DROWSINESS DETECTION SYSTEM

PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report titled DROWSINESS DETECTION SYSTEM was carried out project work under my supervision. Certified further that to the best of my knowledge and belief, the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or an award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

Nowadays, more and more professions require long-term concentration. A countless number of people drive on the highway day and night. Taxi drivers, bus drivers, truck drivers and people traveling long distances suffer from a lack of sleep. Hence it becomes very dangerous to drive while feeling sleepy. Drivers must keep a close eye on the road, so they can react to sudden events immediately. Driver fatigue often becomes a direct cause of many traffic accidents. Therefore, there is a need to develop a system that will detect and alert a driver of his/her drowsiness, which could significantly reduce the number of fatigue-related car accidents. One of the technical possibilities to implement a drowsiness detection system is to use vision-based approach. The computer vision system presented here for detection of driver drowsiness is just a proof of this concept, which can be used after appropriate adjustment.

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.1 MOTIVATION

Driver fatigue is a significant factor in a large number of vehicle accidents. Various studies have suggested that around 20% of all road accidents are fatigue-related, up to 50% on certain roads. Accidents can not only cause severe injuries but also be fatal. Hence it is most imperative to ensure the safety of the driver and the passengers traveling with him/her. We can achieve this by using technology which can play a major role in reducing such accidents.

1.2 CREATIVITY AND INNOVATION

This innovative system combines software components for face detection and a classification algorithm for the eye and mouth state (open vs. closed).The visual input is then used to detect signs of drowsiness. When signs of drowsiness are detected the system issues an alert.

The system uses innovative machine learning algorithms that continuously monitor driver behavior and alerts the driver in real time when certain thresholds are met. The high-speed algorithms provide continuous, real-time analysis of driver imagery without consuming an undue amount of battery power. The system has been demonstrated to be applicable in real time, easily portable to different platforms, highly accurate, and robust.

1.3 SYSTEM FUNCTIONS

In order to capture a clear view of the driver's face the device is mounted securely and aimed precisely at a specific distance. Once mounted, the device begins a training process to determine the face and eye as well as mouth movement. After this calibration, real time monitoring begins, sending an alarm if the eyes or mouth close for prolonged periods; both can be indicators that the driver is falling asleep.

1.4 SCOPE OF THE PROJECT

The advantage of being able to use the ubiquity of the python programming language instead of relying on built-in products with proprietary systems makes it feasible to deploy the system in any vehicle. With today's inexpensive infra-red cameras the device can operate in poor lighting conditions.

With the high rates of accidents caused by drowsy drivers the need for these systems is obvious. Beyond passenger vehicles, drowsiness alert systems can be expected to be applicable to public transportation modalities because taxies,buses, trains, subways, and long-haul truckers all face the same risks from driving drowsy. Adoption in these sectors could be driven by regulatory agencies as part of safety requirements.

1.5 TECHNOLOGIES USED

Python

OpenCV

SciPy

Imutils

Dlib

Pygame

CHAPTER 2

LITERATURE SURVEY

2. MEASURES FOR MEASUREMENT OF DROWSINESS

The study states that the reason for a mishap can be categorized as one of the accompanying primary classes: (1) human, (2) vehicular, and (3) surrounding factor. The driver's error represented 91% of the accidents. The other two classes of causative elements were referred to as 4% for the type of vehicle used and 5% for surrounding factors. Several measures are available for the measurement of drowsiness which includes the following:

1. Vehicle based measure
2. Physiological measures
3. Behavioural measures

2.1.1. VEHICLE-BASED MEASURE

Vehicle-based measures survey path position, which monitors the vehicle's position as it identifies with path markings, to determine driver’s weakness, and accumulate steering wheel movement information to characterize the fatigue from low level to high level. The main advantage of this measure is that it is the easiest to implement and these measures can also avert accidents caused due to other reasons such as drunken driving, etc. But a major disadvantage is that in the subcontinent countries like India, Sri Lanka, etc the lanes are not properly marked. Also, in some cases there was no impact on vehicle-based parameters when the driver was drowsy, which makes the system unreliable.

