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Driver Drowsiness Monitoring System Using Visual Behaviour and Machine Learning

[1]Mrs.B Vijitha, [2]A Sai Deepak, [3]A Sai Abhishek, [4]Ch Teja Kiran

[1]Assistant Professor, Dept.of CSE, Teegala Krishna Reddy Engineering College, Meerpet, Hyderabad,

vijitha.boppena@tkrec.ac.in

[2]BTech student, Dept.of CSE, Teegala Krishna Reddy Engineering College, Meerpet, Hyderabad,
deepaksai1192001@gmail.com

[3]BTech student, Dept.of CSE, Teegala Krishna Reddy Engineering College, Meerpet, Hyderabad,
abhishek.akkirala100@gmail.com

[4]BTech student, Dept.of CSE, Teegala Krishna Reddy Engineering College, Meerpet, Hyderabad,
tejakiranch1143@gmail.com

Abstract: *Drowsy driving is one of the major causes of road accidents and death. Hence, detection of driver's fatigue and its indication is an active research area. Most of the conventional methods are either vehicle based, or behavioral based or physiological based. Few methods are intrusive and distract the driver, some require expensive sensors and data handling. Therefore, in this study, a low-cost, real-time driver's drowsiness detection system is developed with acceptable accuracy. In this system, a webcam records the video and the driver's face is detected in each frame employing image processing techniques. Facial landmarks on the detected face are pointed and subsequently the eye aspect ratio and nose length ratio are computed and depending on their values, drowsiness is detected based on developed adaptive threshold. Machine learning algorithms have been implemented as well in an offline manner.*

Keywords: *drowsiness detection, visual behaviour, eye aspect ratio, mouth opening ratio, nose length ratio.*

I. INTRODUCTION

Drowsy driving is one of the major causes of deaths occurring in road accidents. The truck drivers who drive for continuous long hours (especially at night), bus drivers of long-distance route or overnight buses are more susceptible to this problem. Driver drowsiness is an overcast nightmare to passengers in every country. Every year, a large number of injuries and

deaths occur due to fatigue related road accidents. Hence, detection of driver's fatigue and its indication is an active area

ISSN: 2366-1313

of research due to its immense practical applicability.

The basic drowsiness detection system has three blocks/modules; acquisition system, processing system and warning system. Here, the video of the driver's frontal face is captured in acquisition system and transferred to the processing block where it is processed online to detect drowsiness. If drowsiness is detected, a warning or alarm is sent to the driver from the

warning system. Generally, the methods to detect drowsy drivers are classified in three types; vehicle based, behavioural based and physiological based. In vehicle-based method, a number of metrics like steering wheel movement, accelerator or brake pattern, vehicle speed, lateral acceleration, deviations from lane position etc. are monitored continuously. Detection of any abnormal change in these values is considered as driver drowsiness. This is a nonintrusive measurement as the sensors are not attached on the driver. In behavioural based method, the visual behavior of the driver i.e., eye blinking, eye closing, yawn, head bending etc. are analyzed to detect drowsiness. This is also nonintrusive measurement as simple camera is used to detect these features. In physiological based method [8,9], the physiological signals like Electrocardiogram (ECG), Electooculogram (EOG), Electroencephalogram (EEG), heartbeat, pulse rate etc. are monitored and from these metrics, drowsiness or fatigue level is detected. This is intrusive measurement as the sensors are attached on the driver which will distract the driver. Depending on the sensors used in the system, system cost as well as size will increase. However, inclusion of more parameters/features will increase the accuracy of the system to a certain extent. These factors motivate us to develop a low-cost, real time driver's drowsiness detection system with acceptable accuracy. Hence, we have proposed a webcam-based system to detect driver's fatigue from the face image only using image processing and machine

learning techniques to make the system low-cost as well as portable.

