# Multistage End-to-End Driver Drowsiness Alerting System

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***Abstract*—Drowsiness in drivers is the major cause for these fatal road accidents. Hence detecting drowsiness in drivers and alerting them on time is very important to avoid accidents. Researchers have developed several techniques to detect drowsiness in driver and warn the driver. However, in the past there is no work done towards the end-to-end driver drowsiness alerting system. Therefore, in this proposed system, it will ensure that the driver is awake through its end-to-end multi-stage (i.e., three stage) alerting system. The proposed system, at first performs driver authentication. Next, it detects the driver's face and also checks whether he/she has consumed alcohol or not, in either case the car engine will not start, and a warning mail is sent. Then the system performs drowsiness detection. If the driver is found drowsy then a multi-stage alerting system (i.e., voice alert, seat vibration alert and physical alert) is performed to wake him/her. After the voice alert, the driver has to give his/her fingerprint as proof for not being drowsy. If the system fails to get a fingerprint it starts the vibration alert. Once again system asks for driver's fingerprint, without which the system starts physical alert through robot arm which is performed with three different frequencies (i.e., Low, Medium and High) and three questions are asked after each frequency to make sure the driver is alert. In the process, it creates a log file which contains the driver's drowsiness details, after analyzing which it gives rating to the driver and mail this rating to the concerned person. This rating can be used to choose the driver for a safe and comfortable journey. Thus, the system ensures that driver is alert and avoids road accidents.***

***Keywords*—Driver drowsiness detection; internet of things; voice alert; seat-vibration alert; physical alert; driver rating; haar cascade classifier; eye aspect ratio**

## I. INTRODUCTION

The Internet of Things (IoT) indicates billions of appliances worldwide connected to the internet, gathering and distributing data. IoT is a technology that has steadily gained momentum and is now quietly changing our future. The world around us is becoming more intelligent and receptive because of the Internet of Things, which is merging the digital and physical worlds. IoT technologies have a good range of applications in agriculture, health sector, homes, cities, environment, industry and transport system [1]. In the contemporary world, transportation plays a significant role. People rely on automobiles as their primary source of transportation. In 2021, 79.1 million vehicles were produced globally, which is 1.3 percent more than the year 2020 [2]. Although the automobile has changed how people live and made doing everyday activities easier, it also has a connection to a variety of negative effects, such as road accidents.

As reported in a survey by Foundation for Traffic safety [3], over 96 percent of motorists consider drowsy driving to be highly or extremely risky. Only significantly fewer than 40% of respondents believed that fatigued drivers ran the chance of being pulled over by the police. Approximately 27% of drivers acknowledged that they had driven while feeling so sleepy that it was difficult, at least once in the previous 30 days to keep their eyes open, despite high rates of perceived risk and personal/social disapproval surrounding drowsy driving. According to [4], in India there were nearly 4.49 lakh of road accidents in the year of 2019. Our nation has faced 4,69,418 number of serious injuries and 1,51,417 number of deaths in the year 2019. Each year sleepy driving has caused around 100,000 road mishaps and nearly 1,500 deaths in the United States [5]. Therefore, being drowsy poses a severe risk to road safety, resulting in serious injuries, fatalities, and financial losses. Therefore, it is essential to detect drowsiness in drivers and alert them in time.

Many researchers have implemented numerous techniques to identify driver drowsiness and alert him/her. These researchers have considered different parameters to detect drowsiness. Some of them have used parameters like facial expressions [6], head position [7], blink rate [8], eye closure rate [9, 10] and yawning [11]. Many other systems use driver's biological conditions such as heartbeat rate [12, 13], pulse rate [14], galvanic skin response [15] and also features like steering wheel angle [16, 17], vehicle lane [18], speed variation, etc. Some researchers have combined these parameters for attaining better results [19, 20]. Most of the researchers have considered eye as the region of interest to find drowsiness. Eye Aspect Ratio (EAR) [21], Percentage of Eye Closure (PERCLOS) [9], Template Matching [9, 16] are some of the algorithms used for detecting drowsiness. EAR and PERCLOS gives good accuracy among these algorithms. Many authors have also used different Machine learning algorithms. Classifiers used for classifying drowsy and non-drowsy are SVM [6, 14, 18, 20], CNN [7, 8, 13]. CNN gives good accuracy, but it is computationally intensive.

The authors in [21] have developed a real-time system, implemented using mobile application which detects drowsiness using Eye Closure Ratio (ECR) and Eye Aspect Ratio (EAR). They use Dilib library to detect facial characteristics like eye and eyelids. Then by using these features EAR output is computed and a threshold is set for this output which classifies driver as drowsy or non-drowsy. When the driver is found drowsy, he is given an alert using mobile alarm. In [22], the researchers have created a fatigue detection system depending on grayscale image scanning and

PERCLOS. The suggested system comprises of three sections. In the first section, it determines where the driver's face is generally located in grayscale photos and next it examines the eye locations using a mini template. In second section, it creates a fatigue model applying the information from the previous part and PERCLOS. Depending on the driver's unique sleep model, in the third section, the system continually assesses the driver's condition. When the driver is found drowsy, the system warns him/her using an alarm sound. A drowsiness detection system which detects drowsiness by observing the eye movements is proposed in [23]. By combining data from numerous successive video frames with machine learning models' capacity to recognize various eye behaviors, a temporal aspect is added to the system. EAR value and blink classification techniques are used for detecting drowsiness in drivers. Here each video frame contains a calculation and storage of the EAR values. The time dimension was added to the ML model by concatenating a certain number of consecutive EAR values. Previously known blink patterns are used to assess if a user is sleepy or not. When the driver is found sleepy, the system sends a caution message, and a voice is played to warn the driver. The suggested methodology also includes a user feedback process to modify models based on particular user's feedback to produce even better outcomes.

