



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 2, February 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.118



9940 572 462



6381 907 438



ijirset@gmail.com



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# Drivers Drowsiness Detection with Deep Learning

**Ramshija.K.K, Dr Smitha G.L, Dr P. Vivekanandan**

M Tech Student, Department of Computer Science & Engineering, Royal College of Engineering and Technology,  
Akkikavu, Thrissur, India

Associate Professor, Department of Computer Science & Engineering, Royal College of Engineering and Technology,  
Akkikavu, Thrissur, India

Head of Department of Computer Science & Engineering, Royal College of Engineering and Technology, Akkikavu,  
Thrissur, India

**ABSTRACT:** The developments in technology over the years bring the support to drivers using smart vehicle systems, there has been substantial increase in road accidents too. The most significant reasons for the same is drowsiness. "Drowsiness" is defined as brief and involuntary intrusions of sleep that can occur at any time due to fatigue or a prolonged conscious effort. In vehicle safety technology, driver drowsiness detection is major possible area to prevent large number of sleep induced road accidents. This work, propose an efficient methods of deep learning techniques with adaptive deep neural networks based on MobileNet-V2, which analyzes the videos and detects driver's activities in every frame to learn features automatically and leverage the advantage of the transfer learning technique to train the proposed networks on our training dataset.. Empirical results demonstrate that the proposed method achieves a high accuracy of 95%. As they are very good feature extractors, and can capture and learn relevant features of drowsiness from video at different levels similar to a human brain also instead of focusing on the two regions of the eyes and mouth, the proposed deep neural networks analyze the videos and detect the driver's activities in every frame to automatically learn features of drowsiness such as head orientation, yawning, eyelid opening, eye blinking etc for drowsiness prediction. Experiments were conducted on dataset collected with haar cascade frontal face detector method. After training the session with transfer learning, in the testing face deep neural network model called caffe model for capturing the drivers face and analyzing the awake and drowsy state. By placing a particular count and if the person feel drowsy by giving alarm alerting the driver. the effectiveness of the proposed method in accuracy and reliability. As transfer learning used it solves the problem of small training datasets, training time, and keeps the advantage of the deep neural networks. It provides meaningful solutions in practice to prevent unfortunate automobile accidents caused by drowsiness. The proposal presented here is a promising and can be considered a solid base line for future works.

**KEYWORDS:** Haar Cascade Classifier, Transfer Learning, Caffe Model, MobileNetV2.

## I. INTRODUCTION

"Drowsiness" is defined as brief and involuntary intrusions of sleep that can occur at any time due to fatigue or a prolonged conscious effort. In a vehicle safety technology, driver drowsiness detection is very essential to prevent road accidents. Now-a-days, many people using automobiles for daily commutation, higher living standards, comfortability, and timing constraints to reach destinations. This leads to high volumes of traffic in urban areas and highways. In turn, it will raise number of road accidents with several factors. Driver drowsiness could be the one reason for road accidents. One way to reduce number of accidents is early detection of driver drowsiness and alerting with an alarm.

### *Background*

According to the recent report of National Highway Traffic Safety Administration shows every year around 72,000 road accidents, 800 deaths and 44,000 injuries are occurred due to driver drowsiness. There are different signs of driver drowsiness can be observed while driving the vehicle such as inability to keep eyes open, frequently yawning, moving the head forward etc. To determine the level of driver drowsiness mainly 3 measures are using. These measures are Physiological Measures, Behavioral Measures and Vehicle-based Measures.

- **Physiological measures:** Electrocardiography (ECG), Electroencephalography (EEG), and

Electrooculogram (EOG) are used to access the driver's conditions. Even though these devices provide accurate results, because of their practical limitations, these are not widely accepted.

- **Vehicle based measures:** Drowsiness is analyzed based on steering wheel movements and braking patterns. These methods are reliant on the road nature and driving skills of the driver.
- **Behavioral measures:** Based on person behavior instead of vehicle. Here smart camera is used to capture the driver information. Behavioral Measures are the best ways to detect driver drowsiness.

In our proposed method Behavioral Measures are used to detect driver drowsiness. Figure 1 shows the general architecture of driver drowsiness.

#### Objective

In recent years, building an intelligent system for drowsy driver detection has become a necessity to prevent road accidents. Therefore, it requires a lot of research to design robust alert methods to recognize the level of sleepiness while driving, to suggest an efficient way.

- To detect the early symptoms of drowsiness before the driver has fully lost all attentiveness.