PROBLEM STATEMENT

driver drowsiness monitoring system using visual behavior and machine learning aims to detect when a driver is feeling drowsy or fatigued while driving and alert them to take a break. This can help reduce the risk of accidents caused by drowsy driving. The system would analyze the driver's visual behavior, such as eye closure duration and frequency, blink rate, and gaze direction, using a camera or other visual sensor. It would then use machine learning algorithms to analyze this data and make predictions about the driver's level of drowsiness. If the system

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determines that the driver is feeling drowsy, it would alert them with a visual or auditory warning to take a break and rest. This system could be implemented in a variety of vehicles, including cars, trucks, buscraft. Some additional details that could be included in the problem statement for a driver drowsiness monitoring system using visual behavior and machine learning are: The system should be able to operate in a variety of lighting conditions, including low light and bright sunlight. The system should be able to handle changes in the driver's appearance and facial features, such as facial hair or glasses, without negatively affecting its performance.

The system should be able to accurately detect drowsiness even when the driver is not looking directly at the camera or sensor. The system should be able to distinguish between drowsiness and other factors that may affect the driver's visual behavior, such as distractions or the presence of passengers in the Vehicle.

The system should be able to alert the driver in a non-intrusive manner, such as through a gentle vibration or a subtle auditory warning. The system should be able to adapt to the individual characteristics of each driver and become more accurate over time as it is used. The system should be able to run on a variety of hardware platforms, including embedded systems and mobile devices, and should be energy efficient to minimize the impact on the vehicle's battery.

II. LITERATURE SURVEY

W. L. Ouet.al [3] An intelligent video-based drowsy driver detection system, which is unaffected b various illuminations, is developed in this study. Even if a driver wears glasses, the proposed system detects the drowsy conditions effectively. By a near-infrared-ray (NIR) camera, the proposed system is divided into two cascaded computational procedures: the driver eyes detection and the drowsy driver detection. The average open/closed eyes detection rates without/with glasses are 94% and 78%, respectively, and the accuracy of the drowsy status detection is up to 91%. By implementing on the FPGAbased embedded platform, the processing speed with the 640×480 format video is up to

frames per second (fps) after software optimizations.

W. B. Hornget.alA [4] vision-based real-time driver fatigue detection system is proposed for driving safely. The driver's face is located, from colour images captured in a car, by using the characteristic of skin colours. Then, edge detection is used to locate the regions of eyes. In addition to being used as the dynamic templates for eye tracking in the next frame, the obtained eyes' images are also used for fatigue detection in order to

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generate some warning alarms for driving safety. The system is tested on a Pentium III 550 CPU with 128 MB RAM. The experiment results seem quite encouraging and promising. The system can reach 20 frames per second for eye tracking, and the average correct rate for eye location and tracking can achieve 99.1% on four test videos. The correct rate for fatigue detection is l00%, but the average precision rate is 88.9% on the test videos.

Alshaqaqi,et.al [5]. Drowsiness detection has many implications including reducing roads traffic accidents importance. Using image processing techniques is amongst the new and reliable methods in sleepy face. The present pilot study was done to investigate sleepiness and providing images of drivers' face, employing virtual-reality driving simulator. In order to detecting level of sleepiness according to the signal, information related to 25 drivers was recorded with imaging rate of 10 fps, Moreover, on average 3000 frames were analyzed for each driver. The frames were investigated by transforming in grey scale space and based on the Cascade and Viola & Jones techniques and the images characteristics were extracted using Binary and Histogram methods. The MPL neural network was applied for analysing data.70% of information related to each driver were inserted to the network of which 15% for test and 15% for validation. In the last stage the accuracy of 93% of the outputs were evaluated. The intelligent detection and usage of various criteria in long-term time frame are of the advantages of the present study, comparing to other researches. This is helpful in early detection of sleepiness and prevents the irrecoverable losses by alarming [6].

In existing system, the driver drowsiness detection system involves controlling accident due to unconsciousness through Eye blink. Here one eye blink sensor is fixed in vehicle were if driver loses consciousness, then it alerts the driver through buzzer to prevent vehicle from accident. In future we can implement Drowsiness Detection System in aircraft in order to alert causes irritation in the eye, May damage retina highly expensive and distract the driver

III. PROPOSED WORK

A block diagram of the proposed driver drowsiness monitoring system has been depicted in Fig1. At first, the video is recorded using a webcam. The camera will be positioned in front of the driver to capture the front face image. From the video, the frames are extracted to obtain 2-D images using OpenCV. Face and facial landmarks like positions of eye and nose are marked on the images detected using Viola-Jones algorithm after detecting the face and facial landmarks Eye Aspect

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Ratio is used for determining if the eye is opened or closed.