A drowsiness detection system to examine the potential of smart watches and other wrist-worn wearables for the identification of driver drowsiness across a range of age groups is suggested in [24]. The authors have organized two simulators for this study – a low-level simulator and a high-level simulator. Study with high-level simulator was undertaken with two age groups to more thoroughly validate the methodology. Estimation of the heart rate signal and driving status were taken in the first step. The gathered information was prepared for feature extraction in the subsequent step. The final phase involved creating data sets by labeling the features in accordance with the subject's detected state during the simulator drive. A variety of machine learning methods were then used to classify the labeled data. The findings showed that drowsiness varies by age group i.e., younger drivers are more likely to become sleepy than older drivers. Authors have not discussed about in what way they will alert the driver once he/she is found drowsy. The study in [25] discusses a deep learning network-based Electroencephalogram (EEG) categorization system for drowsiness detection. The device EmotivEPOC+ headset is used to collect EEG signals, which is then preprocessed. Data preparation, signals interpretation, and data amplification are the three main focuses of the preprocessing stage. In data preparation, noises are removed from the data. Signal interpretation is based on research into Alpha-Theta waves from the occipital and temporal areas, which are used to assess alertness and drowsiness, respectively. By multiplying the vectors at random intervals, segments were extended to a predetermined length in the data amplification. Then the proposed model is analyzed by using different CNN networks. The system achieved an accuracy of 90.14%.

From all these approaches, it can be seen that the way of warning the driver when he is found drowsy is not specified in many of the works. Many researchers have used simple buzzers or alarms to alert the driver and there is no way provided to ensure that the driver is awake after the buzzer or alarm goes off. It is important to have a good system to alert the driver, because many people have the habit of sleeping off after the alarm stops. In a real scenario, when a person is in drowsy state, simple alarms or buzzers will not help him/her to be alert. Hence, the proposed system introduces a multi-stage alerting system to wake the driver when he/she is found drowsy.

The proposed system starts with driver authentication by detecting the driver's face and also checks whether he/she has consumed alcohol or not, in either case the car engine will not start, and a warning mail is delivered to the concerned person. Then the system performs drowsiness detection. If the driver is found drowsy then a multi-stage alerting system (i.e., voice alert, seat vibration alert and physical alert) is performed to wake him/her. After the voice alert, the driver has to give his/her fingerprint as proof for not being drowsy. If the system fails to get a fingerprint, it starts the vibration alert. Then again driver has to give his/her fingerprint, without which the system starts physical alert through robot arm which is performed with three different frequencies (i.e., Low, Medium and High) and three questions are asked after each frequency to make sure the driver is awake. If the driver is found alert after any of these multistage alerts, the system continues with detecting drowsiness. In the process, it creates a log file containing the driver's drowsiness details, by analyzing which it gives rating to the driver and mail the rating to the concerned person. This rating can be used by passengers while choosing drivers for their journey. Thus, the system ensures that driver is alert and avoids road accidents to save lives. This paper is separated into III principle segments. In segment II we discuss the methodology used in the proposed system. Result of the proposed system is discussed in segment III. The conclusion is given in the end.

## II. Methodology

The proposed system has two modules – Driver Authentication and Driver Drowsiness Detection and Alerting. Driver authentication module checks for authorized driver and alerts the owner in case the driver is not authorized. Driver drowsiness detection alerting module detects drowsiness in driver and alerts him until he is awake with its multistage alerts. The Fig. 1 represents the flow chart of the suggested system.

### A. Driver Authentication

The proposed system starts with driver authentication. As soon as the driver enters the car the system does a face recognition using Haar Cascade Classifier. If the face matching fails, a warning message is delivered to the possessor of the vehicle and the vehicle's engine will not start. After successful face recognition, the system does an alcohol test on the driver using alcohol sensor. If he/she has been detected positive, then the vehicle's engine will not start, and a warning message is sent to the concerned person. Hazards due to drunk driving can be prevented by this alcohol test. If no alcohol content is detected, the system moves to drowsiness detection and alerting module.

