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Real Time Driver Drowsiness Detection Using Opencv And Facial Landmarks

[1]L.Thulasimani, [2]Poojeevan P, [3]Prithashasni S P

[1]Facult ,Department of Electronics and Communication Engineering, PSG College of Technology Coimbatore - 641004, India
[2]Department of Electronics and Communication Engineering,PSG College of Technology Coimbatore - 641004, India
[3]Department of Electronics andCommunication Engineering, PSG College of Technology Coimbatore - 641004, India

Email: [1]ltm.ece@psgtech.ac.in, [2]17l134@psgtech.ac.in, [3]17l136@psgtech.ac.in

Abstract— In recent years driver fatigue is one of the major causes of vehicle accidents in the world. Majorstudies have suggested that around 20% of all road accidents are fatigue related. Drowsy Driving can be extremely dangerous, a lot of road accidents are related to the driver falling asleep while driving and subsequently losing control of the vehicle. However, initial signs of fatigue and drowsiness can be detected before a critical situation arises. A direct way of measuring driver fatigue is measuring the state of the driver i.e. drowsiness. So it is very important to detect the drowsiness of the driver to save life and property. This project is aimed towards developing a prototype of drowsiness detection system which detects the eye closure, yawning and head tilt of the driver and give warning to driver upon detecting drowsiness.

Keywords— Image Processing, Fatigue detection, Facial landmark detection, Real time video survillance

1. INTRODUCTION

The proposed system is a real time system which captures image continuously and measures the state of the eye, mouth and head according to the specified algorithm using openCV and dlib library in python Integrated Development Environment(IDE). In this project facial landmarks are used to detect the eye closure, yawn and head tilt. Facial landmarks works by extracting the key facial features. The complete face is mapped into 68 co-ordinates. Eye closure is detected by estimating the EAR value. When EAR value goes below a particular threshold eye closure will be detected. The yawn is detected by estimating the MAR value. When the MAR value goes above the threshold value, yawn will be detected. Head tilt of the driver is detected by estimating the roll pitch and yaw values. Lane line detection is carried out by canny edge detection and hough transform.The image containing the lane line is given as input. The image is processed and canny edge detection is performed and lane will be detected. The threshold value for EAR is set as 0.2.To differentiate between the eye blink and mild sleep, EAR value has to be lower than the threshold for particular frame period which is set as 20.The difference between eye blink and mild sleep can be found by EAR plot. The threshold value for MAR is set as 0.5.For detecting the head tilt in both directions. The threshold roll value is set as -15 and +15.The prototype can work just when the eye, mouth and head are found and works in encompassing lighting conditions too. The canny edge

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detection technique is effective in detecting edges especially non-continuous lines can be detected efficiently.
In recent years, the fatigue-driving-detection system has become a hot research topic. The detection methods are categorized as subjective and objective detection. In the subjective detection method, a driver must participate in the evaluation, which is associated with the driver's subjective perceptions through steps such as self-questioning, evaluation and filling in questionnaires. Then, these data are used to estimate the vehicles being driven by tired drivers, assisting the drivers to plan their schedulesaccordingly.

A. Objective

The main idea of this project is to plan a system to distinguish driver's sluggishness by persistently checking the facial expressions of the driver by facial landmark detection concept.
The objectives of the project are as follows:

1. To identify eye closure of the driver and by estimating the Eye Aspect Ratio (EAR) value.
2. To identify mouth opening (yawning) of the driver by calculating Mouth Aspect Ratio (MAR) value.
3. To identify the head tilt of the driver by calculating the Euler angles with respect to rotational motion of the head.
4. To detect the lane lines in the input image by canny edge detection and hough transform andpipeline the concept to video files.
5. To alert the driver upon identifying the drowsiness.

B. Brief Description

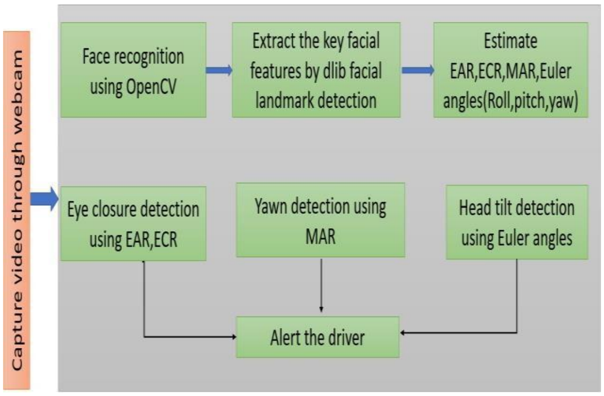

Fig 1. Design – software architecture of the processDrivers face is monitored continuously and frames

