Journal of Engineering Sciences
Vol 12, Issue 7, July/2021
ISSN NO:0377-9254

Real Time Drowsiness Detection System for Driver Monitoring

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Abstract. Drowsiness is amongst the significant causes of road accidents. In today's era, road accidents are one of India's most serious issues, resulting in human loss. Experts say, Drivers who keep driving long distances on the same pace without regular breaks or pauses are likely to be the victims for drowsiness which further leads to road accidents. On the other hand, intoxicated driving, crossing the speed limit, breaking rules and regulations set by the government are few causes of road accidents. There is definitely a major need for developing a system which detects drowsiness or fatigue of a person, especially drivers. Inattentiveness must be warned in pretty high range, to notify drivers of the state which they are currently in. This article proposes a Real Time Drowsiness Detection System For Driver Monitoring with the help of computer vision and machine learning algorithms. The system detects the eye closure, yawning, head bending to identify the drowsiness or fatigue of the driver and make alterations accordingly. The proposed system uses simple and unimpaired methodologies for developing a low cost, accurate model for reducing road accidents and thereby saving human lives.

Keywords: Machine learning, Drowsiness detection, Face recognition, Alarm generation , Water sprinkler activation, Computer vision.

1. Introduction

Drowsiness is a complex phenomenon which states that the driver has less conscious levels. Several direct or indirect methods for detecting the fatigue or drowsiness of drivers are stated. Driving for long hours can be tiresome. Now a days, fatigue and laziness is taking over the daily lifestyle of people. Lack of sleep (uneven sleeping hours), mental and physical stress, addiction to electronic devices are also some of the causes of drowsiness.

The major and supreme reasons for causes of road accidents is drowsiness in India and worldwide as well. Researchers paid lot of attention on the vast increment of road accidents due to drowsiness. It has been proven by researchers that the performance of drivers kept deteriorating with increase in drowsiness. Most of the accidents occur at mid night, stated the top researchers. Keeping this in mind, increase of intelligence systems and vehicles has taken place. Apart from speed of the vehicle, steering wheel movement and continuous driving duration, various other parameters such as eye closure rate, yawning, head bending are considered to be an integral part of a Smart Vehicle System (SVS).

Various other parameters including medical parameters like heart beat rate, pulse rate etc could be implemented.In this system,high vision cameras are used to detect and record the run time images of the driver and generate warning signals accordingly. With respect to this concern,various researchers have mentioned many different models and systems for the automation of measurement of drowsiness. Based on vision, various algorithms were implemented to detect objects such as face. Levels of eye closure was taken as a measure to detect drowsiness. Later, recognition of symptoms of drowsiness of a driver using infrared camera was done. Researchers used the concept of bright pupils and deduced an algorithm for eye detection and detection of drowsiness. On similar basis, eye localization and segmentation were taken as the main concepts. This ultimately led to a non Linear Support Vector Machine (SVM) which is used to upskill the model to detect the drowsy eyes. All these methodologies seemed to be complicated. In the proposed article, the methodology proposed in our system, experimental results, future scope, limitations to the proposed work and conclusion are stated.

2 Literature Survey

2.1 Face and Eye Detection by CNN Algorithms

In this paper a novel approach to critical parts of face detection problems is given, based on analogic cellular neural network (CNN) algorithms. The proposed CNN algorithms find and help to normalize human faces effectively. Time requirement is a fraction of the previously used methods. The algorithm starts with the detection of heads on colored pictures using deviations in color and structure of the human face and that of the background. By normalizing the distance and position of the reference points, all faces should be transformed into the same size and position. For normalization, eyes serve as points of reference. Other CNN algorithm finds the eyes on any grayscale image by searching characteristic features of the eyes and eye sockets. Tests made on a standard database show that the algorithm works very fast and it is reliable.