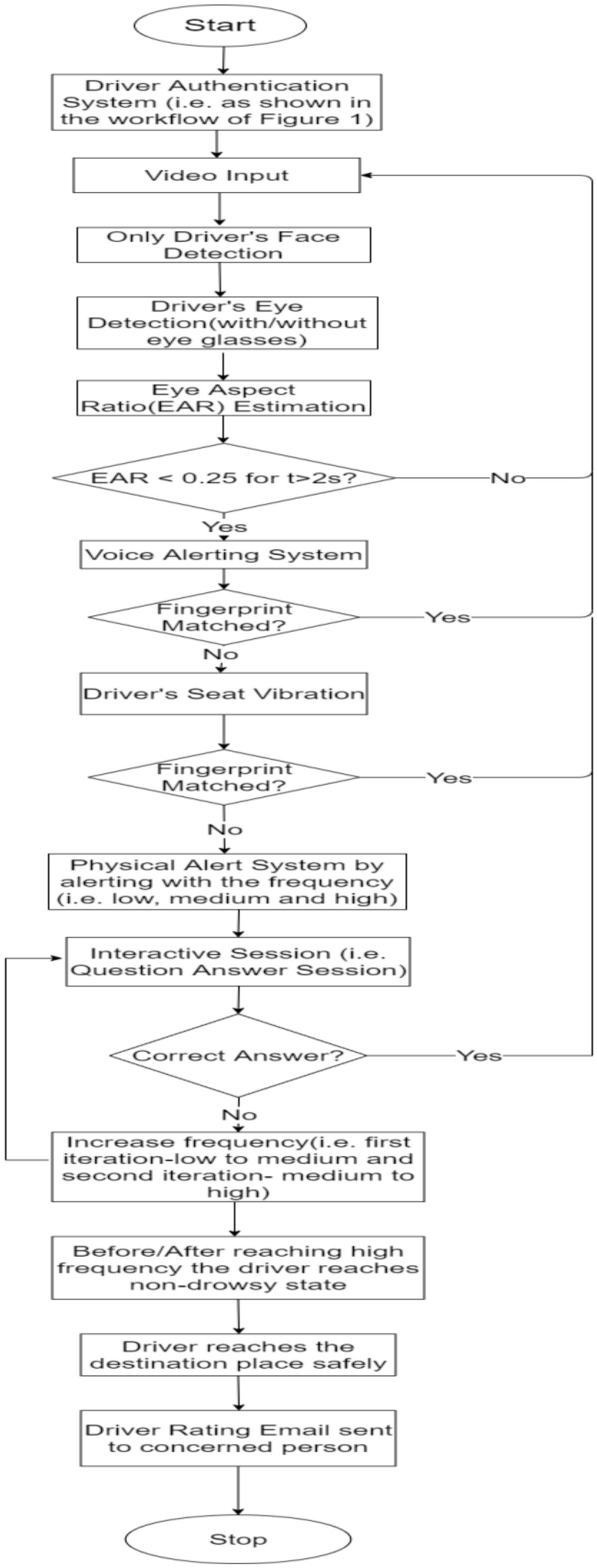



Fig. 1. Flowchart of the proposed system.

## B. *Driver Drowsiness Detection and Alerting*

The system, as seen in Fig. 1 takes continuous video input of the vehicle driver's face and performs face detection and eye detection respectively. After the eye detection, the proposed system performs EAR (Eye Aspect Ratio) estimation. If the estimated EAR is greater than threshold amount (i.e., 0.25) then the driver is not in sleepy state and hence the system again goes back to monitor the video input. If the estimated EAR is less than threshold amount for more than 2 seconds, then the driver is drowsy. Now, the system undergoes multi-stage alerting (i.e., voice alert, driver's seat vibration alert and physical alert).

*1) Voice alerting system:* When a sleepy driver is discovered, the voice alert is performed by telling the driver to be alert. Next the system asks for the fingerprint of the driver. If the system gets the fingerprint input, the driver is awake, and the system goes back to monitor the video input. If fingerprint input is not provided by the driver, then the system starts the second stage of alerting (i.e., Seat Vibration Alert).

*2) Driver's seat vibration alerting system:* In this stage, the system vibrates the driver's seat of the vehicle to awake him/her. After the car seat vibrates, the system again asks driver to provide his fingerprint, if it is given by the driver then he is awake, and the system goes back to video input monitoring. If the fingerprint is not obtained, then the system starts the third stage of alerting.

*3) Physically alerting the driver by using robot arm:* The proposed system physically alerts the driver by three measures of frequencies (i.e., low, medium and high frequency). After physically alerting the driver with low frequency, our proposed system asks the driver's name, father's name and place. If correct answer is provided by the driver, then the system continues to observe the video input of the driver (i.e., he/she is in non-drowsy state). If it receives wrong answer, then the system again starts physically alerting the driver with the medium frequency. Likewise, the physical alerting system alerts the driver with high frequency.

All the above stages of drowsy detection and alerting are recorded in the form of log file and using this file it gives rating to the driver as Excellent, Good, Average and Bad. This rating is then mailed to the concerned person. The system stops once the driver reaches the destination.

## C. *Haar Cascade Classifier*

Haar cascade classifier suggested by Viola and Jones [26] is one among the few object identification algorithms. We use this algorithm in the proposed system for driver's face detection. For detecting a face, this technique uses four steps: Haar-like attribute, intrinsic image, AdaBoost learning, and The Attentional Cascade. The camera module captures driver's facial behaviour in the form of video. This video is divided into many image frames and these image frames are given as input to Haar Cascade Classifier.

*1) Haar-like Attribute:* Collecting Haar-like attributes on the input image frame is the first step in Haar Cascade Classifier. The crucial component of the Haar cascade classifier is the Haar-like attributes. These attributes make it simple to determine lines or borders and parts where there is a sudden change in the pixel brightness. These rectangular attributes are moved across the image, and the aggregate number of pixels in the white and black parts is subtracted from one another. The darker portion has a pixel value of 1 and lighter portion has a pixel value of 0. We compute the aggregate of all the image pixels situated in the Haar attributes black and white areas respectively and then Haar value is calculated by taking the difference between them as shown in equation (1). If there is an edge in the image separating light pixels on the left from dark pixels on the right, the Haar value will be close to 1.

Haar value = (Sum of dark pixels/ Number of dark pixels) – (Sum of light pixels/ Number of light pixels) (1)

The edge attribute is used to detect edges, is the difference between the sums of the pixels inside the two rectangular sections. The line feature determines the sum within two outer rectangles subtracted from the sum within a centre rectangle and is used mostly for line detection. The four-rectangle attribute calculates the difference between rectangle diagonal pairings.