arecaptured via web camera. The captured image is processed in openCV environment. In order to detect the drowsiness the first step is to detect the face taken by the camera. Then the facial expressions like the eye closure, yawning, speaking, eating, head position is detected by Facial landmark detection concept. The captured image is send to the processor for imageprocessing. It converts the received image to digital signal using openCV.
The eye closure is detected by estimating Eye Aspect Ratio (EAR).When EAR goes below the threshold value,drowsiness is confirmed and driver is alerted. The yawn detection is carried out by estimating Mouth Aspect Ratio (MAR).When MAR value goes above the threshold value, yawning is confirmed. The head tilt is detected by calculating the Euler

angles. When roll value goes below or goes above thresholds, head tilt is detected.

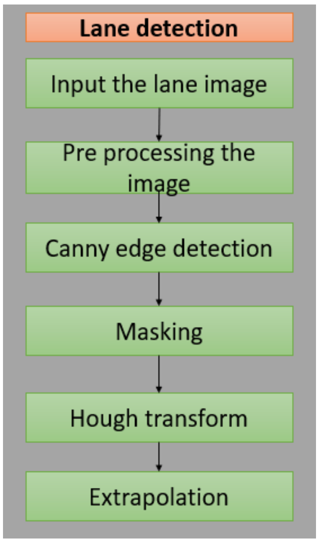

Fig 2. Flow chart for lane detection

The lane line detection helps to avoid the risk of getting in another lane. The lane image will be passed as input and it will be processed and lane will be detected in the image. The preprocessing step involves gray scale conversion and blurring. The blurred image is given to canny edge detector function. The unwanted region from the edge detected output is removed by masking and hough transfom is performed. After performing hough transform, extrapolation of line is done and weight value is added to fit the detected lines in the original image.

2. METHODOLOGY

The proposed drowsiness detection system deals with eye closure detection, yawn detection and head tilt detection.The project is carried out in openCV environment using dlib facial landmark detector.The lane detection is performed by Canny edge and hough transform technique and implemented in both image and video files.

A. *Facial Landmarks detection*

Facial landmarks have been successfully applied to face alignment, head pose estimation, face swapping, blink detection and much more.
Detecting facial landmarks is a subset of the shape prediction problem. Given an input image (and normally an ROI that specifies the object of interest), a shape predictor attempts to localize key points of interest along the shape.

Detecting facial landmarks is therefore a two-step process:
Step 1: Localize the face in the image.
Step 2: Detect the key facial structures on the face ROI.

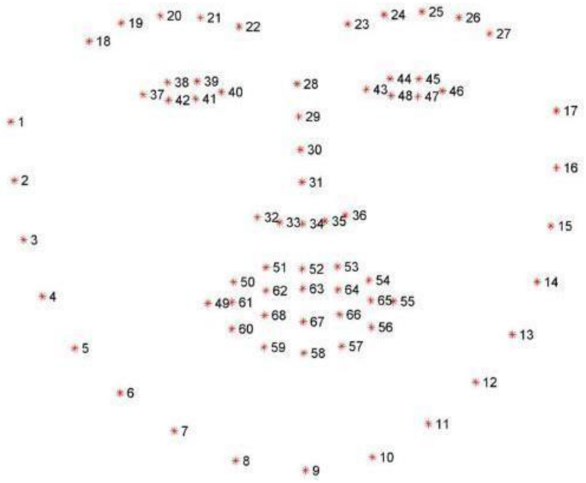

Fig 3. Visualization of the 68 facial landmark co-ordinates

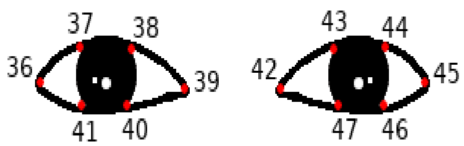

Fig 5. Landmark indices of eyes.

The facial detection is done using dlib python library module, OpenCV in Python IDE.Dlib is a landmark's facial detector with pre-trained models which is used to estimate the location of 68 coordinates (x, y) that map the facial points on a person's face.