2.1.2. PHYSIOLOGICAL MEASURE

Physiological measures are the objective measures of the physical changes that occur in our body because of fatigue. These physiological changes can be simply measured by:

- Monitoring Heart Rate using ECG sensor.
- Monitoring Brain Waves using special caps embedded with electrodes.
- Monitoring muscle fatigue using pressure sensors.
- Monitoring eye movements using electro oculogram.

These measures are very effective and also give the result in real time. However, these are not completely reliable as the illumination condition affects the output and the accuracy of the system. Monitoring heart beats and brain wave is very complex especially in a moving car, but this measure is the most accurate way to detect drowsiness.

2.1.3. BEHAVIOURAL MEASURE

Certain behavioural changes take place during drowsing like

1. Yawning
2. Amount of eye closure

3. Eye blinking

4. Head position

2.2. CLASSIFIERS FOR FACE DETECTION

2.2.1. HAAR CASCADE CLASSIFIER

In haar cascade classifier primarily the haar structures are slide over one by one on an image, throughout the pixel values masked in black portion are added similarly all the pixel values overlaid in the white part are added, finally the sum values are compared and accordingly a threshold value is determined. The classifier works on the principle of haar wavelet comparison and returns true value for object/face detection. This process is fast but not completely accurate as it may happen that a certain section of image has similar wavelets to that of the desired output.

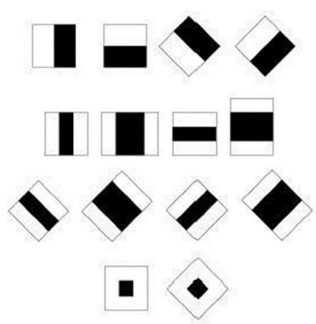


Fig-1: HAAR Features

In cascade classifiers there are n number of weak classifiers arranged in a cascade form. They are placed in such a manner that the first weak classifier is the simplest and then the complexity in each subsequent weak classifier increases linearly making the last weak classifier most complex. The combination of all these weak classifiers form a strong classifier. The main advantage of this classifier is its time efficiency.

2.2.2. HISTOGRAM OF ORIENTED GRADIENT IMAGE DESCRIPTOR

Histogram of Oriented Gradient (HOG) along with Linear Support Vector Machine (SVM) is used to set up highly accurate object classifiers. At first feature matrix is extracted using HOG descriptor and then these features are used to train SVM classifier. The histogram of oriented gradients (HOG) is a feature descriptor used in computer vision and image processing for the purpose of object detection.

The technique counts occurrences of gradient orientation in localized portions of an image. This method is similar to that of edge orientation histograms, scale-invariant feature transform descriptors, and shape contexts, but differs in that it is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy. HOG uses merits of both multi-class and bi-class HOG based detectors to build three stage algorithms with low computational cost. In the first stage, the multi-class classifier with coarse features is used to estimate the orientation of a potential target object in the image; in the second stage, a biclass detector corresponding to the detected orientation with intermediate level features is used to filter out most of false positives; and in the third stage, a bi-class detector corresponding to the detected orientation using fine features is used to achieve accurate detection with low rate of false positives. In this way, features are extracted from an image. After the features are extracted, they are fed to linear SVM algorithm for classification.

CHAPTER 3

SYSTEM DESIGN

3.1. MEASURE USED

Among all these strategies, the most precise technique depends on human physiological measures. Though this method gives the most accurate results regarding drowsiness. But it requires placement of several electrodes to be placed on head, chest and face which is not at all a convenient and annoying for a driver. Also, they need to be very carefully placed on respective places for perfect result. On the other hand, vehicular based method is non-intrusive but mostly affected by the geometry of road and condition like micro sleeping which mostly happens in straight highways cannot be detected. Hence, we will be mostly focusing on behavioural measures such yawning, and amount of eye closure also called (PERCLOS) percentage of closure as it provides the most accurate information on drowsiness. It is also non-intrusive in nature, hence does not affect the state of the driver and also the driver feels totally comfortable with this system. Environmental factors like road condition do not affect this system. The case of micro nap is also detected according the given threshold value.