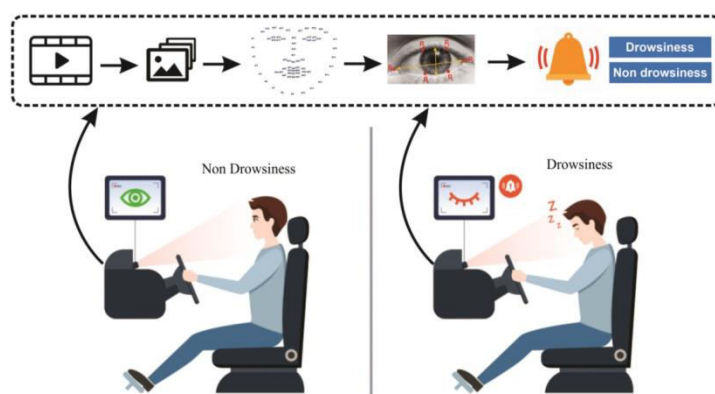


Figure 1: GENERAL MODEL OF A DROWSY DETECTION SYSTEM

- To detect blinks and yawns based on appropriate thresholds for each driver.
- To analyze the videos and detect driver's activities in every frame to learn all features automatically.
- To leverage the advantage of the transfer learning technique to train the proposed networks on our training dataset.

#### Scope of the project

In recent years, driver drowsiness has been one of the major causes of road accidents and lead to severe physical injuries, deaths and significant economic losses. The mortality rate due to drowsiness is very high because the acknowledgement, observation and vehicle control abilities reduces sharply when a person falls asleep. Most often drowsiness happens suddenly so driver loss his consciousness and control that he cannot make awareness to co-driver. Most of the heavy vehicles are allowed on the road in night with particular time limit only. So heavy drivers sometimes included in day job in order to meet their livelihood and at night they will be driving too. So statistics indicate the need of a reliable driver drowsiness detection system which alert the driver before a mishap happens is one of the relevant topic in researchers.

## II. RELATED WORKS

#### Sensor based drowsiness detection

Around 2012 Most paper for drowsiness detection were based on sensors. Arun Sahayadhas, Kenneth Sundaraj proposed paper "Detecting Driver Drowsiness Based on Sensors: A Review" includes method of detecting Vehicle position in lane monitoring Uses a lane monitoring camera. Monitoring a driver this way only works as long as a driver actually steers a vehicle actively instead of using an automatic lane-keeping system. Steering Wheel Movement (SWM) is measured using steering angle sensor and it is a widely used vehicle-based measure Physiological measurement Requires body sensors to measure parameters like brain activity, heart rate etc (electrocardiogram (ECG), electroencephalogram (EEG) and electro-oculogram (EOG)[1].



*Machine Learning based detection*

Hussein Ali Ameen, Azmi Sidek, Saravanaraj Sathasivam proposed the paper "Drowsiness Detection System using Eye Aspect Ratio Technique". In this paper, They address, the state of the car driver using Eye Aspect Ratio (EAR) technique. A developed system that occupied with the Pi camera, RaspberryPi 4 and GPS module are used to detect and analyse continuously the state of eye closure in real time. The role of the system is to detect eyes location from images and calculate the value of EAR. According to the experimental results, it successfully detects person during drowsy condition. However, there is still space for the performance improvement. The further work will focus on detecting the distraction and yawning of the driver[2].

*Deep Learning based detection*

An Eye-tracking based driver drowsiness system was proposed by Said et al [3]. In this work the system finds the driver's drowsiness and rings the alarm to alert to the driver. In this work, Viola Jones model was used to detect the face region and eye region. It has produced an accuracy of 82% in indoor tests and an accuracy of 72.8% for outdoor environment.

For bus driver monitoring, Mandal et al. [4] developed a vision-based fatigue detection system. In this work, A HOG and SVM are used for head-shoulder detection and driver detection respectively. Once driver is detected they used OpenCV face detector for face detection and OpenCV eye detector for eye detection. Spectral Regression Embedding 462 was used to learn the eye shape and a new method was used for eye openness estimation. Fusion was applied to fuse the features generated by two eye detectors I2R-ED and CV-ED. PERCLOS was calculated for drowsiness detection.

Jabbar et al. [5] proposed Convolutional Neural Network (CNN) technique of the ML algorithm to detect microsleep and drowsiness. In this paper, detection of driver's facial landmarks can be achieved through a camera that is then passed to this CNN algorithm to properly identify drowsiness. Here, the experimental classification of eye detection is performed through various datasets like without glasses and with glasses in day or night vision. So, it works for effective drowsiness detection with high precision with android modules.