*2) Intrinsic image:* Every pixel in an intrinsic image is calculated by using the primary image so that it is equivalent to the sum of all the pixels to its upper right and to its left. The amount at some point (m, n) is given by equation (2).

$$I(m,n) = \sum_{\substack{m'<m \\ n'<n}} i(m',n') \tag{2}$$

where $i(m,n)$ is the original image and $I(m,n)$ is the integral image. The value of the intrinsic image, $I(m,n)$, is derived by adding the preceding index values from left to right. Over the primary image, the integral image can be calculated in a single pass by applying the following equations (i.e., equation (3) and equation (4)).

$$s(m,n) = s(m,n-1) + i(m,n) \tag{3}$$

$$I(m,n) = I(m-1,n) + s(m,n) \tag{4}$$

The Intrinsic Image's endmost pixel in the bottom right corner will be equal to the aggregate of all the pixels in the Primary Image. For whatever attribute size, the Intrinsic Image demands only four continual value additions every time to calculate the Haar value. The total of $i(m,n)$ across the rectangle extended by A, B, C, and D is shown in equation (5).

$$\sum_{\substack{m0<m<m1 \\ n0<n<n1}} i(m,n) = I(D) + I(A) - I(B) - I(C) \tag{5}$$

Where $i(m,n)$ is the sum of pixel values of the rectangle ABCD and the values $I(A)$,$I(B)$,$I(C)$ and $I(D)$ are the pixel values at position A, B, C and D respectively.

*3) AdaBoost algorithm:* After finding Haar attributes in the input image, we have to make a classification function, which will classify the input image frames into two classifications (i.e., the input image that contains face and that does not contain face). To achieve this, we need a training data set which contains images with and without faces, and the Haar attribute set. In the selected Haar attributes, majority of them won't complement the face features nicely or will be unnecessary. Typically, a basic 24*24 image yields approximately 1,60,000 attributes. Many of these Haar attributes will be irrelevant while performing face detection. So, in this case, a feature selection strategy is required to choose a subset of attributes from the vast set, which will not only choose attributes that perform better than the rest but will also eliminate the unnecessary ones. For this purpose, we use a boosting technique called AdaBoost which is an iterative machine learning process which will select subset of attributes and also train the classifier.

AdaBoost uses the combination of several weak classifiers generated using same set of training dataset which creates a strong classifier. Training data set contains many images with and without human face. At first, on the training set, a basic classifier is trained and predictions are made. Each sample is initially given the same weight. The weight will be decreased if the sample is correctly classified and increased otherwise. This will make the incorrectly classified sample stand out so that a new sample set may be created. Next, the weak classifier is created by training the new sample set and it makes predictions based on the training set, updates the weights, and so on. By overlapping these weak classifiers, the strong classifier will be created. At the end we will be left with most pertinent features needed for face detection. In this way, the number of features selected is reduced to 6000.

*4) The attentional cascade:* After selecting Haar attributes and training the classifier, now system detects face in the input image frame. The Attentional Cascade is an approach to building a cascade of classifiers that improves face detection performance while drastically cutting down on calculation time. AdaBoost-trained classifiers are used to build the stages of the cascade. Fig. 2 represents the architecture of the cascade classifier.

The Haar attributes selected after applying AdaBoost are run on the input image frames by using cascade classifier to detect the face. This is done with the presumption that not all the Haar attributes need to be run on every window. We can say that the face features are absent on a specific sub-window if one Haar attribute fails on that sub-window and hence we can move to next sub-window where there might be a facial feature present. The cascade classifier works as below:

*1)* The classifier divides the input image into smaller sections, or sub-windows.

*2)* We then make use of a cascade ordering of N detectors, each of which picks up a type of Haar attributes from the image frame it is fed with. After attribute extraction is finished, a confidence rating is given for each sub-window.

*3)* The sub-windows (or images) that have the high confidence rating are identified as faces and are submitted to the accumulator while the remaining images are rejected. The cascade then restores the succeeding frame or image, if any, and continues the process.

The process continues in the same manner and at the last stage driver's face is detected.