SYSTEM ARCHITECTURE

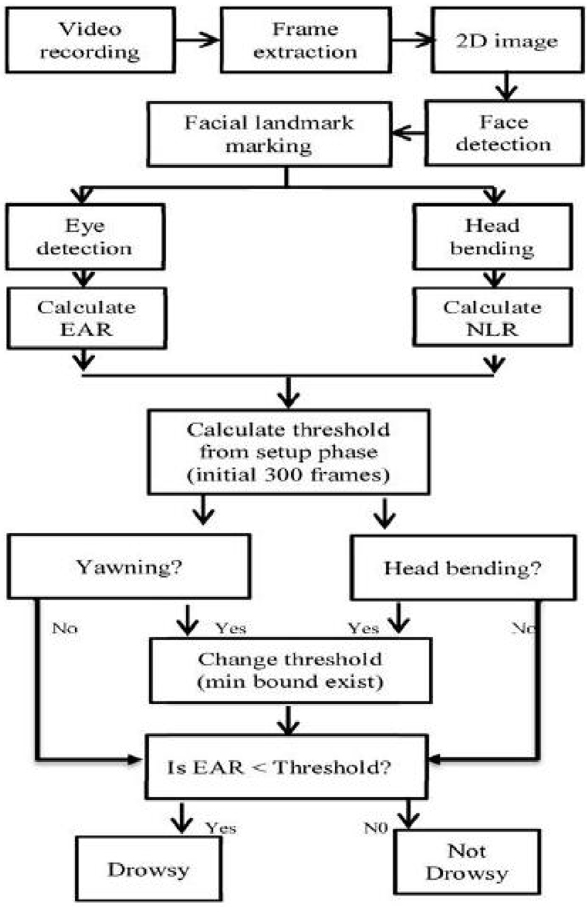

Fig.1 System architecture

ARCHITECTURE OF DISCRIPTION

Visual sensor: This could be a camera or other type of sensor that captures images or video of the driver's face and eyes.

Data pre-processing: The data collected by the visual sensor will need to be pre-processed to extract features that are relevant for detecting drowsiness. This may include cropping the images to focus on the driver's face and eyes, converting the images to grayscale, and applying image processing techniques to enhance the visibility of the driver's eyes. Feature extraction: Machine learning algorithms will need to be trained on data that includes features that are relevant for detecting drowsiness. These features could include the duration and frequency of eye closures, the blink rate, and the gaze direction. Machine learning model: The machine learning model will be trained on a labeled dataset that includes examples of drowsy and non-drowsy drivers. The model will learn to recognize patterns in the data that are indicative of drowsiness.

Alert generation: If the machine learning model predicts that the driver is drowsy, the system will generate an alert to alert the driver to take a break and rest. This alert could be a visual warning, such as a flashing light, or an auditory warning, such as a beep or spoken message.

System evaluation: The performance of the system should be regularly evaluated to ensure that it is accurately detecting drowsiness and generating appropriate alerts. This could be done using data from real-world driving situations or through simulations.

IV. IMPLEMENTATION

MODUL DESCRIPTION

Modules

- Face Detection
- Eye Detection

ISSN: 2366-1313

- Closed eye state Detection:
- Alert System

Modules Description

Face Detection

The first step is to extract the face region from the real time video stream for which the Viola-Jones algorithm is used. The algorithm presented by Paul Viola and Mike Jones was the first of ts kind real-time face detector. The algorithm has 4 steps HAAR Feature Selection, Creating an Integral Image, Adaboost Training and then Cascading Classifiers.

Eye Detection

After face detection the region of the face is defined, now we can search for eyes in this defined region soon this region again the Viola-Jones Cascade classifier is applied to detect eyes.

Closed eye state Detection:

The EAR or the Eye Aspect Ratio is used for determining if the eye is opened or closed. The EAR is a constant value which rapidly falls to 0 when the eye is closed. The EAR is calculated for 20 consecutive frames and if the average EAR is less than the threshold which is 0.25 the trigger is generated.

Alert System

The alert system displays the message on the console and running video stream of application, it can give sound alert also.