3.2. CLASSIFIER USED

HOG features are capable of capturing the pedestrian or object outline/shape better than Haar features. On the other hand, simple Haar-like features can detect regions brighter or darker than their immediate surrounding region better than HOG features. In short HOG features can describe shape better than Haar features and

Haar features can describe shading better than HOG features. That is also why Haar features are good at detecting frontal faces and not so good for detecting profile faces. This is because the frontal face has features such as the nose bridge which is brighter than the surrounding face region. But the profile face's most prominent feature is its outline or shape, hence HOG would perform better for profile faces. HOG and Haar-like features are complementary features; hence combining them might even result in better performance. HOG features are good at describing object shape hence good for pedestrian detection. Whereas Haar features are good at describing object shading hence good for frontal face detection. HAAR cascade classifier is affected by the varying light intensity. Also, if an object has HAAR wavelets similar to that of a face it recognizes that object as a face. On the other hand, these limitations are overcome by HOG classifier as it works on the principle of segmentation. Therefore, we are using HOG classifier in this system.

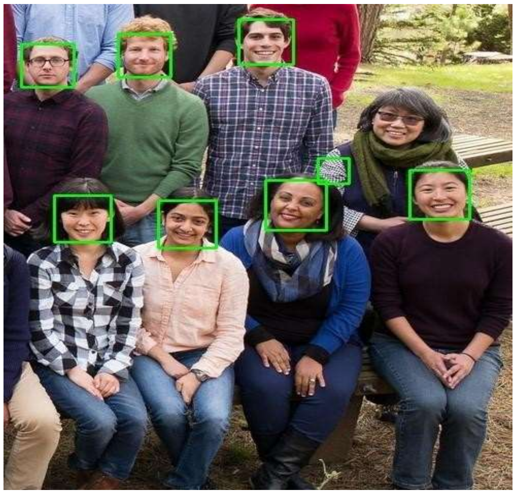
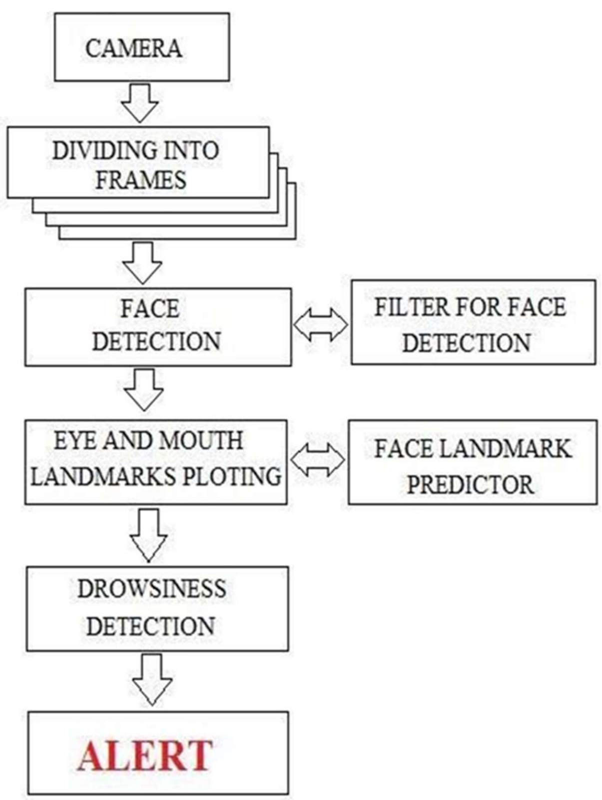


Fig-4: Erroneous face detection using HAAR cascade classifier

Fig-5: Perfect detection of 68 Facial Landmarks using HOG classifier

3.3. FLOW DIAGRAM



CHAPTER 4

IMPLEMENTATION

4.1. TOOLS USED

4.1.1. OPENCV

OpenCV is an open-source computer vision and machine learning software library in Python. Haar Cascade is a machine learning based approach where features are extracted from images using a kind of filter, similar to a convolutional kernel. Among the many features, Adaboost is used to select the best features and trains the classifiers that uses them. This algorithm constructs a strong classifier as a linear combination of weighted simple weak classifiers. Applying all the features on all the windows will take a lot of time. Instead of applying all the features on a window, a cascade of classifiers is used to group the features into different stages of classifiers and apply them one-by-one. If a window fails the first stage, the algorithm discards it and won't consider remaining features on it. If it passes, the algorithm applies the second stage of features and continues the process. A pre-trained Haar cascade model for human face is offered by OpenCV.