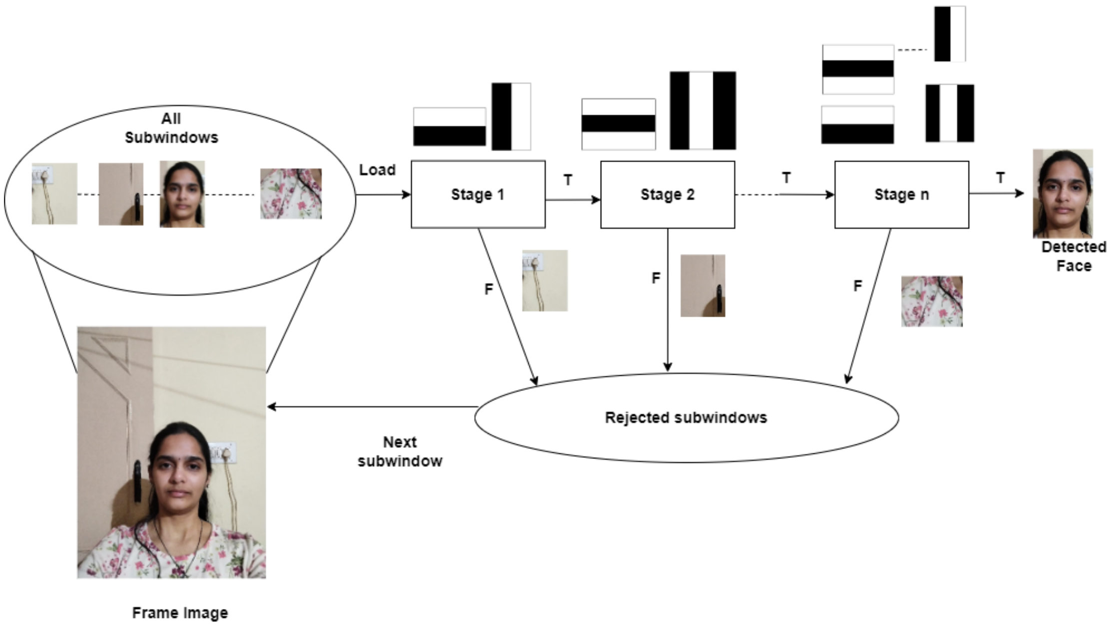


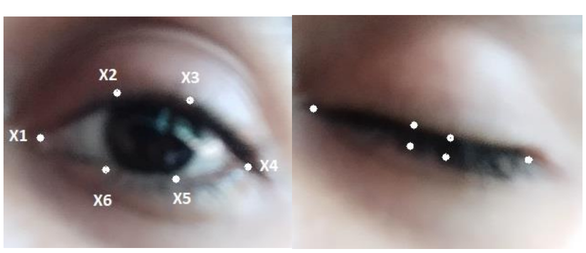

Fig. 2. Cascade classifier architecture.

### D. Eye Aspect Ratio (EAR)

After the driver's face is detected, face landmarks are detected using Dlib library. We use the Dlib library's pre-trained model to initialize the face landmark detector. After detecting facial landmarks, the drowsiness is detected on the basis of eye blink rate. Eye Aspect Ratio (EAR) [27], detects eye blink. Suppose that the driver flickers his/her eyes repeatedly, it indicates that they are drowsy. In order to determine the eye blink frequency, it is important to precisely detect the eyes shape. Based on the eye landmarks detected previously using Dilib library, the EAR value is calculated and is used to assess the eye-opening state. For every video frame six landmark coordinates around the eyes are taken. Then equation (6) is applied to compute the eye aspect ratio.

$$EAR = \frac{||X2-X6||+||X3-X5||}{2||X1-X4||} \quad (6)$$

Where X1, X2, X3, X4, X5 and X6 are the 2D landmark positions. As indicated in Fig. 3(a), the X2, X3, X5, and X6 are utilized to compute height, whereas the X4 and X1 are utilized to compute eye width in meters (m). The EAR remains persistent when the eye is open, but as the eye gets closed, it rapidly goes to zero, as indicated in Fig. 3(b).




(a) When Open (b) When Closed.

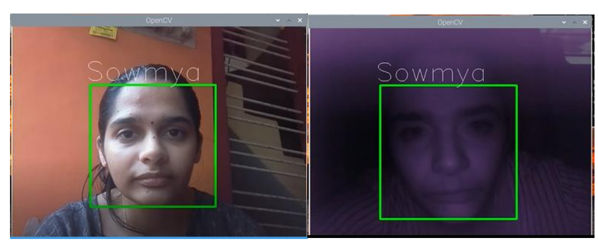
Fig. 3. Eye landmarks.

$$EAR = \begin{cases} y > 0; eyes\ open \\ y \cong 0; eyes\ close \end{cases} \quad (7)$$

Equation (7) illustrates the EAR value extent when the eyes are closed and open. When eyes are open, the EAR can be some integer value y that is larger than 0, but when they are closed, the EAR will be near to 0. A threshold amount of 0.25 is taken for deciding whether the person is drowsy or not, If the EAR value remains close to 0.25 or less for a time of 02 seconds or more, then the driver is considered to be sleepy [28].

## III. Results and Discussion

In this paper, we are proposing a Multistage End-to-End Driver Drowsiness Alerting System to detect drowsiness in drivers and alert them with multi-stage alerting system. The system detects drowsiness both in day and night condition, and also when the driver is wearing eye glasses. It is implemented using Raspberry Pi 3 Model B. Picamera has been utilized for recognizing and monitoring the driver's face and Infrared (IR) Light Emitting Diode (LED) is used during night driving.The system starts with driver authentication by detecting driver's face and recognizing it for an authorized driver. The Haar cascade classifier is applied for face recognition.




a: At Day Condition b: At Night Condition

Fig. 4. Face authentication.

Fig. 4(a) displays the result of face authentication at daytime and Fig. 4(b) shows the outcome of face authentication at nighttime. Here the face is identified and recognized both at day and night conditions. A green box is drawn around the identified face and his name is displayed on top of this box. The system then tests for alcohol consumption using alcohol sensor as shown in Fig. 5. If the driver is not authenticated or if he has consumed alcohol, then the system stops the vehicle engine, and an alert email is delivered to the vehicle owner. The alert mail is given in Fig. 6.

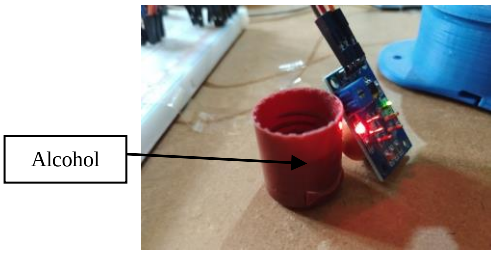



Fig. 5. Alcohol sensor.

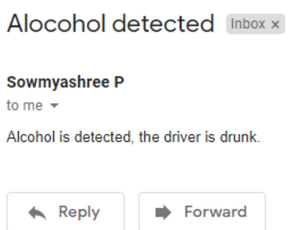
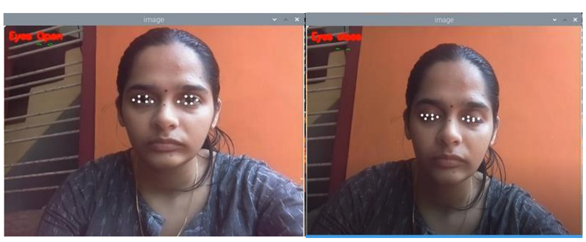



Fig. 6. Alcohol detection warning email.

