Driver Drowsiness Alert System with Effective Feature Extraction

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ABSTRACT

Driver drowsiness is one of the major factor for road accidents. Around 20% of accidents are caused due to drowsy drivers. That's why a driver alert system is the need of the hour. The prime purpose of this system is to detect the driver fatigue and alert the driver. This is done by obtaining frames of the driver's face, captured by the camera attached in the car. The eyes and mouth of the driver are detected and the closure of the eyes and wide opening of the mouth, after the threshold value is surpassed the driver is alert Raspberry pi is the CPU of the system with all the programming in python. A manual ON/OFF is also provided in case the car is in stationery position. The system works irrespective of the color or shape of the face. The ignition of the car doesn't go off when the system alerts to avoid further accidents on highways, etc. Thus this system will definitely reduce the number of accidents caused due to driver drowsiness alerting the driver in real time.

Keywords Term— Drowsiness Detection, Eye Detection, Face Detection, Facial Landmarks, OpenCv.

1. INTRODUCTION

Drivers generally, turn a blind eye to drowsiness while driving but its share in the causes of accidents is significantly high. Drowsiness is taken lightly by everyone, there is no law to punish drowsy drivers nor any devices to detect drowsiness like Breathalyzer which detects if the driver is drunk or a speedometer to check an over speeding car. Also none of the cars have a preventive measure for drowsiness. Thus the primary aim of the project is to develop a prototype drowsiness alert system. This system will accurately monitor the driver's eyes and mouth. This can be used in any car as the camera can be fixed on the car roof without disturbing the driver's line of sight.

A recent study shows that young drivers are more likely to drive sleepy than drunk. The percentage of drowsy driver causing accidents is increasing rapidly. The national sleep foundation (NSF) reported that 51% of adult drivers had driven a vehicle while feeling drowsy and 17% had actually fallen asleep. Unlike drunk where the driver is not in the right state of mind to drive the car, when a driver is sleepy all it needs is to be alerted whereas shutting down the engine can cause a different accident altogether.

The system mainly consists of only three components raspberry pi 3b, camera and a buzzer. The camera attached in the car captures the face of the driver and continuously monitors the eyes and mouth of the driver. The raspberry pi analyses the frames constantly and alerts the driver in real time via buzzer if any irregularity are detected. The buzzer keeps on buzzing until the input is inconsistent, thus bringing the driver back to his senses. Due to its miniature structure it can be easily fitted in any car. Also this system is comparatively cheap than the other safety measures installed in the car.

2. LITERATURE SURVEY

2.1. 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. Behavioral Measure

Certain behavioral 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.

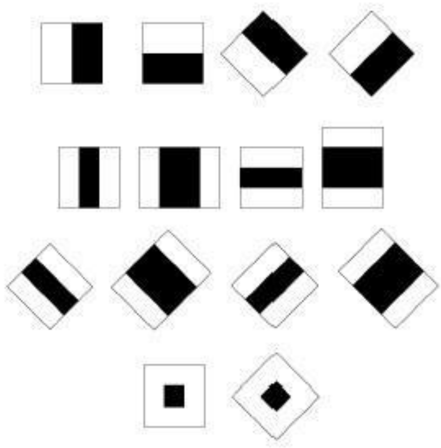

Fig-1: HAAR Features

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 forms a strong classifier. The main advantage of this classifier is its time efficiency.

Fig-2: Face Dectection

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 bi-class 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.

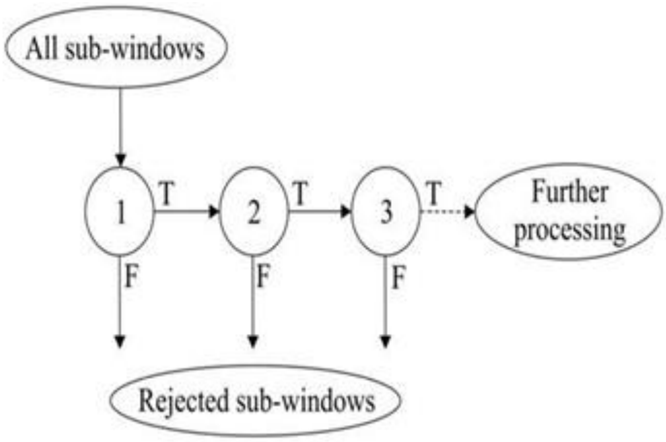

Fig-3: Edge Detection for Lenna Image

3. PROPOSED METHOD

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 behavioral 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 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.