4.1.2. SciPy

SciPy is a free and open-source Python library used for scientific computing and technical computing. SciPy contains modules for optimization, linear algebra, integration, interpolation, special functions, FFT, signal and image processing, ODE solvers and other tasks common in science and engineering. SciPy builds on the NumPy array object and is part of the NumPy stack which includes tools like Matplotlib, pandas and SymPy, and an expanding set of scientific computing libraries. This NumPy stack has similar users to other applications such as MATLAB, GNU Octave, and Scilab. The NumPy stack is also sometimes referred to as the SciPy stack.

4.1.3. Imutils

A series of convenience functions to make basic image processing functions such as translation, rotation, resizing, skeletonization, and displaying Matplotlib images easier with OpenCV and both Python 2.7 and Python 3.

4.1.4. Dlib

Dlib is a modern C++ toolkit containing machine learning algorithms and tools for creating complex software in C++ to solve real world problems. It is used in both industry and academia in a wide range of domains including robotics, embedded devices, mobile phones, and large high-performance computing environments. Dlib's open source licensing allows you to use it in any application, free of charge.

In this project it is used to generate a classifier that detects and maps facial landmarks.

4.1.5. PyGame

PyGame is a Python wrapper module for the SDL multimedia library. It contains python functions and classes that will allow you to use SDL's support for playing cdroms, audio and video output, and keyboard, mouse and joystick input.

The PyGame module used specifically in this project is pygame.mixer.This module contains classes for loading Sound objects and controlling playback. The mixer module has a limited number of channels for playback of sounds. Usually programs tell pygame to start playing audio and it selects an available channel automatically. All sound playback is mixed in background threads. When you begin to play a Sound object, it will return immediately while the sound continues to play. A single Sound object can also be actively played back multiple times.

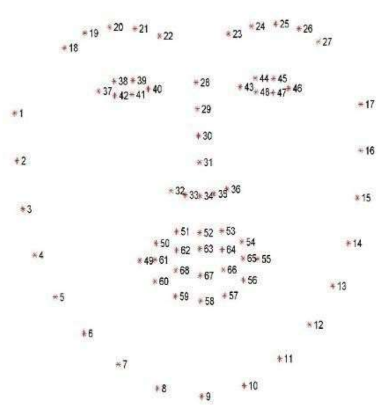
4.2. ALGORITHM

1. At first, a camera is set up that monitors a stream for faces (OpenCV library is used for rapid and accurate image processing).

Each pixel in the given image is classified as a skin pixel or a non-skin pixel. The different skin regions in the skin-detected image are identified by using connectivity analysis to whether each region identified is a face or not.

2. If a face is detected, the landmarks of facial features like eyes and mouth are mapped on the face using dlib library.

- Facial Landmark- It is an inbuilt HOG SVM classifier used to determine the position of 68(x, y) coordinates that map to facial structures on the face.
- The indexes of the 68 coordinates can be seen on the image below:



3. After locating the eye and mouth landmarks, the eye aspect ratio and mouth aspect ratio is calculated to decide whether the driver is drowsy or not. (The eye aspect ratio and mouth aspect ratio are calculated by computing the Euclidean distance between the landmarks using SciPy library.)

4. Further if the eye aspect ratio and mouth aspect ratio varies abruptly from the pre-defined threshold value for a specific amount of time then the buzzer alerts the driver in real time measure varies from person to person. Hence aspect ratio is the flawless parameter to exactly determine eye closure.

4.3. DESCRIPTION OF FEATURES

If the distance between eye lids is measured for determining eye closure, then it may not be the best parameter as this measure varies from person to person. Hence aspect ratio is the flawless parameter to exactly determine eye closure.

Aspect ratio: Aspect ratio is an image projection attribute that describes the proportional relationship between the width and height of an image, in this case eye. The aspect ratio is generally constant when the eye is open and starts tending to zero while closing of eye. Since eye blinking is performed by both eyes synchronously the aspect ratio of both eyes is averaged.