B. *Eye Closure Detection*

The face is continuously captured using web camera and the captured frames are processed in opencv environment. The face is detected and key facial features are extracted using dlib facial landmark detector.The landmark indices for both eye regions are highlighted in the frame.The Eye Aspect Ratio (EAR) is estimated continuously and displayed in the frame.When eyes are opened,EAR value will be high.When the eyes are closed,value of EAR will be lesser.When the EAR value goes below a certain threshold,eye closure will be detected.Upon detecting the eye closure driver is alerted by triggering the alarm.

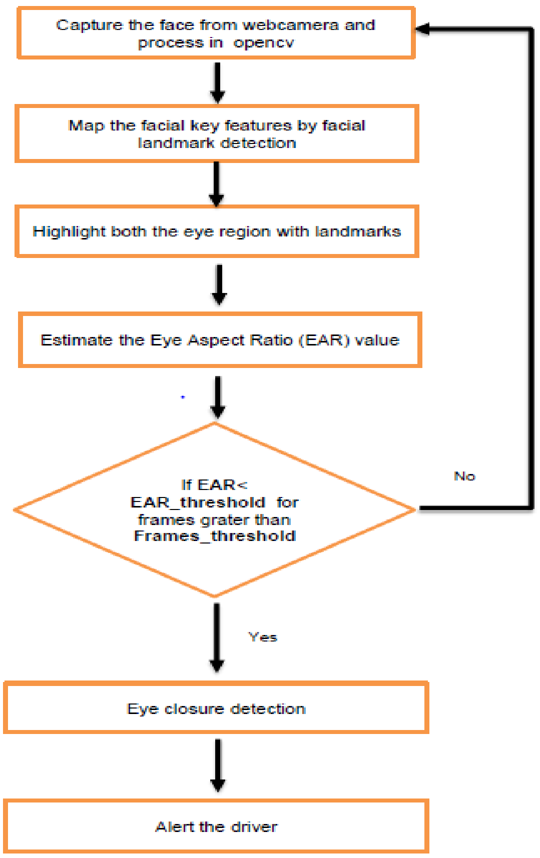

Fig 4. Process flow of eye closure detection

C. Eye Aspect Ratio

EAR refers to the aspect ratio of the eye region, which is often used to calculate the temporal consistencyand speed of left and right eye blinks and in fatigue detection.

These co-ordinates are used to estimate the value of EAR. Landmark indices for right eye → [36,37,38,39,40,41] Landmark indices for left eye → [42,43,44,45,46,47]

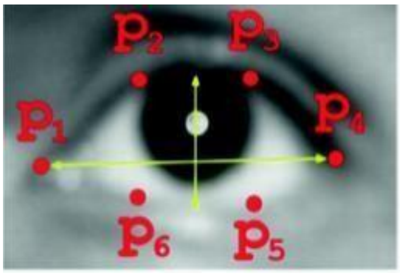

Fig 6. Landmarks when eyes opened

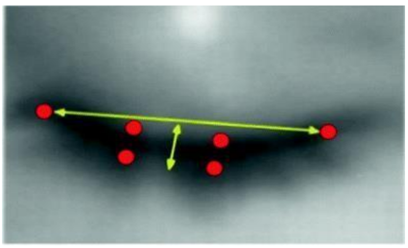

Fig 7. Landmarks when eyes opened

The formula to estimate the Eye Aspect Ratio (EAR) isgiven by as:

$$EAR = \frac{|p2-p6|+|p3-p5|}{|p1-p4|}$$

The numerator of this equation computes the distance between the vertical eye landmarks while the denominator computes the distance between horizontal eye landmarks, weighting the denominator appropriately since there is only one set of horizontal points but two sets of vertical points.

D. *Yawn Detection*

The face is captured through webcam and processed in opencv environment.The mouth landmark indices are detected and highlighted.The Mouth Aspect Ratio (MAR) is estimated.When the mouth is closed the value of MAR will be lesser.When the driver yawns MAR value will increase. When MAR value raises above the threshold value,the yawning will be detected. Upon detecting the yawning,driver is alerted by triggering alarm function.