2.2 Face Detection using Haar Cascades

Object Detection using Haar feature-based cascade classifiers is an effective object detection method proposed by Paul Viola and Michael Jones in their paper, "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001. It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is used to detect objects in other images. Here we will work with face detection. Initially, the algorithm needs a lot of positive images (images of faces) and negative images (images without faces) to train the classifier. Then we need to extract features from it. For this, Haar features shown in the below image are used. They are just like our convolutional kernel. Each feature is a single value obtained by subtracting sum of pixels under the white rectangle, from sum of pixels under the black rectangle.

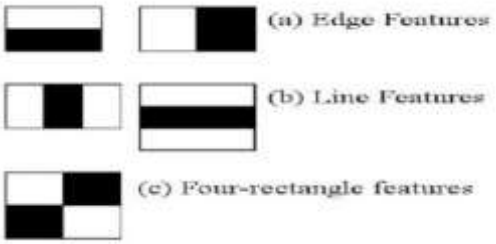

Fig 1.Haar Cascade classifier

2.3 Eye Detection Using Morphological and Color Image Processing

Eye detection is required in many applications like eye-gaze tracking, iris detection, video conferencing, auto-stereoscopic displays, face detection and face recognition. This paper proposes a novel technique for eye detection using colour and morphological image processing. It is observed that eye regions in an image are characterized by low illumination, high density edges and high contrast as compared to other parts of the face. The method proposed is based on assumption that a frontal face image (full frontal) is available. Firstly, the skin region is detected using a color based training algorithm and six-sigma technique operated on RGB, HSV and NTSC scales. Further analysis involves morphological processing using boundary region detection and detection of light source reflection by an eye, commonly known as an eye dot. This gives a finite number of eye candidates from which noise is subsequently removed. This technique is found to be highly efficient and accurate for detecting eyes in frontal face images.

2.4 Algorithm for Eye Detection on Grey Intensity Face

This paper presents a robust eye detection algorithm for grey intensity images. The idea of our method is to combine the respective advantages of two existing techniques, feature based method and template based method, and to overcome their shortcomings. Firstly, after the location of face region is detected, a feature based method will be used to detect two rough regions of both eyes on the face. Then an accurate detection of iris centres will be continued by applying a template based method in these two rough regions. Results of experiments to the faces without spectacles show that the proposed approach is not only robust but also quite efficient.

2.5 Real-Time Face Detection Using Edge Orientation Matching

In this paper we describe our ongoing work on real-time face detection in grey level images using edge orientation information. We will show that edge orientation is a powerful local image feature to model objects like faces for detection purposes. We will present a simple and efficient method for template matching and object modelling based solely on edge orientation information.

We also show how to obtain an optimal face model in the edge orientation domain from a set of training images. Unlike many approaches that model the grey level appearance of the face our approach is computationally very fast. It takes less than 0.08 seconds on a Pentium II 500MHz for a 320x240 image to be processed using a multi-resolution search with six resolution levels. We demonstrate the capability of our detection method on an image database of 17000 images taken from more than 2900 different people. The variations in head size, lighting and background are considerable. The obtained detection rate is more than 93% on that database.

3 Proposed Methodology

In the proposed work, Implementation of features for facial landmark detection is done to identify the state of the driver. 68 predefined landmarks for prediction of shape and to identify the regions of the face like eye, mouth etc. Many variations in parameters of the distinguished points report various expressions of the person. The recognition of facial landmark is carried out as:

Fig 2.The facial landmarks

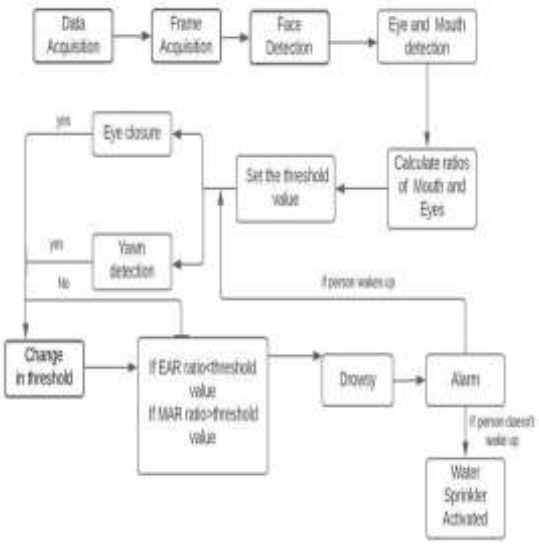

Fig 3.The block diagram of a Real time drowsiness detection and Monitoring system for drivers