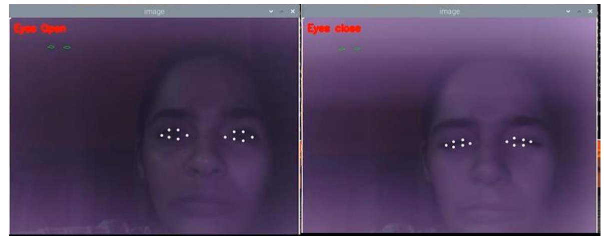
After driver authentication, the system starts detecting drowsiness. The system detects the shape of both left and right eye and estimates EAR to determine whether the eye is open or closed. A threshold value is taken to decide whether the eye is closed or open. If the EAR output remains less than threshold for greater than 2 seconds, the person is said to be drowsy. The system can detect drowsiness in both day and night condition and also when the driver is wearing eye glasses. The result of eye detection when the driver's eyes are open in day condition is shown in Fig. 7(a) and 7(b) show the result of eye detection when driver is drowsy.



a: Open Eye b: Drowsy Eye

Fig. 7. Eye detection at day condition.

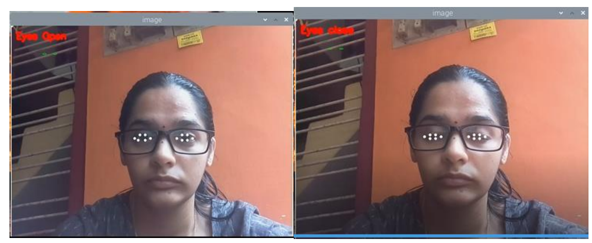
Fig. 8(a) and 8(b) show the result of eye detection when the driver's eyes are open, and eyes closed in night condition respectively.




a: Open Eye b: Drowsy Eye

Fig. 8. Eye detection at night condition.

The result of eye detection while driver is wearing eye glasses in day time is shown in Fig. 9.



a: Open Eye b: Drowsy Eye

Fig. 9. Eye detection with eye glasses.

After performing drowsiness detection, if the driver is found drowsy then a multistage alerting system (i.e., voice alert, seat vibration alert and physical alert) is performed to wake him/her. The multistage driver drowsiness alerting system consists of:

### A. *Voice Alerting System*

The system continuously monitors the driver's eye for drowsiness. It detects drowsiness by applying EAR algorithm. If the driver is found drowsy, as seen in Fig. 10, then the system starts the first stage alert, i.e. voice alert.

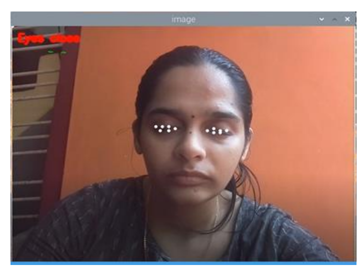
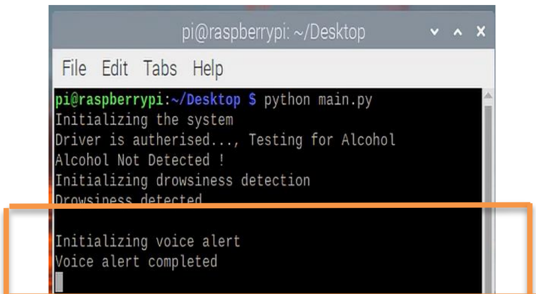


Fig. 10. Drowsy eyes.

Fig. 11 shows the voice alerting system. We use a Bluetooth speaker for providing voice alert to the driver. When the voice alert is initialized, a voice saying "wake up" is played thrice using the speaker, shown in Fig. 11(a). Fig. 11(b) shows respective output.


a: Bluetooth Speaker.

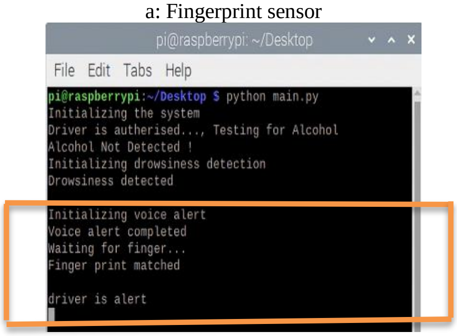



b:Output

Fig. 11. Voice alerting system.

Once the speaker stops playing the voice, the system asks the driver to give his/her fingerprint as a proof for not being drowsy. Fig. 12(a) shows the fingerprint sensor used in the system and Fig. 12(b) shows the respective output. If the system reads a fingerprint and it is matched with driver's fingerprint, then it indicates that the driver is alert. The system continuously observes the driver's eyes for detecting drowsiness. If the driver is still in drowsy state and the system doesn't receive fingerprint, then it starts the next stage alert (i.e., Seat Vibration Alert).

a: Fingerprint sensor



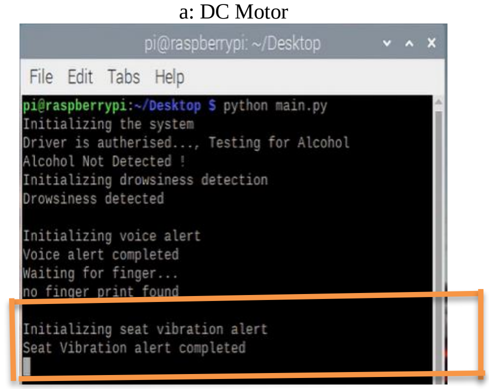

b: Output

Fig. 12. Fingerprint module.