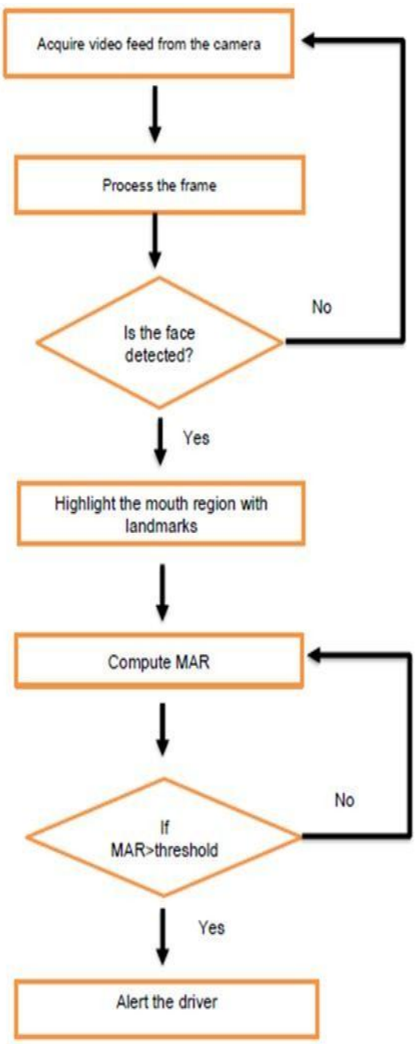

Fig9.ProcessFlowofyawndetection

E. Mouth Aspect Ratio

MAR is the ratio of vertical distance of mouth to the horizontal distance of the mouth. The three vertical distances and one horizontal distance are considered in MAR estimation.When driver yawns,the vertical distances will start increasing and the horizontal distance will decrease slightly. MAR value for yawning person is assumed to greater than 0.43 for faithful detection while the other values of MAR less than threshold are omitted.

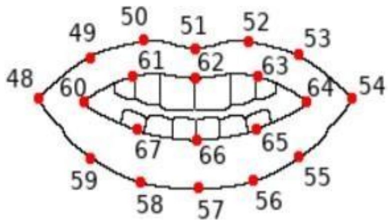

Fig 8. Landmark indices for mouth region

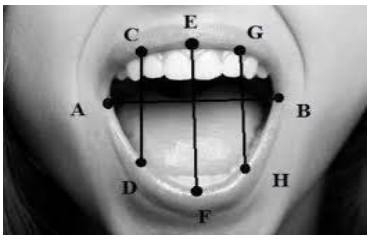

Fig 9. Landmark indices when mouth is opened

The formula for estimating the Mouth Aspect Ratio (MAR) is given by as:

$$MAR = \frac{|CD|+|EF|+|GH|}{3*|AB|}$$

When the mouth is opened the three vertical distances will be greater and the horizontal distance willbe lesser. So as a result, MAR value will increase upon yawning.

F. Head Tilt Detection

The main objective is head tilt detection is to find the relative orientation (and position) of the human's head with respect to the camera. In particular, in the headpose estimation task, it is common to predict relative orientation with Euler angles – yaw, pitch and roll.

A 3D rigid object has only two kinds of motions with respect to camera

Translation :

Moving the camera from its current 3D location to new 3D location is called translation. Translation is represented by a vector which is equal to difference between two locations.It has three degrees of freedom.

Rotation :

The camera can be rotated about the X,Y and Z axes. A rotation, therefore, also has three degrees of freedom.The rotation is represented by euler angles- roll,pitch and yaw.

