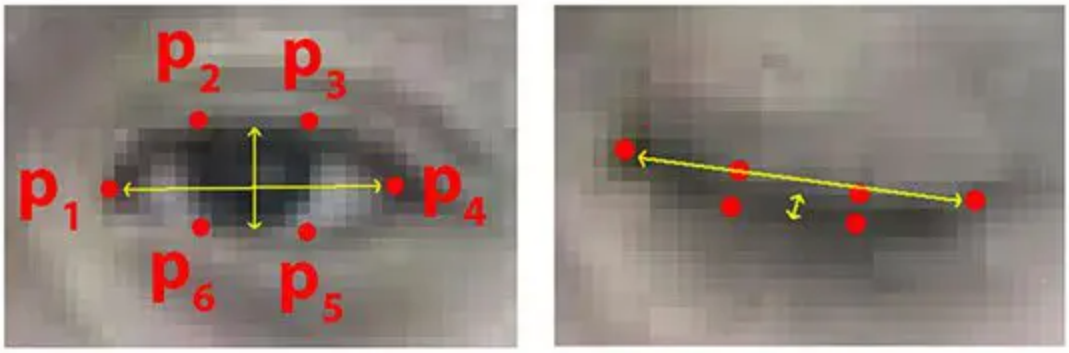
The dlib library is used to detect and isolate the facial landmarks using pre-trained data. We have used the Shape_predictor_68_landmarks.dat model to train the shape predictor method of dlib. Dlib's facial landmark detector is detecting 68 facial landmarks on drivers' facial images from which we are utilizing the eye landmarks in order to localize the eye. Because eye localization is only necessary for eye blink detection.

We have used a metric Eye aspect ratio which is one of the efficient and fast algorithms for detecting eye blink. Captured eye landmarks which are basically 6 (x,y) coordinates points are then fed to this metric *Eye aspect ratio,* which then determines whether the eye is blinked or not. *The eye aspect ratio* computes the ratio of distances between the horizontal and vertical eye landmarks.

$$\mathbf{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

EAR formula

Where p1….p6 are 2D pupil coordinates. here EAR value is compared with the threshold value taken as 0.25. if the value is lower than the threshold, the driver is in a drowsy state. In that case, he will be alerted by an alarm. Generally, when eyes are open and the EAR value is nearer to 0.25 so, that is the threshold set.



Facial landmarks of the eye utilized by EAR

We have installed the picamera2 for taking the real-time input video of the driver to analyze the drowsiness. The facial landmark detector will be detecting facial landmarks for each frame of this real-time video. This picamera2 needed to be fit on the dashboard of the driving vehicle to continuously capture the face of the driver. For the initial setup, we connected the raspberry pi board with a buzzer to alert the driver if drowsiness was detected. We have used GPIO (General Purpose Input/Output) pins for connecting the buzzer to the board. GPIO pins can be used for connecting and communicating with all manner of electronic components, acting as a physical interface between the Raspberry Pi and the electronic gadget. We utilized Board GPIO pins instead of BCM pins, as we found working with Board pins easier than BCM pins. The green ground wire of the buzzer is connected to the ground pin and the yellow wire is connected to pin 40. We wrote separate code for generating an alarm from the buzzer whenever drowsiness is detected.

The challenges we have faced :

1. Due to the fact that we are still learning about embedded systems, setting up the raspberry pi4 was a really challenging process.
2. There are different driver issues raised and clashing of versions consumed more time.
3. The raspberry pi camera was not working properly, identifying the right version of the picamera was challenging.

Finally, we were able to run the code on a raspberry pi board by clearing all the challenges.