METHODOLOGY

Data Acquisition

The video is recorded using webcam (Sony CMU-BR300) and the frames are extracted and processed in a laptop. After extracting the frames, image processing techniques are applied on these 2D images. Presently, synthetic driver data has been generated. The volunteers are asked to look at the webcam with intermittent eye blinking, eye closing, yawning and head bending.

The video is captured for 30 minutes duration using OPenCV.

Face Detection

After extracting the frames, first the human faces are detected. Numerous online face detection algorithms are there. In this Face and facial landmarks like positions of eye and nose are marked on the images detected using Viola-Jones algorithm after detecting the face and facial landmarks Eye Aspect Ratio is used for determining if the eye is opened or closed. In this method, after training, the classifier is tested on the labeled data and the false positive sample feature values are used again for training purpose. For the test image, the fixed size window is translated over the image and the classifier computes the output for each window location. Finally, the maximum value output is considered as the detected face and a bounding box is drawn around the face. This non-maximum suppression step

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removes the redundant and overlapping bounding boxes.

Facial Landmark Detection

Marking After detecting the face, the next task is to find the locations of different facial features like the corners of the eyes and mouth, the tip of the nose and so on. Prior to that, the face images should be normalized in order to reduce the effect of distance from the camera, non-uniform illumination and varying image resolution. Therefore, the face image is resized to a width of 500 pixels and converted to grayscale image. After image normalization, ensemble of regression trees [11] is used to estimate the landmark positions on face from a sparse subset of pixel intensities. In this method, the sum of square error loss is optimized using gradient boosting learning. Different priors are used to find different structures. Using this method, the boundary points of eyes, mouth and the central line of the nose are marked and the number of points for eye, mouth and nose are given in Table I. The facial landmarks are shown in Fig 2. The red points are the detected landmarks for further processing.

Table.1 Facial landmark points

Parts	Landmark Points
Mouth	[13-24]
Right eye	[1-6]
Left eye	[7-12]
Nose	[25-28]

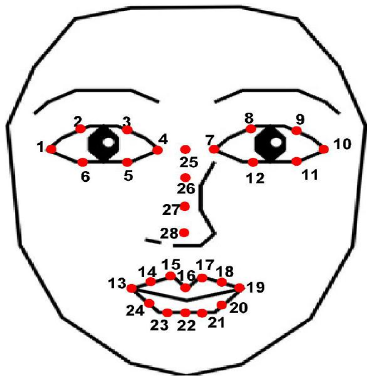

Fig.2 The facial landmark points

Feature Extraction

After detecting the facial landmarks, the features are computed as described below. Eye aspect ratio (EAR): From the eye corner points, the eye aspect ratio is calculated as the ratio of height and width of the eye as given by where represents point marked as i in facial landmark and is the distance between points marked as i and j. Therefore, when the eyes are fully open, EAR is high value and as the eyes are closed, EAR value goes towards zero. Thus, monotonically decreasing EAR values indicate gradually closing eyes and it's almost zero for completely closed eyes (eye blink). Consequently, EAR values indicate the drowsiness of the driver as eye blinks occur due to drowsiness. Mouth opening ratio (MOR): Mouth opening ratio is a parameter to detect yawning during drowsiness. Similar to EAR, it is calculated as defined, it increases rapidly when mouth opens due to yawning and remains at that high value for a while due to yawn (indicating that the mouth is open) and again decreases rapidly. Towards zero. As yawn is one of the characteristics of drowsiness, MOR gives a measure regarding driver drowsiness. Head Bending: Due to drowsiness, usually driver's head tilts (forward or backward) with respect to vertical axis. So, from the head bending angle, driver drowsiness can be detected. As the projected length of nose on the camera focal plane is proportional to this bending, it can be used as a measure of head bending. In normal condition, our nose makes an acute angle with respect to focal plane of the camera. This angle increases as the head moves vertically up and decreases on moving down. Therefore, the ratio of nose length to an average nose length while awake is a measure of head bending and if the value is greater or less than a particular range, it indicates head bending as well as drowsiness. From the facial landmarks, the nose length is calculated and it is defined as 28 25 nose length (p p) NLR average nose length − = The average nose length is computed during the setup phase of the experiment as described in the next sub-section.