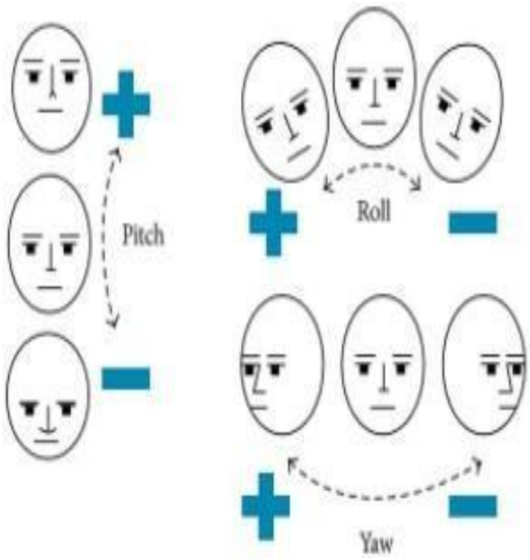

Fig 10. Three relative Euler motions of head

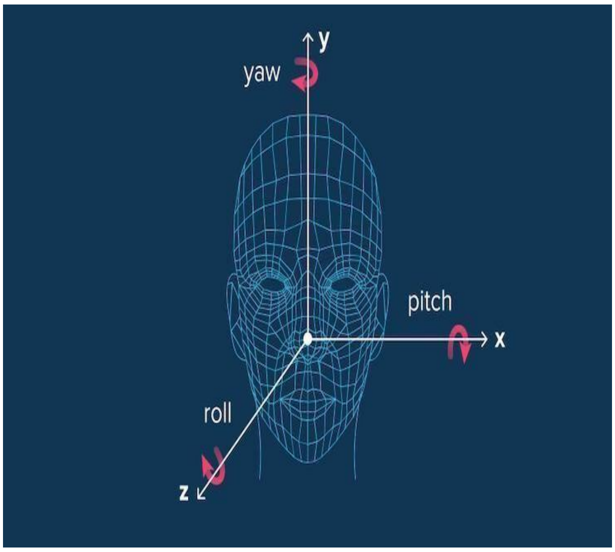

Fig 11. Euler motion's and its coordinates

G. Lane Line Detection

Lane Line detection is a critical component cars to describe the path for cars and to avoid the risk of getting in another lane.

The lane detection pipeline follows these steps:

1. Pre-process image using grayscale and gaussian blur
2. Apply canny edge detection to the image
3. Apply masking region to the image
4. Apply Hough transform to the image
5. Extrapolate the lines found in the hough transform the construct the left and right lane lines

6. Add the extrapolated lines to the input image

3. RESULTS AND ANALYSIS

A. *Facial landmark detection output*

The first step in the proposed work is to detect the facial landmarks in the face.The dlib facial landmark detector is used to extract the landmarks of key facial features in the face.The detected output is shown in Fig. 12.The whole face is mapped to 68 landmark co-ordinates as shown in the figure.

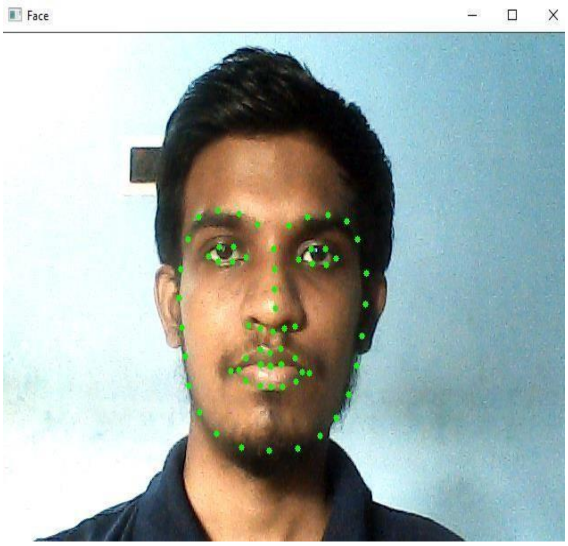

Fig 12. Facial landmarks of detected face

B. *Eye closure detection outputs*

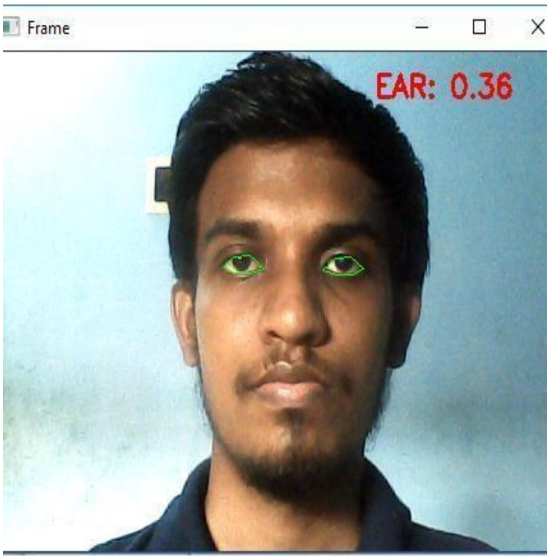

Fig 13. Output when eyes are opened

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The value of EAR will be higher when eyes are opened as shown in the Fig. 13.When eye is closed the value EAR will start decreasing.The threshold value of EAR is set as 0.2.When EAR goes below 0.2,it is understood that the eyes are closed.It can be either eye blink or mild sleep.The EAR value has to be lower than the threshold for 20 consecutive frames to confirm the drowsiness of the driver.When the drowsiness is detected the system will give alert as shown in the Fig. 14.