The work proposed by Dwivedi et al. in [6], used deep learning for detecting facial features. It used a 3-layered CNN for detecting facial features by the image of the driver, that are fed as input to the CNN network. Another advancement of this work was proposed by Park et al. [7]. He used three features and used 3-CNN models to detect these three features. The features used were behavioral features, environmental and background, and facial features. The output of these models is classified into four categories as: non-drowsiness, drowsiness with yawning, nodding and eye blinking.

*IoT based drowsiness detection*

Anil Kumar Biswal, Debabrata Singh proposed paper "IoT-Based Smart Alert System for Drowsy Driver Detection"[8], they address a drowsy driver alert system that has been developed using technique in which the VideoStream Processing (VSP) is analyzed by eye blink concept through an Eye Aspect Ratio (EAR) and Euclidean distance of the eye. Face landmark algorithm is also used as a proper way to eye detection. When the driver's fatigue is detected, the IoT module issues a warning message along with impact of collision and location information, thereby alerting with the help of a voice speaking through the Raspberry Pi monitoring system.

Dr.K.S.Tiwari, Supriya Bhagat proposed the paper "IOT Based Driver Drowsiness Detection and Health Monitoring System"[9]. This paper provides USB Camera for Eye-Blink Monitoring System and provide buzzer that alerts the driver during the drowsy condition. Driver's location can be track using GPS. The health monitor of driver is taken care by wearable heart beat sensor, temperature sensor. Alcohol sensor is provided to detect the alcoholic condition of a rider, and when this condition exists the vehicle speed goes down.

**III. PROPOSED METHOD**

Adaptive deep neural networks are proposed and developed on the advanced networks of MobileNet-V2 which are more efficient in terms of memory and complexity compared to the basic CNN models in the prior works. The use of these proposed deep neural networks is motivated by the fact that they are very good feature extractors, since they can capture and learn relevant features of drowsiness from an image or video at different levels similar to a human brain; instead of focusing on the two regions of the eyes and mouth, the proposed deep neural networks analyze the videos and detect the driver's activities in every frame to automatically learn all features of drowsiness such as head orientation, yawning, eyelid opening, eye blinking, nodding etc. for drowsiness prediction. Experiments were conducted on a large dataset to test the effectiveness of the proposed method in accuracy and reliability. Therefore, our method achieves the high accuracy of 90%; it also leveraging the advantage of transfer learning, the proposed networks are trained on our training dataset. This solves the problem of small training datasets, training time, and keeps the advantage of the deep neural networks. In this method, the drowsiness detection using deep neural networks (DNNs) includes two phases, the training and testing.

#### IV.METHODOLOGY

##### *a,Data Set Collection*

I had collected around 1000 drowsy and non drowsy image using haar cascade frontal face detection model. The repository has the models stored in XML files, and can be read with the OpenCV methods.

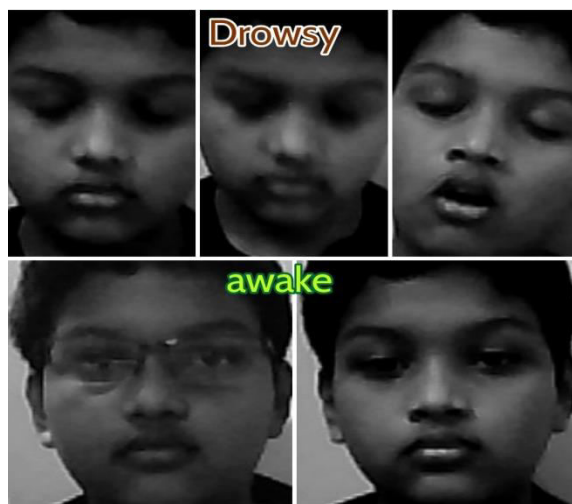


Figure 2: SAMPLE DATASET

**Haar Cascade** is a feature-based object detection algorithm to detect objects from images. A cascade function is trained on lots of positive and negative images for detection. Haar cascade uses the cascade function and cascading window. It tries to calculate features for every window and classify positive and negative. If the window could be a part of an object, then positive, else, negative. The main step included in haar classifier is as follows

- **Haar Features**

The darker areas in the haar feature are pixels with values 1, and the lighter areas are pixels with values 0. Each is responsible for finding out particular feature in the image. Such as an edge, a line or any structure in the image where there is a sudden change of intensities.