A)Workflow

High vision cameras are embedded to monitor and capture to extract frames one by one and generate the alerts accordingly. Each extracted frame is analyzed to study the pattern of facial features; using Haar Cascade Classifier and determined Eye Aspect Ratio(EAR) and Mouth Aspect Ratio(MAR) for each frame [12]. EAR and MAR values exceed their respective threshold values, a blink and a yawn is considered respectively. The system alerts the driver by playing an alarm if eye blinking rate and yawns are suspected for a certain number of consecutive frames. The alarm is activated to grab the driver's attention and it keeps on ringing until driver wakes up.

The monitor is embedded with high capacity computer vision based cameras to extract frames one after the other and to generate alarms based on the information accessed. Each frame is analyzed after extraction and the pattern for facial features are studied using classifier like Haar Cascade. The Eye Aspect Ratio(EAR), Mouth Aspect Ratio(MAR) for each frame is analyzed. The EAR and MAR values for each frame is compared with it's respective threshold value. The system is embedded with an alarm system if eye closure and yawning is suspected for certain consecutive frames. In few cases, the driver doesn't come into active state even after the generation of alarm. In such cases, a water sprinkler system is activated which sprays water on the face of the driver to get him back to consciousness or active state.

B)Facial Features and Gesture Detection

1)Data Acquisition: In this data acquisition video is recorded by using the web cam and frames are extracted in laptop. After thiswe use image processing techniques like open CV are applied to extract the image. As soon as the driver sit in front of the web cam video is recorded. Then we detect features like eye closure, eye blinking and yawning.

2)Frame Acquisition: A high resolution digital camera is set up in the car in such a way that it captures the complete view of the driver. A video is captured and consequently frames are extracted,analyzed to detect the current state of the driver.

3) Face Detection: To locate the frontal face of the driver, algorithms like Histogram of Oriented Gradients(HOG) and Linear Support Vector Machine (SVM) are implemented. This is so done to get accurate results with very few false positive values.

4)Eye Detection and Mouth Detection*:* 68 pixels in (x,y) coordinates of the facial landmarks of the face are acquired by the pre-trained shape predictor in dlib library. The probability of distance between pairs of pixels is used to detect the eyes and mouth in the facial region and Euclidean distance is implemented to assess the distance between the coordinates on the eyes and mouth, thereby finding out the current state of the driver.

C)Eye Closure

Here we consider Eye Aspect ratio(EAR).This EAR ratio is calculated as the ratio of height and width of the eye given by the formula

$$EAR = \ ||P2- P6||+||P3- P5|| /2||P1-P4||$$

Where P1 represents point marked as I in facial landmark and (Pi –Pj) is the distance between points marked as I and j. By using the above formula we can

demonstrate whether the driver is drowsy or not by comparing eye closing and eye opening ratios.

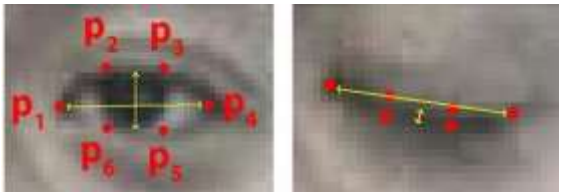

Fig 4.Represents EAR ratio

D)Yawn Counts

Using the dlib landmarks predictor function, 8 coordinates are marked on the mouth starting from the left corner of the mouth in clockwise direction. As shown in Figure-4. The relation between the horizontal and vertical co-ordinates is considered. To determine MAR, the ratio of vertical distance between lower and upper lips to the horizontal distance between the lip corners is calculated.