Fig 14. Output when eyes are closed

C. EAR Response

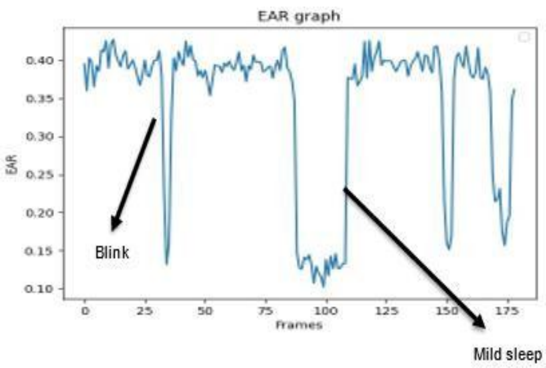

Fig 15. EAR plot

The graph is plotted between the frames and value of EAR at the corresponding frame.The response of the plot is shown in the Fig 15.The graph is plotted using matplot library.An empty list is created.The value of EAR at each frame is appended in that list.Finally the list contains the values of EAR for all the frames.The difference between blink and mild sleep is shown in the figure.For drowsiness detection,the value of EAR should be low for 20 consecutive frames.

***D.** Yawn Detection*

When the mouth is closed,the value of MAR will be lesser.When mouth is opened MAR value will increase.The threshold value of MAR is set as 0.5.When MAR goes above this threshold,yawning is confirmed and alert is given to drowsy driver.The ouputs when mouth is closed and opened are shown in the Fig 16 and Fig 17 respectiv

Fig 16. Output when mouth is closed

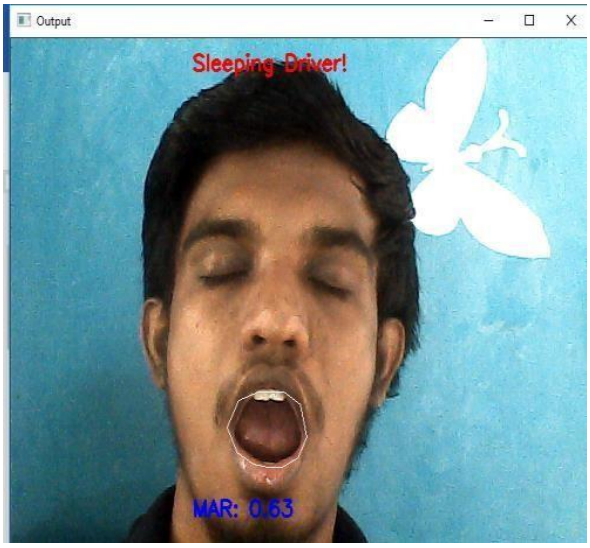

Fig 17. Output when mouth is opened

***E.** MAR Response*

The graph is plotted between frames and MAR value at each frame.The response of the graph is shown in the Fig. 4.18 .The threshold value for MAR is set as 0.5 as shown in the Fig 18 .

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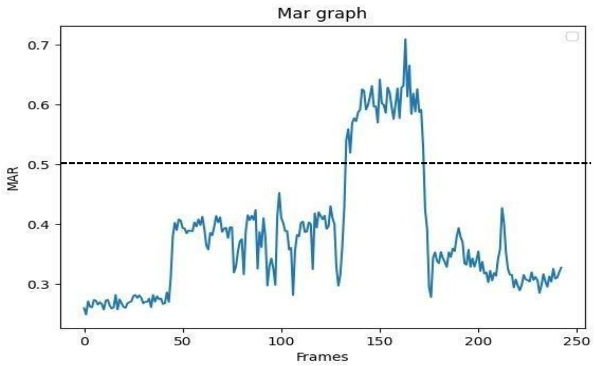