The objective is to find out the sum of all the image pixels lying in the darker area of the haar feature and the sum of all the image pixels lying in the lighter area of the haar feature and then find out their difference. Now if the image has an edge separating dark pixels on the right and light pixels on the left, then the haar value will be closer to 1. That means, we say that there is an edge detected if the haar value is closer to 1. In the example above, there is no edge as the haar value is far from 1. To detect an edge anywhere in the image, the haar feature needs to traverse the whole image for a single rectangle on either side, it involves 18 pixel value additions (for a rectangle enclosing 18 pixels). Imagine doing this for the whole image with all sizes of the haar features. This would be a hectic operation even for a high performance machine. To tackle this, they introduced another concept known as The Integral Image to perform the same operation.

- **Integral image** An Integral Image is calculated from the Original Image in such a way that each pixel in this is the sum of all the pixels lying in its left and above in the Original Image. The calculation of a pixel in the Integral Image can be seen in the table. The last pixel at the bottom right corner of the Integral Image will be the sum of all the pixels in the Original Image

|   |   |   |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 1 | 1 | 1 |

|   |   |   |
|---|---|---|
| 1 | 2 | 3 |
| 2 | 4 | 6 |
| 3 | 6 | 9 |

Table 1: INPUT IMAGE      Table 2: INTEGRAL IMAGE

Figure 3: Input and integral image

- **Adaboost** There are approximately 16000+ features values in a detector based resolution but only few

set is needed to identify the face. That is lots of relevant and irrelevant features. In order to find the best features among all adaboost algorithm is using. After finding out these features a weighted combination of all features used in finding out whether it contain face or not. It would be able to include the features if more than half is obeyed. Actually finding out these features are called weak classifiers and adaboost combine these weak classifiers and form a strong classifier. If  $F_1(x)$  is the strong classifier and  $f_1(x), f_2(x), f_3(x)$  are weak classifiers then

$$F_1(x) = \alpha_1 f_1(x) + \alpha_2 f_2(x) + \dots \quad (1)$$

• **Cascading** Scanning the detector many times through the same image each with a new size is one of the basic principle of ViolaJones algorithm. Even if the image contain one or more faces it is clear that excessive large sub window contain non faces. so the algorithm would disregard the non faces quickly and concentrate more on probable faces. A single strong classifier is not a good idea as the computational cost is high. So a cascade classifier is used which composed of each stages containing strong classifiers. so features are grouped into stages and each stage has many features too. The job of each stage is to determine whether the subwindow is definitely face or not a face.

### ***b, Training***

#### *Loading dataset and data augmentation*

Firstly loading the dataset by defining the path and categories. preprocessing the collected raw data into an understandable format. The main aim of this step is to study and understand the nature of data that was acquired in the previous step and also to know the quality of data. As the dataset is of images which saved in the two folder awake and drowsy collected using haar cascades, loading them into proper size of  $224 \times 224$  and format.

Also in these step based on existing images in dataset, to improve dataset new images are creating by applying some augmentation steps like orientation, horizontal flips, zooming shearing etc

#### *Splitting dataset and Training through transfer learning model*

In order to extract features and train, the training dataset is passed through deep neural networks (DNNs). MobileNet-v2, is using and by making improve- ments in some layers of these networks to adapt the drowsiness detection to our model. Constructing an adaptive network by adding layers such as Flatten, Dense (Relu), Dropout, Dense (Softmax) and by suppressing the AveragePooling2D layer of the MobileNet-v2 network. It aims at solving the problem of overfitting and helps the model to converge faster.

#### *Transfer learning and MobilenetV2*

Transfer learning refers to the situation where what has been learned in one setting is exploited to improve generalization in another setting. First train a base network on a base dataset and task, and then we repurpose the learned features, or transfer them, to a second target network to be trained on a target dataset and task. Taking advantage of the transfer learning approach, the proposed networks are pretrained on datasets of Bing Search API, Kaggle, and RMFD. We use the pre-trained weights and re-train them on our training dataset to fine- tune the parameters of these networks. This leads to faster learning, a shorter training time, and no requirement for large training datasets.

