An Effective Model to Alert a Drowsy Driver using Eye Closure Rate

Pavan Kumar Tadiparthi, Venkata Suma Priya Kankipati, Jessie Alekhya Kandimalla, Priyanka Gottimukkala, Pradeep Kumar Bheemavarapu

Abstract: Transportation plays a major role in today's world. To move from one place to another place (long distances) which cannot be covered by walk, we use vehicles which consumes less time to reach destination. According to statistics, by 2050 the urban population will increase by 68% which leads to an increase in transportation that causes pollution and increase in the rate of road accidents. There are many methods and prevention measures to control pollution. The road accidents are caused due to distracted driving, high speed, drowsy driving and disobeying traffic rules. Among these, drowsy driving has been a cause for 20% of road accidents which is because of fatigue driving. In this article, a model is proposed based on image processing technique which is segmentation and a deep convolutional neural network architecture to improve the performance of the model when compared to the existing models. The proposed model works with better performance in different lighting conditions.

Index Terms: Image Segmentation, Drowsiness, Convolutional Neural Network, Haar feature selection, driver fatigue.

I. INTRODUCTION

Fatigue driving is the state of a driver, after a prolonged period of continuous driving who experiences mental and physical functional disorders. If the driver does not have a good sleep at night, even a short period of driving can still cause fatigue driving. Detecting driver drowsiness plays a key role in reducing number of fatal injuries in traffic accidents. According to worldwide statistics, 20-50 million are injured/killed in car accidents. Development of various techniques for monitoring the driver on a continual basis and then preventing drowsiness of a driver is a major trend and challenge in the area of accident prevention system.In the last two decades, many researchers had proposed various techniques to detect driver drowsiness. Pilutti et al., [1] elucidated the driver's state in lane-keeping task by considering the distance between the driver's vehicle & the vehicle that is in front of it and attaching sensors to vehicle parts such as the steering and the accelerator pedal.

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These systems are affected by the external factors such as lighting and road quality. I. Garcia et al., [2] proposed a method which involves finding where the eyes are located and the condition of eye is detected using the retinal reflections of infrared waves. S. Elsenbruch et al., [3] proposed a methodology that elucidates HRV (Heart rate variability) has 3 frequency bands namely low, very low and high frequency bands. Dong et al., [4] suggested that eye can be analysed by the distance calculation between the two eyelids. Dasgupta et al., [5] indicated the sleepiness by the eyelid closure amount. Boon-Giin Lee et al., [6] proposed an approach to monitor levels of safety by developing an android application which analyses the features such as characteristics of eye, speed of the vehicle etc.

Due to increase in road accidents caused by drowsy driver, there is a need to develop a system which keeps the driver alert. The objective of this article is to concentrate on driver's in-alertness.

The rest of the article is presented as follows: Section II of the article describes the dataset considered. Methodology is explained in Section III. Section IV of the article explains the experimentation process. Section V highlights the experimentation results and the article concludes in Section VI.

II. DATASET

The dataset used to carry out the experimentation comprises of 3000 images with different people's eye with different states of eye drowsiness under different lighting conditions.

III. PROPOSED METHODOLOGY

To detect the drowsiness of the driver the following steps are to be considered. Each of the considered video frames are processed one by one and binarized. Face is detected from the frames using the face detection algorithm and then the eyes from the detected face using the haar feature extraction algorithm. CNN is used to train the given images as mentioned in section [III] of the article processes the eye image and calculate the eye closure rate.

If the score is greater than the minimum score named threshold value, which indicates that the driver is drowsy and alerts the driver by sending a signal to awake the driver, the score gets reduced if the driver turns into alert state and the alert signal halts. If the score is less than the threshold this indicates that the driver is in the active state.
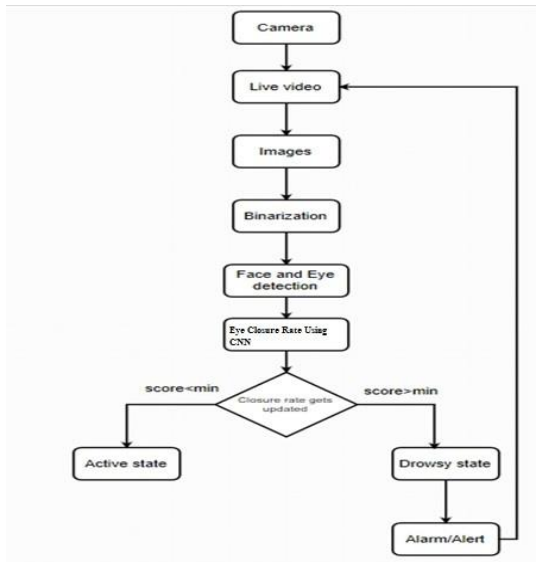
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Fig 1: System Architecture of the proposed model

The preliminary techniques used for experimentation of the proposed model are:

A. SEGMENTATION

Image segmentation is used to sub-divide a larger image into smaller segments. This simplifies the process of analyzing the image. It is used to locate object and curves in images. It assigns a label to every pixel such that pixel with same label represents same property.