Classification

After computing all the three features, the next task is to detect drowsiness in the extracted

frames. In the beginning, adaptive thresholding is considered for classification. Later, machine learning algorithms are used to classify the data. For computing the threshold values for each feature, it is assumed that initially the driver is in complete awake state. This is called setup phase. In the setup phase, the EAR values for first three hundred (for 10s at 30 fps) frames are recorded. Out of these three hundred initial frames containing face, average of 150 maximum values is considered as the hard threshold for EAR. The higher values are considered so that no eye closing instances will be present. If the test value is less than this threshold, then eye closing (i.e., drowsiness) is detected. As the size of eye can vary from person to person, this initial setup for each person will reduce this effect. Similarly, for calculating threshold of MOR, since the mouth may not be open to its maximum in initial frames (setup phase) so the threshold is taken experimentally from the observations. If the test value is greater than this threshold then yawn (i.e., drowsiness) is detected. Head bending feature is used to find the angle made by head with respect to vertical axis in terms of ratio of projected

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nose lengths. Normally, NLR has values from 0.9 to 1.1 for normal upright position of head and it increases or decreases when head bends down or up in the state of drowsiness. The average nose length is computed as the average of the nose lengths in the setup phase assuming that no head bending is there. After computing the threshold values, the system is used for testing. The system detects the drowsiness if in a test frame drowsiness is detected for at least one feature.

To make this Thresholding more realistic, the decision for each frame depends on the last 75 frames. If at least 70 frames (out of those 75) satisfy drowsiness conditions for at least one feature, then the system gives drowsiness detection indication and the alarm. To make this thresholding adaptive, another single threshold value is computed which initially depends on EAR Threshold value. The average of EAR values is computed as the average of 150 maximum values out of 300 frames in the setup phase. Then offset is determined heuristically and the threshold is obtained as offset subtracted from the average value. Driver safety is at risk when EAR is below this threshold. This EAR threshold value increases slightly with each yawning and head bending upto a certain limit. As each yawning and head bending is distributed over multiple frames, so yawning and head bending of consecutive frames are considered as single yawn and head bending and added once in the adaptive threshold. In a test frame, if EAR value is less than this adaptive threshold value, then drowsiness is detected and an alarm is given to the driver. Sometimes it may happen that when the head is too low due to bending, the system is unable to detect the face. In such situation, previous three frames are considered and if head bending was detected in those three frames, drowsiness alarm will be shown