MAR=||P1– P5||+||P2– P4||2||P6– P3||]

While yawning, the distance between lower and upper lips increases. As soon as MAR value exceeds a certain threshold, the yawn count is incremented .

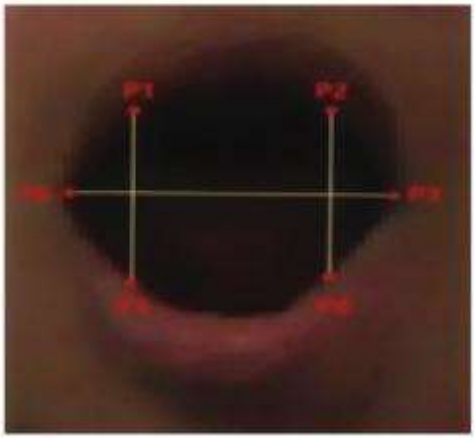

Fig 5.Represents MAR ratio

E)Alarm Activation

When the Eye Closure and Yawn Counts exceed certain specified threshold values for a certain number of frames, the system will take the state of the driver into account as drowsy and will generate an alarm. This would help the driver get back to his original active state.

F)Hardware

In this project we consider user-friendly hardware components such as

- Arduino
- Relay Module
- Battery (9V)
- Motor(3-6V)

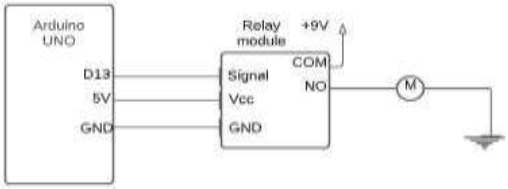

Fig .6 Block diagram of Water Sprinkler

As per the EAR and MAR ratios if the driver doesn't wake up even after the generation of alarm, then these ratios are sent to the Arduino. After receiving these ratios , the Relay Module gets triggered and then it sends 5V of supply to the battery and the water sprinkler gets activated after comparing the thresholds.

G)Water Sprinkler Activation

After the generation of the alarm for certain specified number of times, if the driver doesn't wake up and doesn't turn the alarm off, a water sprinkler is activated which helps in sprinkling water on the face of the driver, thereby waking him up.

4 Results

In our project we develop a GUI application with the help of Tkinter module for the user interface. In this user interface two buttons are located START CAMERA and STOP CAMERA.As soon as we click start camera button the input video is starts recording and EAR and MAR ratios are calculated as mentioned above .This process get terminated after clicking the stop button.

The output results of this Real Time Drowsiness Detection System For Driver Monitoring are as follows:

Fig 7. Represents Normal person with facial landmarks

Fig 8. Represents EAR ratio is detected when the person is drowsy(Alarm generate)

Fig 9. Represents MAR ratio is detected when person is drowsy(Alarm generate)

Fig 10. Water Sprinkler is activated after the alarm generation

5 Conclusion

In the proposed work, a low cost, Real Time Driver Drowsiness Monitoring System has been proposed, based on visual behavior and machine learning. The work is entirely based on Visual behavioral features like Eye Aspect Ratio, Mouth Aspect Ratio are computed from the streaming video and captured through a webcam. An adaptive threshold technique has been developed to detect the drowsiness of driver in real time. The developed system works accurately with the generated synthetic data. Machine learning algorithms have been used for classification and subsequently the feature values are stored. In future, wearable devices such as smart watches or other devices can be used to identify parameters like pulse rate, heart rate, BP etc to detect drowsiness more accurately and efficiently.

6 Acknowledgments

This research project was partially supported by the Department of Computer Science and Engineering, Andhra Loyola Institute of Engineering and Technology, Jawaharlal Nehru Technological University. We are grateful to Assistant Professor Mrs.M.MohanaDeepthi for leading us to develop and contribute a paper to the conference.

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