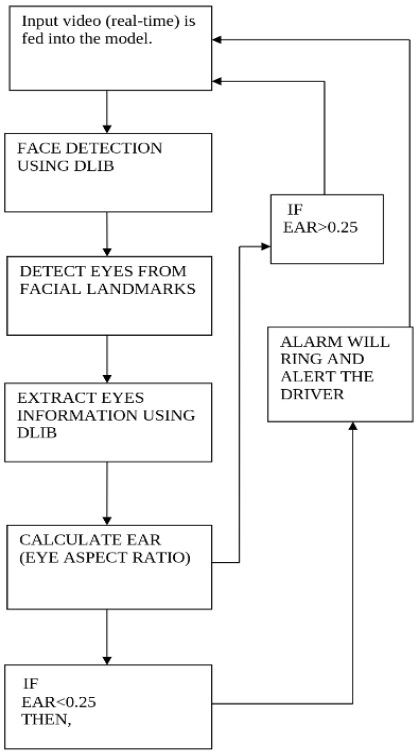
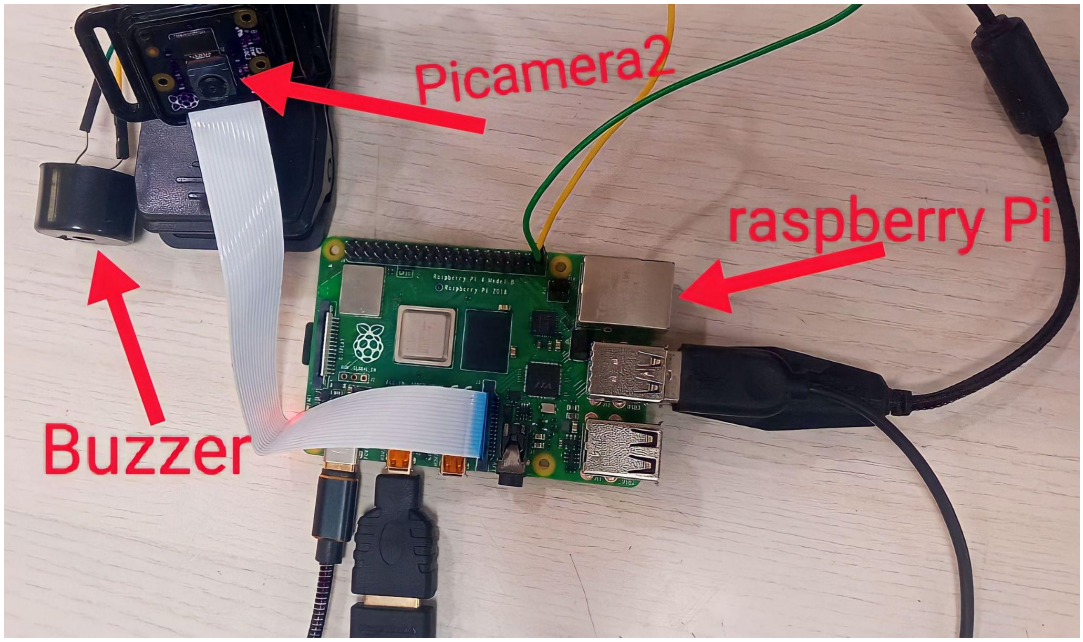
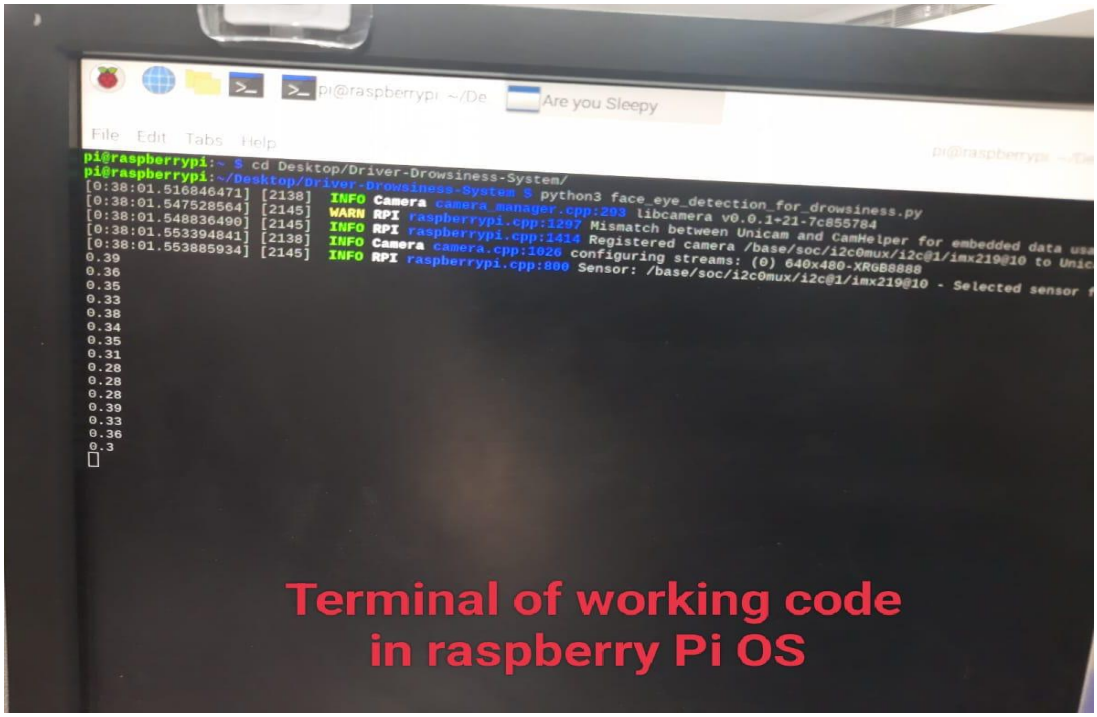