Fig 18. MAR plot

F.*Head Tilt detection outputs*

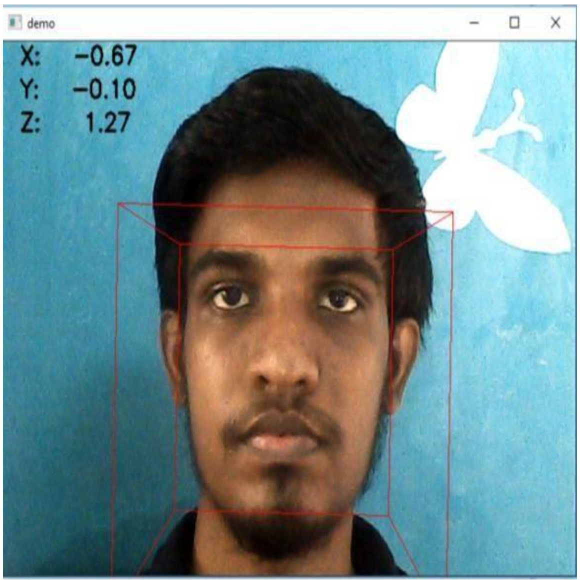

Fig 19. Output when head is straight

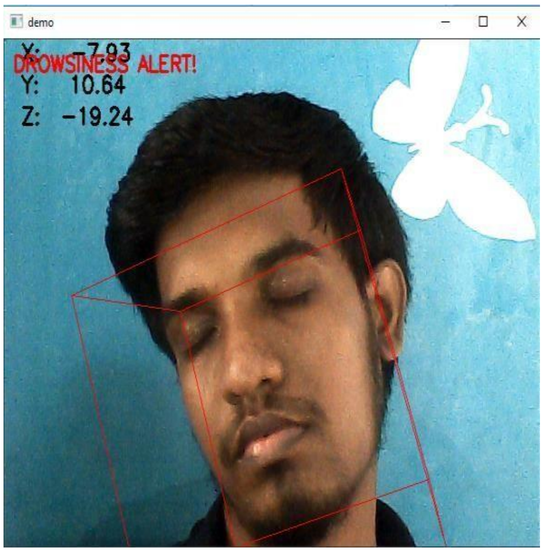

Fig 20. Output when head is tilted right

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When head is in straight position,the values of Euler angles-roll,pitch and yaw are ideally 0 and pratically they vary between -2 and 2 as shown in the Fig 19. The value of roll is considered for the head tilt detection.

When head is tilted in right hand side the value of roll increases negatively.The threshold is set as -15.When value of roll goes below the -15,drowsiness is confirmed as shown in the Fig 20.

Fig 21. Output when head is tilted left

When head is tilted in left hand side the value of roll increases positively. The threshold is set as +15.When value of roll goes below the +15 drowsiness is confirmed as shown in the Fig 21.

G. *Lane detection outputs*

The input image containing lanes as as shown in the Fig 22.The goal is to detect the two lanes and highlight it using different colour lines.

Fig 22. Input lane image

The preprocessing of the image involves grayscale conversion and blurring which are shown in the Fig 23 and Fig 24 respectively.

Fig 23. Grayscaled image

Fig 24. Blurred image

The blurred image is passed to Canny edge detctionfunction.The edges are detected and the output is shown in the Fig 25.

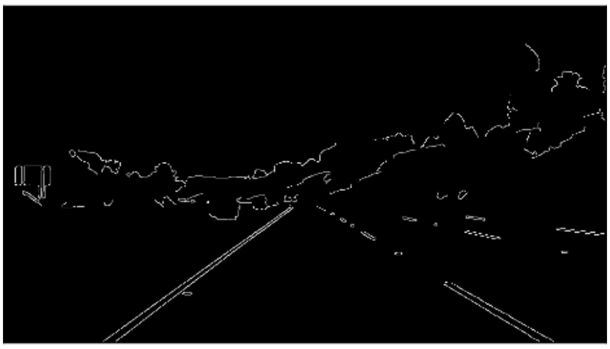

Fig 25 . Edge detected image

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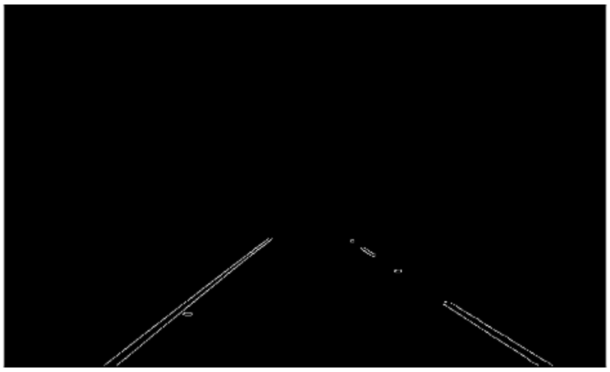

Fig26.Edge detected output after masking

The region of interest alone is extracted from theedge detected image by applying mask.The mask removes the unwanted region and produces output as shown in the Fig 26.

The hough lines are drawn on the edge detected output by taking hough transform.The output afterhough transform is shown in the Fig 27.