EAR = |CD| + |EF| / 2 * |AB|

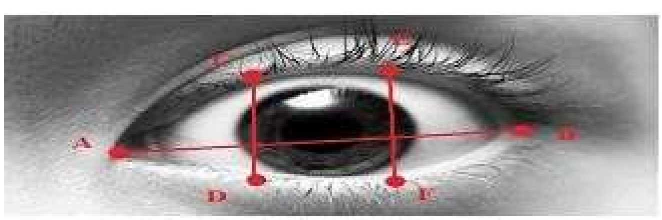


Fig-8: Coordinates for Eyes

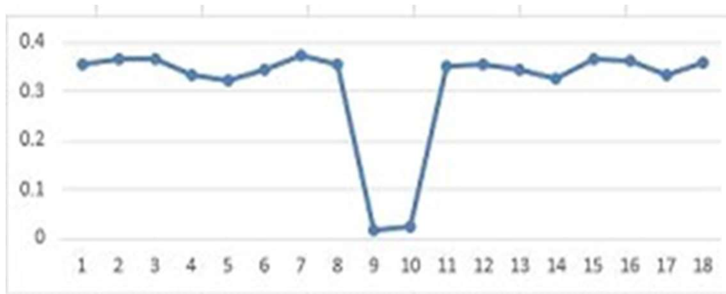


Fig-9: Variation in EAR with Eyes opening and closing

From the graph it is can be seen that the threshold value is 0.3.upto the 8th frame the eye aspect ratio is above the threshold value indicating that the eye is open but as soon as the eye closes the eye aspect ratio drops drastically i.e. from the 8th frame to 12th frame the eye is shut again from the 12th frame as the eye is opened the eye aspect ratio increases above 0.3.

Similarly to determine the yawning parameter the aspect ratio of the mouth is calculated. It is calculated by the following formula,

MAR = |CD| + |EF| + |GH| / 3 * |AB|

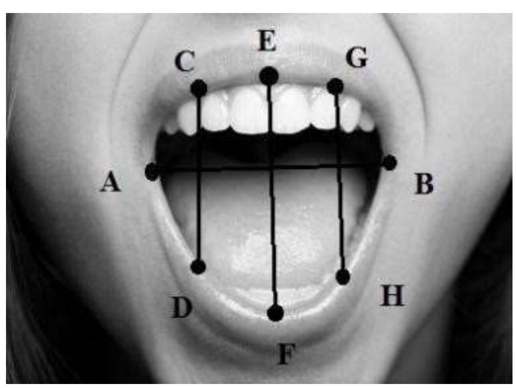


Fig-10: Coordinates for Mouth

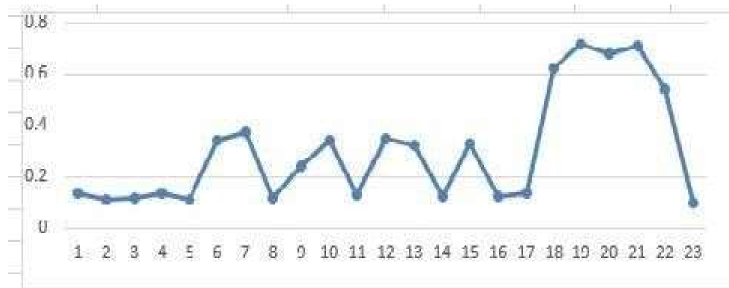


Fig-11: Variation of MAR with Mouth opening and closing

From the graph it is clearly visible that when the mouth is close the mouth aspect ratio almost zero which is case of first 5 frames. When the mouth is slightly open the mouth aspect ratio increases slightly. But in the frames from 17th to 23rd where the mouth aspect ratio is significantly high it is clear that the mouth is wide open most probably for yawning.

CHAPTER 5

RESULTS AND PERFORMANCE ANALYSIS

The results were analyzed for both drowsiness detection due to eye blinking and mouth movement. We have specified the following values for the respective parameters in the source program:

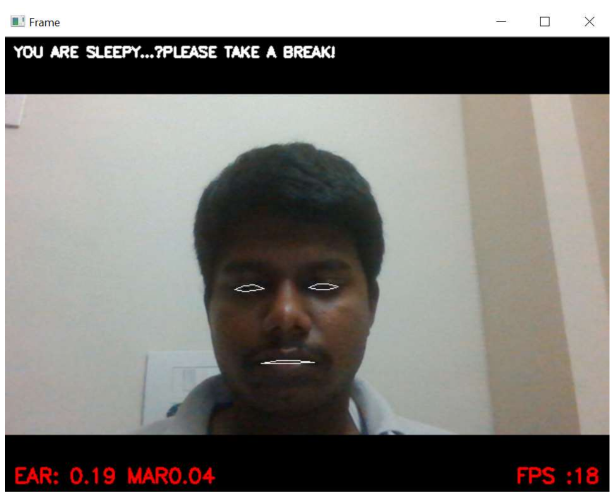
EYE_DROWSINESS_THRESHOLD = 0.25

EYE_DROWSINESS_INTERVAL = 0.75

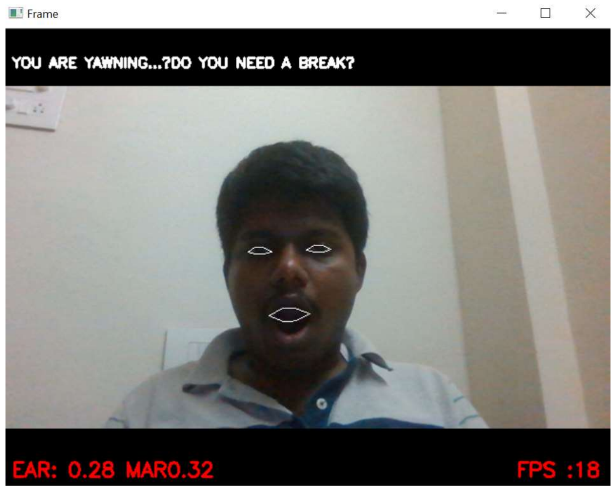
MOUTH_DROWSINESS_THRESHOLD = 0.25

MOUTH_DROWSINESS_INTERVAL = 0.75

DISTRACTION_INTERVAL = 1.00

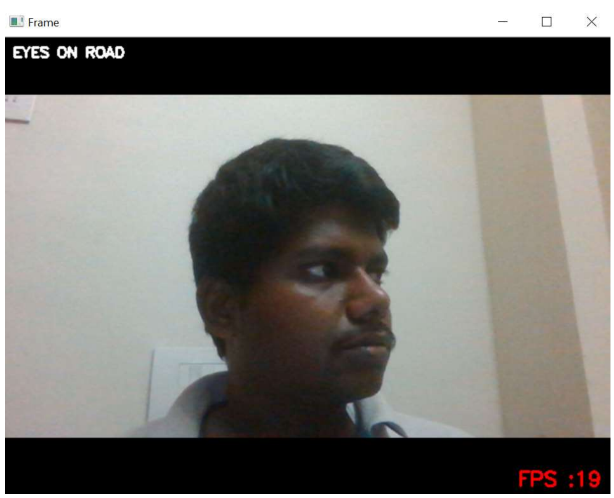


As we can see, when the eye blink lasts more than the specified threshold time thereby lowering the Eye Aspect Ratio (EAR) below the specified threshold value, the driver is alerted by ringing an alarm and popping a special message onscreen. Since the eyes have to be open as much as possible during driving, the program is designed such that the driver is alerted when EAR is *less* than the specified value.



Whereas the mouth has to closed as much as possible during driving, hence the driver is alerted when the Mouth Aspect Ratio (MAR) is *more* than the specified value. The driver is alerted in a similar vein as eye blink detection but with a different message popped up for yawn detection.

The system also works in a similar fashion when both eye blink and yawn is detected at the same time.



The system also works for head movement when the driver is not paying attention to the road. An alarm is rung and a special message is popped on screen.

It is to be noted that for all the above scenarios the alert tones, the messages and the parameters can be changed individually in the source program as per individual requirements. An IR camera can also be attached for improved facial detection in darker environments.

CHAPTER 6

CONCLUSION

This project was successful in providing a solution to alert the driver before a mishap happens. Detecting the driver drowsiness, which is one of the major cause of road accidents, will reduce deaths and injuries to a great extent. There are various methods to detect drowsiness, the best being the behavioral method. HOG classifier is used by calculating the aspect ratio of eyes and mouth. Thus this system detects drowsiness and alerts the driver in real time.

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