Diagram of the proposed method

This model is now capable of detecting drowsiness by monitoring the eyes and mouth. Our prototype is even capable of detecting the driver's drowsiness when the driver is wearing spectacles or a mask. From the above diagram, we can easily understand the working of our prototype. Whenever a driver is detected drowsy, an alarm beep is generated which awakens the driver.

Here are **some screenshots** attached of the working pi board and terminal.





WORKING CODE :

buzzer:

```
#buzzer setup
GPIO.setmode(GPIO.BOARD)
GPIO.setwarnings(False)
BUZZER= 40
GPIO.setup(BUZZER, GPIO.OUT)
GPIO.output(BUZZER, GPIO.LOW)
```

Eye_aspect_ratio(EAR) function:

```
def eye_aspect_ratio(eye):
    A = distance.euclidean(eye[1], eye[5])
    B = distance.euclidean(eye[2], eye[4])
    C = distance.euclidean(eye[0], eye[3])
    EAR = (A+B)/(2.0*C)
    return EAR
```

dlib model training :

```
picam2 = Picamera2()
picam2.configure(picam2.create_preview_configuration(main={"format": 'XRGB8888', "size": (640, 480)}))
picam2.start()


hog_face_detector = dlib.get_frontal_face_detector()
dlib_facelandmark = dlib.shape_predictor("models/shape_predictor_68_face_landmarks.dat")
```

6. FUTURE WORK/ Conclusion:

As of now, we have developed the face detection model using the inbuilt dlib libraries. From the above implemented model, we are able to detect and make driver alert of the drowsiness using the buzzer but till the end of the course, we would like to extend the work by adding a few other techniques to make drivers conscious of driving such as: by playing music on Spotify and by sending a text to emergency contacts, whenever the driver is detected drowsy.
Also, limitation of this work is that we cant use a picamera to detect drivers' drowsiness at night time because raspberry pi cameras will not work properly without light. Just by the buzzer

sound, the driver may go to sleep again or the driver may not listen to the alarm, because of this again we have a high probability of accidents.
By using a night vision camera mounted on the dashboard of the vehicle, we can overcome this limitation, and the drowsiness of the driver can be detected accurately using eye aspect ratio even at night time.
Also, only detection methods are not enough and have limitations, so we will further explore the ways to predict the driver's drowsiness currently, only detection methods are available. Also, Music has a huge effect on mood and mental state. When a driver is detected as drowsy, an alarm beeps, and then some type of music starts playing according to the driver's drowsiness. By listening to music drivers will become energetic and drowsiness decreases so now we will have a low probability of accidents.
To play music on Spotify whenever the driver is drowsy, we will connect raspberry pi with Spotify, then whenever the driver is detected sleepy, music will be played. This is not sufficient since the driver may go into a deep sleep; thus, we will ensure that close relatives of the driver become aware of this situation and reach out to the driver asap. For this, we will connect raspberry pi to telegram messenger, with which SOS messages will be sent automatically to close people's contacts, whenever the driver is drowsy.

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