## B. Seat Vibration Alerting System

After voice alert, if the system does not receive the fingerprint, then the next stage of alerting system (i.e., seat vibration alert) is initialized. Here the driver's seat vibrates for one minute time to make him alert. Fig. 13(a) shows the DC motor we used to provide driver seat vibration alert and Fig. 13(b) shows the respective output. Once the seat vibration stops, the system asks for driver's fingerprint as shown in Fig. 14. If driver provides a fingerprint and it is matched, then the driver is alert and hence the system goes back to monitor driver's eye. Else, if no fingerprint is provided, the system starts next stage alert (i.e., Physical Alert).

a: DC Motor




b: Output

Fig. 13. Seat vibration alerting system.

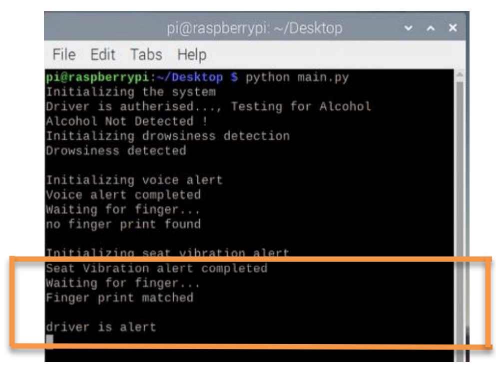



Fig. 14. Output of fingerprint module after seat vibration alert.

## C. Physical Alerting System

After seat vibration alert if the system does not receive the fingerprint, the system starts physical alert through robot arm which is performed with three different frequencies (i.e., Low, Medium and High Frequency). Fig. 15 shows the robot arm used to provide physical alert and respective output is shown in Fig. 16.

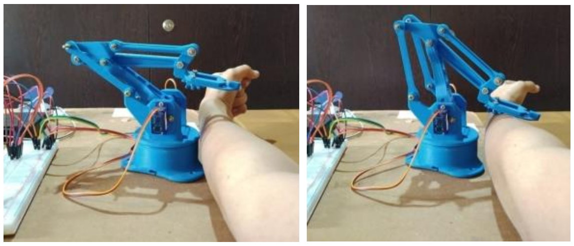
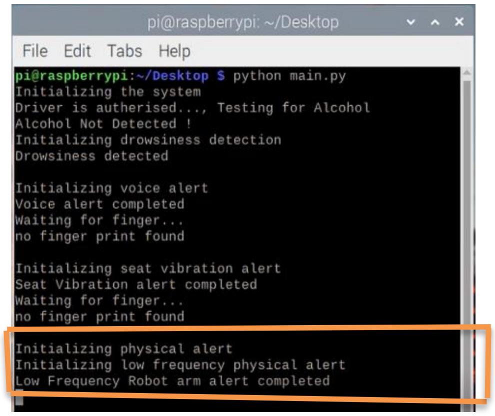


Fig. 15. Physical alert through robot arm.



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pi@raspberrypi: ~/Desktop
File Edit Tabs Help
pi@raspberrypi:~/Desktop $ python main.py
Initializing the system
Driver is autherised..., Testing for Alcohol
Alcohol Not Detected !
Initializing drowsiness detection
Drowsiness detected

Initializing voice alert
Voice alert completed
Waiting for finger...
no finger print found

Initializing seat vibration alert
Seat Vibration alert completed
Waiting for finger...
no finger print found

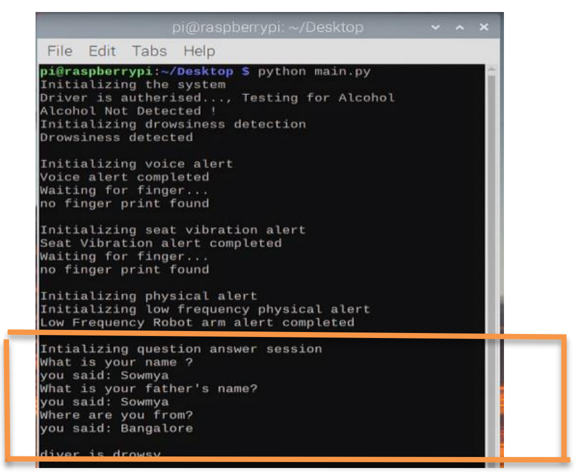
Initializing physical alert
Initializing low frequency physical alert
Low Frequency Robot arm alert completed
```

Fig. 16. Output of physical alerting system.

After low frequency physical alert, the system starts a question-and-answer session with the driver to make sure he is awake. The following are the questions asked:

*1)* What is your name?
*2)* What is your father's name?
*3)* Where are you from?

For all the above questions the driver has to answer correctly, even if one question is answered incorrectly then the system concludes the driver is drowsy and goes for next frequency physical alert (i.e., medium frequency). Fig. 17 shows the output of question-and-answer session.