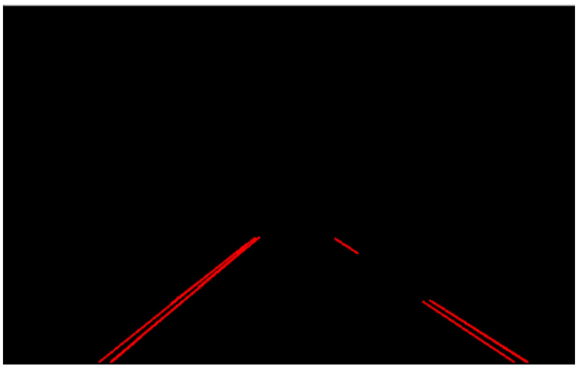

Fig 27. Hough transformed output

The detected lane lines are thickened by extrapolation of the image.The extrapolated output is shown in the Fig 28.

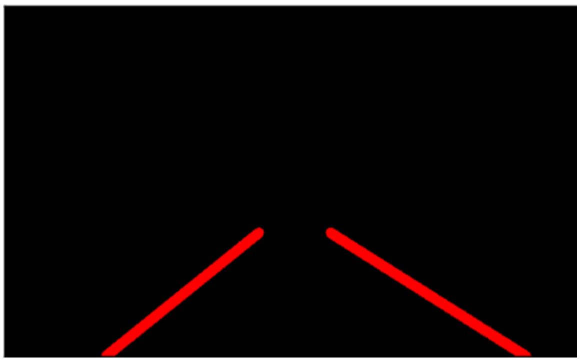

Fig 28. Extrapolated output image

The detected lane lines are fitted to the input image by adding weight value.The final output is shown in the Fig 29 in which the lane lines are detected.

Fig 29. Lane line detected output

Accuracy of eye closure and yawn detection

The counter for blink and yawn are created. Whenever eye blink or yawn is detected the counter will be incremented by 1.To find the accuracy of the eye closure detection and yawn detection, the 5 samples (persons) are taken for consideration. Each person is requested to blink 20 times and yawn times. The corresponding counter values are also noted and tabulated in table 1 and 2.

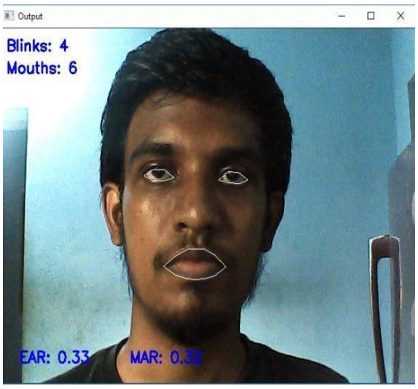

Fig 30. Counter for blink and yawn

Sample number	No of times blinked	No. of times blink detected	Accuracy
1	30	29	96.66%
2	30	28	93.33%
3	30	29	96.66%
4	30	28	93.33%
5	30	28	93.33%

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Table 1. Accuracy of eye closure detection

The accuracy of eye closure detection iscalculated by,

$$\text{Accuracy [Eye Closure]} = \frac{\textit{no.of blinks detected}}{\textit{no.of times blinked}} \text{ X } 100\ \%$$

The accuracy of eye closure detection is foundto be **94.66 %**

Sample number	No of times yawned	No. of times yawn detected	Accuracy
1	30	29	96.66%
2	30	29	96.66%
3	30	29	96.66%
4	30	28	93.33%
5	30	29	96.66%

Table 2 Accuracy of yawn detectionThe accuracy of yawn detection is calculated by,

$$\text{Accuracy [Yawn detection]} = \frac{\textit{no.of yawns detected}}{\textit{no.of times yawned}} \text{ X } 100\ \%$$

The accuracy of yawn detection is found to be **95.99 %.**

4. CONCLUSION

The proposed system is a real-time system as it has a high operation speed. From the experimental results, the system is applicable to different circumstances and can offer stable performance. In the real time driver fatigue detection system it is required to slow down a vehicle automatically when fatigue level crosses a certain limit. Instead of threshold drowsiness level it is suggested to design a continuous scale driver fatigue detection system. It monitors the level of drowsiness continuously and when this level exceeds a certain value a signal is generated which controls the hydraulic braking system of the vehicle.

The accuracy of drowsiness detection is calculated by finding the eye blinks and yawn of various samplesfor several number of times.The values obtained in eyeblinks and yawn detection are tabulated.The accuracy of eye blink detection is estimated as 94.66 % .The accuracy of yawn detection is estimated as 95.99 %
.The system detects the eye blinks and yawn most of the time accurately.The system works fine in poor lighting conditions also.The system is fast and once it starts capturing frames it continuously detects the faceand perform detection till it is stopped.

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