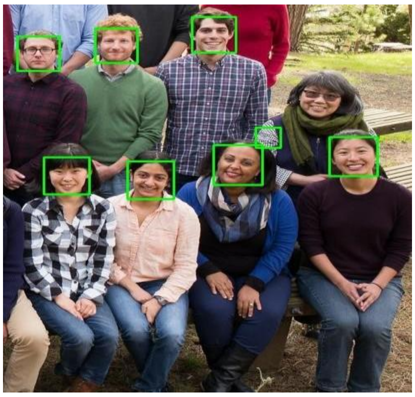

Fig-4: Erroneous face detection using HAAR cascade classifier

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

4. FLOWCHART

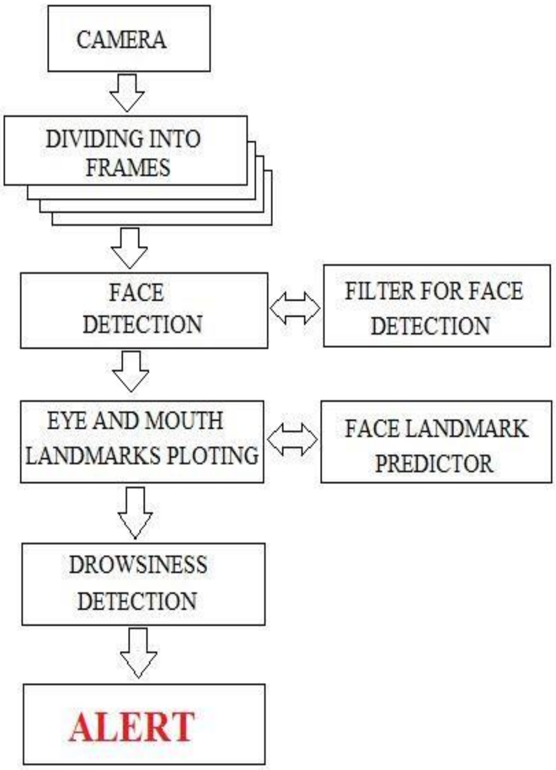

Fig-6: Flowchart for the System

5. 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 a 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:

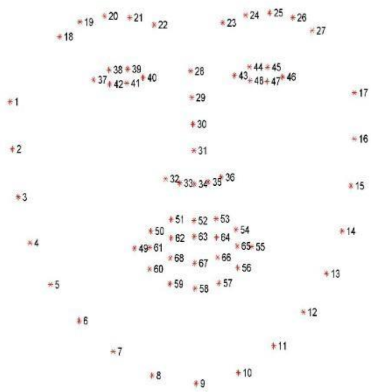

Fig-7: 68 cocrdinates of Facial Landmarks

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 is 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

6. 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.

$$EAR = \frac{|CD| + |EF|}{2 * |AB|}$$

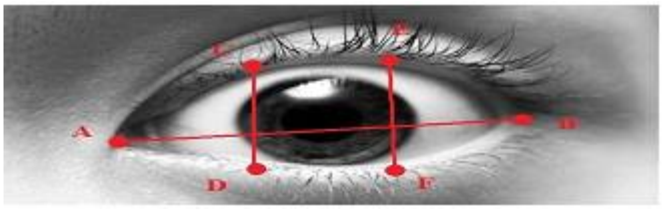

Fig-8: Coordinates for Eyes

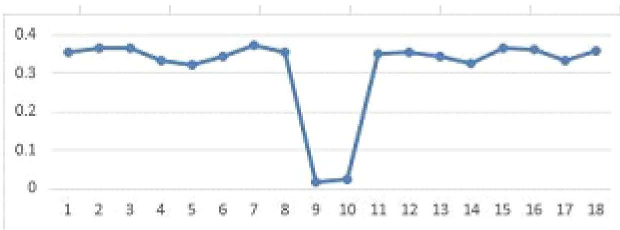

Fig-9: Variation in EAR with Eyes opening and closing

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,

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

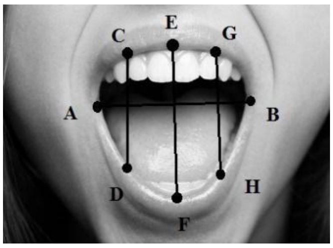

Fig-10: Coordinates for Mouth

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.

7. CONCLUSION

The paper intends to present 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 behavioural 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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