B. FACE DETECTION PROCESS

First step for eye detection is face detection. An algorithm named Viola–Jones object detection framework is used for object detection (here objects are face and eyes) which includes all the necessary steps for face detection. We are using selection of Haar characteristics.

C. HAAR FEATURE SELECTION

There are certain features in common that we can find on most of the human faces. Such characteristics are called Haar characteristics. Several types of rectangles can be applied for extracting Haar entities. Here is an example of rectangles used in Haar feature selection:

Fig 2: Sample Haar rectangles

The value of the function can be obtained by just subtracting summation of white pixel areas from the summation of black pixel areas as follows.

$$\Sigma(pixels\ of\ black\ area) - \Sigma(pixels\ of\ white\ area)$$
(1)

EYE DETECTION PROCESS

Viola-Jones algorithm for detecting face based on eyes coding. Steps involved in it are:

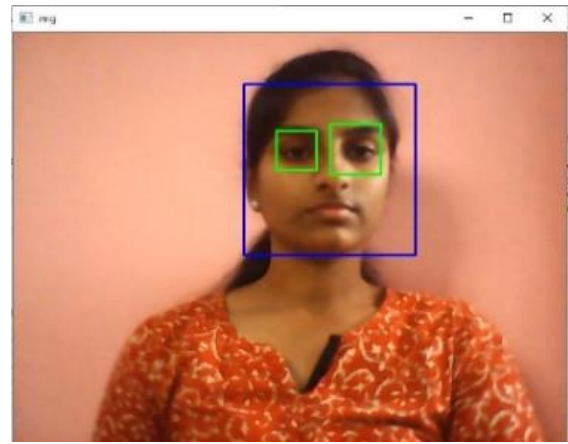1: Detection of eyes in already detected faces

2: Eye detection

Fig 3: Haar feature extraction

D. CONVOLUTION NEURAL NETWORK (CNN)

CNN is used to differentiate between a set of given images. As humans can identify the differences in a given image, we can use CNN to make the system able to differentiate. CNN takes an image as input and pass it through a series of convoluted layers and the output can be obtained as a probability of classes describing the image.

The CNN architecture used in the proposed model is as follows: 4 hidden layers with 3 Conv2D layers with (32, 32, 64) units having kernel size 3*3 and another fully connected hidden layer with 128 units. The output layer has 2 units. The ReLU activation function is used in all layers.

IV. EXPERIMENTATION

The images are taken from the webcam. Webcam is accessed on a continual basis; an infinite loop is run which captures the images. Firstly, to recognize the face in the image, we must convert the image to grayscale. Then using haar cascade classifier for face and eye detection as already discussed in section [III] of the article. We use the CNN classifier to predict the condition of the eye discussed in section [III] of the article. The score value is compared with the threshold value and alert is given accordingly as mentioned in section [III] of the article.

The entire experimentation is carried out in PYTHON (version 3.7.0) environment using keras and tensorflow modules.

V. EXPERIMENTATION RESULTS

The experimentation is conducted with the proposed model by considering the set of images described in section II of the article for training and we have considered live data for validation. The results are divided into two sub-sections as follows:

A. HAAR FEATURE EXTRACTION

After applying Haar feature extraction process of Viola–Jones, we detect the face and eyes from the given input image.
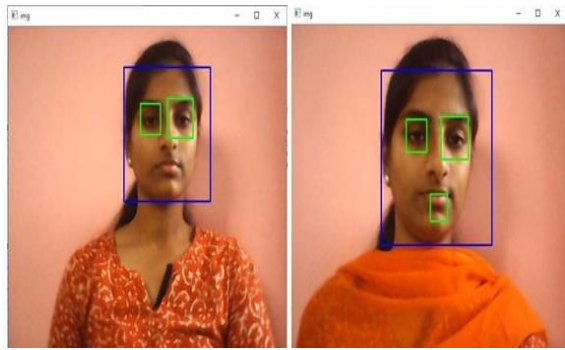
Fig 4: Detecting eyes and face

After the extraction of face and eyes, the state of the eyes is determined and the score changes according to the driver's state.

B. THE STATE OF EYES DETERMINATION

Fig 5a,6a,7a,7b indicates open eye state i.e. the eye closure score is less than the threshold value. In Fig 6b score is increasing as the person closes the eyes but still score is below threshold, where as Fig 5b represents that the person closed the eyes and score increases accordingly and crosses the threshold then an alert is given. Fig 5c,6c,7c illustrates a case where the person still continues to be in drowsy state hence the alarm doesn't stop alerting.

VI. CONCLUSION

In this article, we have developed a model that computes the driver's eye closure value to detect drowsiness. The model uses the Viola Jones method to extract the features (face and eyes) using haar feature

extraction and recognize whether the eyes are open or closed. The results are presented in Section V of the article. From the above results it can showcased that the proposed model performs well under different lightning conditions.

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