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V. RESULTS

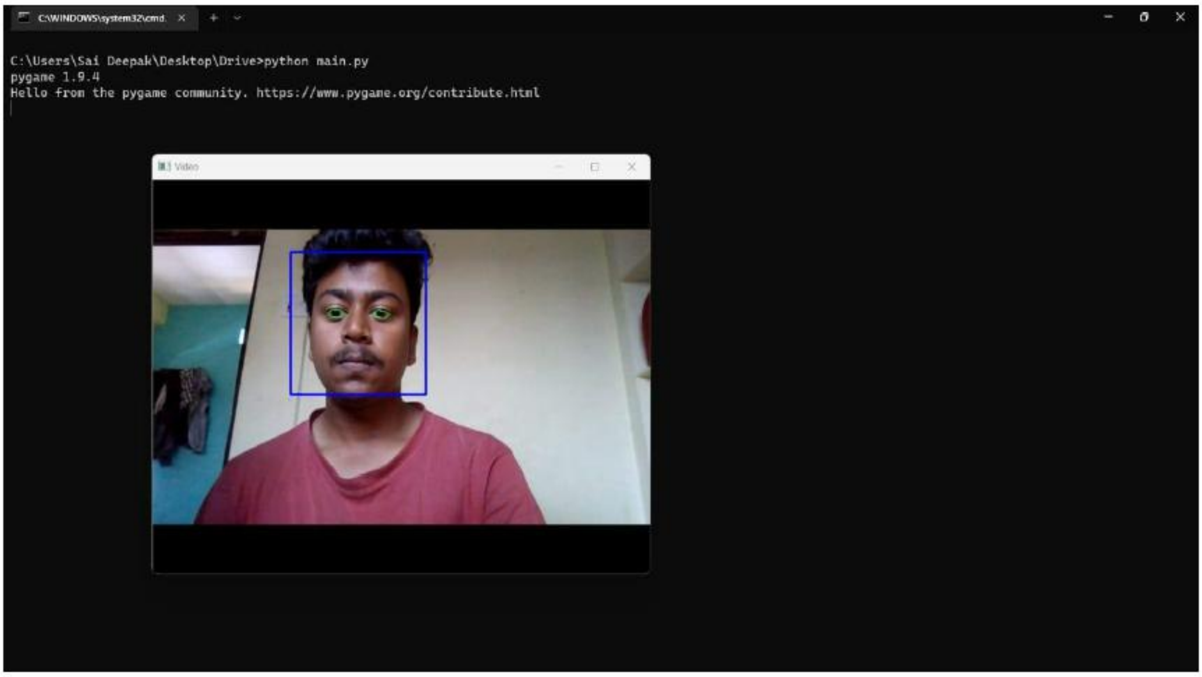

Fig.3 Image uploaded

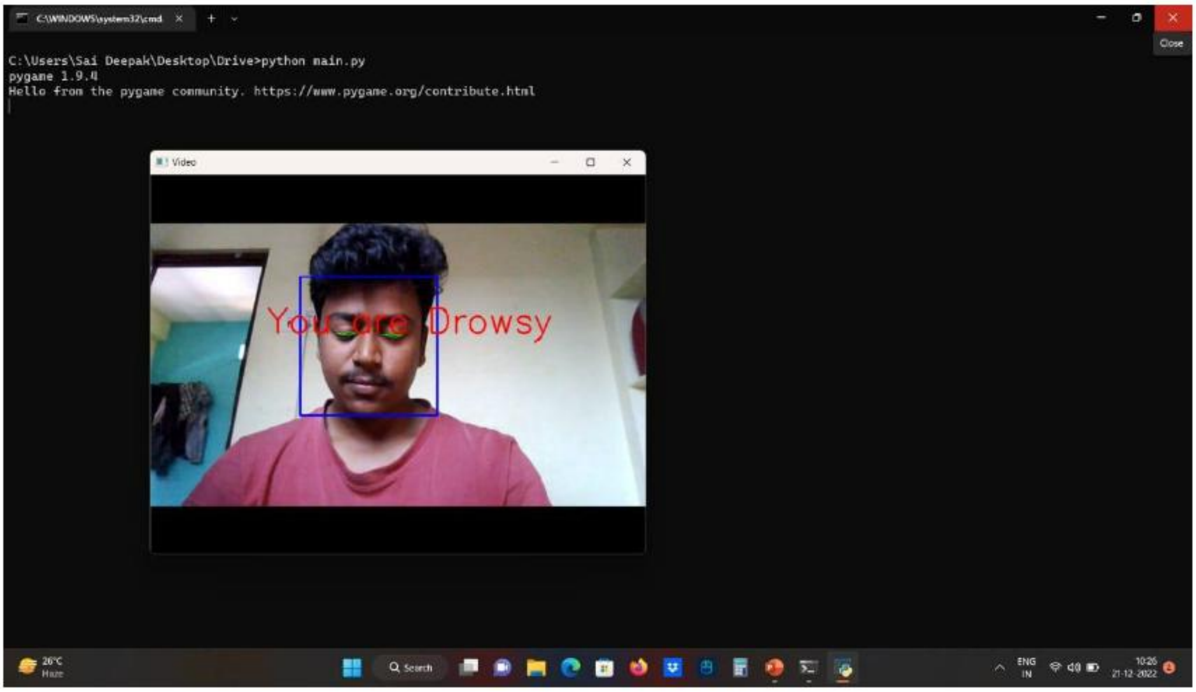

Fig.4 drowsy face recognition

VI. CONCLUSION

In this project, a low-cost, real-time driver drowsiness monitoring system has been developed based on visual behavior and machine learning. Here, visual behavior features like eye aspect ratio, and nose length ratio are computed from the

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streaming video, captured by a webcam. An adaptive threshold technique has been developed to detect driver drowsiness in real time. Machine learning algorithms have been used for visual behaviour features and classification. From the video, the frames are extracted to obtain 2-D images using OpenCV. Face and facial landmarks like positions of eye and nose are marked on the images detected using Viola-Jones algorithm after detecting the face and facial landmarks Eye Aspect Ratio is used for determining if the eye is opened or closed this give better accuracy, work will be carried out to implement them in the developed system to do the classification (i.e., drowsiness detection.

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