```
pi@raspberrypi: ~/Desktop
File Edit Tabs Help
pi@raspberrypi:~/Desktop $ python main.py
Initializing the system
Driver is autherised..., Testing for Alcohol
Alcohol Not Detected !
Initializing drowsiness detection
Drowsiness detected

Initializing voice alert
Voice alert completed
Waiting for finger...
no finger print found

Initializing seat vibration alert
Seat Vibration alert completed
Waiting for finger...
no finger print found

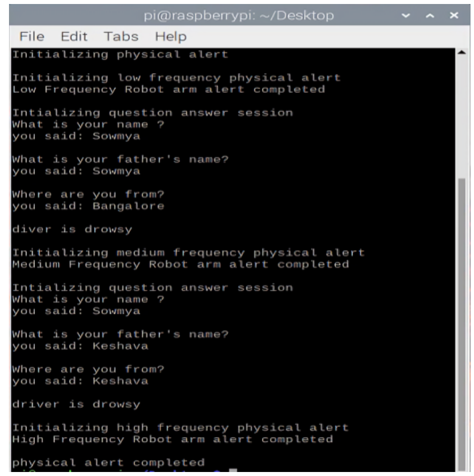
Initializing physical alert
Initializing low frequency physical alert
Low Frequency Robot arm alert completed

Intializing question answer session
What is your name ?
you said: Sowmya
What is your father's name?
you said: Sowmya
Where are you from?
you said: Bangalore

diver is drowsy
```

Fig. 17. Question and answer session.

After medium frequency physical alert, once again the question-and-answer session is started with the same questions. If the driver provides wrong answer again, the system starts high frequency physical alert. After these many alerts driver will definitely be alert. Fig. 18 shows the output of complete physical alert.



```
pi@raspberrypi: ~/Desktop
File Edit Tabs Help
Initializing physical alert

Initializing low frequency physical alert
Low Frequency Robot arm alert completed

Intializing question answer session
What is your name ?
you said: Sowmya

What is your father's name?
you said: Sowmya

Where are you from?
you said: Bangalore

diver is drowsy

Initializing medium frequency physical alert
Medium Frequency Robot arm alert completed

Intializing question answer session
What is your name ?
you said: Sowmya

What is your father's name?
you said: Keshava

Where are you from?
you said: Keshava

driver is drowsy

Initializing high frequency physical alert
High Frequency Robot arm alert completed

physical alert completed
```

Fig. 18. Complete output of physical alerting system.

We create a log file for each driver which contains his/her drowsiness and alerting details. Fig. 19 shows a part of log file.

```
Initializing the system 2022-07-29 15:59:13,135
Starting Driver Face Authentication 2022-07-29 15:59:18,148
Initializing the system 2022-07-29 16:03:33,145
Starting Driver Face Authentication 2022-07-29 16:03:38,151
Driver is autherised...,Driver name is Sowmya 2022-07-29 16:04:13,191
Testing for Alcohol 2022-07-29 16:04:13,191
Alcohol Not Detected ! 2022-07-29 16:04:13,192
Initializing drowsiness detection 2022-07-29 16:04:23,213
Drowsiness Detected 2022-07-29 16:04:44,988
Voice alert completed 2022-07-29 16:04:58,352
No fingerprint found, driver is still drowsy. Starting seat vibration 2022-07-29 16:05:03,293
Seat vibration alert completed 2022-07-29 16:05:18,310
No fingerprint found, driver is still drowsy. Starting physical alert 2022-07-29 16:05:23,273
Low frequency physical alert completed 2022-07-29 16:05:40,293
Sowmya is alert after low frequency physical alert 2022-07-29 16:06:03,132
physical alert completed 2022-07-29 16:06:08,140
Initializing drowsiness detection 2022-07-29 16:06:08,141
```

Fig. 19. Log file.

By analyzing this log file, we rate the drivers as Excellent, Good, Average and Bad. The driver who gets alert by voice alerting system is rated as Excellent and the driver who gets alert by seat vibration is rated as Good. The drivers who get alert after low frequency or medium frequency physical alert are rated Average. A Bad rating is given to the drivers who get alert after high frequency physical alert. This rating is then mailed to the concerned person. Fig. 20 shows the mail that has been sent to the concerned person containing the driver's name and his rating for the journey. This rating can help peoples to choose a good driver for a safe and enjoyable journey. Thus, our proposed system provides multistage end-to-end driver drowsiness detection and alerting functionality. This system helps us to avoid road accidents and save people's lives.

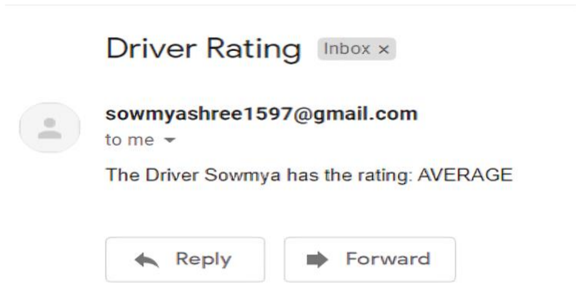



Fig. 20. Driver rating email.

## IV. Conclusion and Future Work

In the literature, various researchers have developed techniques to check drowsiness of the driver. However, in the past, there is no work done towards ensuring that driver is awake after the alerting system goes off. Hence, we suggest a driver drowsiness detection system which ensures that driver is alert through its multi-stage alerting system. The system starts with driver authentication by face recognition and alcohol testing. Then it detects drowsiness in driver, and if he/she is found drowsy, multi-stage alerting system is started. In the first stage a voice alert is given. After the voice alert, the driver has to give his/her fingerprint as a proof for not being drowsy. If the system fails to get a fingerprint it starts the vibration alert. Then again driver has to give his fingerprint, without which the system starts physical alert through robot arm which is performed with three different frequencies (i.e. Low, Medium and High) and three questions are asked after each frequency to make sure the driver is alert. We create a log file containing the driver's drowsiness details, by analyzing which we rate the driver and mail the rating to the concerned person. This rating can be used while hiring the driver for a safe and comfortable journey by avoiding road accidents. Thus, the system ensures that driver is alert and avoids road accidents. Future work can be to detect drowsiness when the driver is wearing sunglasses.

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