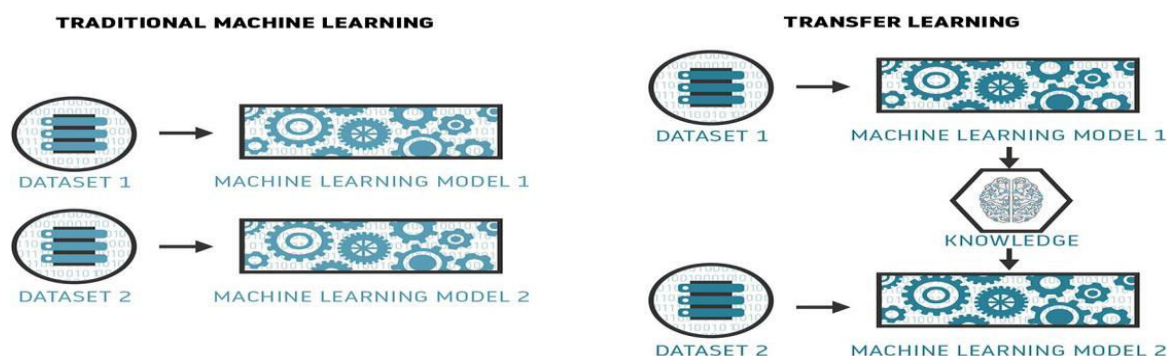


Figure 4: TRANSFER LEARNING

MobileNetV2 is a convolutional neural network architecture that seeks to perform well on mobile devices. It is based on an inverted residual structure where the residual connections are between the bottleneck layers. The intermediate

expansion layer uses lightweight depthwise convolutions to filter features as a source of non-linearity. As a whole, the architecture of MobileNetV2 contains the initial fully convolution layer with 32 filters, followed by 19 residual bottleneck layers. In MobileNetV2, a better module is introduced with inverted residual structure. Non-linearities in narrow layers are removed this time. With MobileNetV2 as backbone for feature extraction, state-of-the-art performances are also achieved for object detection and semantic segmentation. In MobileNetV2,

- There are two types of blocks. One is residual block with stride of 1. Another one is block with stride of 2 for downsizing.
  - There are 3 layers for both types of blocks.
  - The first layer is  $1 \times 1$  convolution with ReLU6.
  - The second layer is the depthwise convolution.
  - The third layer is another  $1 \times 1$  convolution but without any non-linearity. It is claimed that if ReLU is used again, the deep networks only have the power of a linear classifier on the non-zero volume part of the output domain.
  - And there is an expansion factor  $t$ . And  $t=6$  for all main experiments. If the input got 64 channels, the internal output would get  $64 \times t = 64 \times 6 = 384$  channels.
- After compiling the model, training the head of network and fitting the model making predictions as drowsy or awake. About 95% result is obtained and obtained the plot as 6.

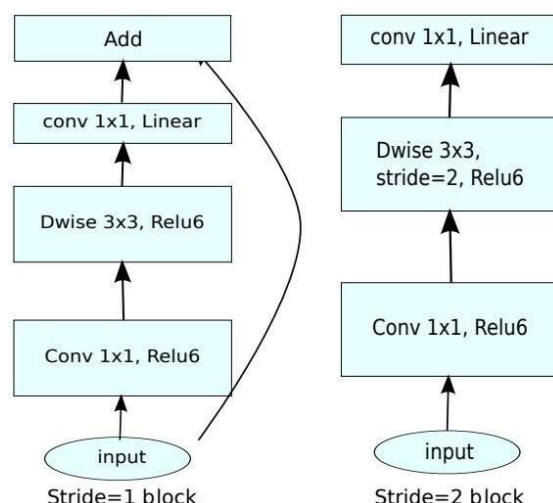


Figure 5: MOBILENETV2 ARCHITECTURE

### c, Testing

After training our model, Deep Neural Network Face Detector in OpenCV is used in the testing phase for face detection. In these stages by passing our trained model and Caffe model, it is predicting whether awake or drowsy.

- **Deep Neural Network Face Detector in OpenCV or the Caffe model.** It is a Caffe model which is based on the Single Shot-Multibox Detector (SSD) and uses ResNet-10 architecture as its backbone. It was introduced post OpenCV 3.3 in its deep neural network module. For general computer vision problems, OpenCV's Caffe model of the DNN module is the best. It works well with occlusion, quick head movements, and can identify side faces as well. Moreover, it also gave the quickest fps among all. Deep Neural Network layers which are nothing but a neural network which contain more hidden layers along with one input and output layer, in this network each layer consists of different features of the processing image whereas a normal neural network consists of only one hidden layer, deep neural network processes the faces in a better way using the more hidden layers. In this method whenever a face is present it will detect the faces and draw a rectangular box around the face and above the box it shows accuracy or confidence in detecting the face. The overall steps are as follows.
- Grabbing the dimensions of the frame using `frame.shape()` and then constructing a blob from it using `cv2.dnn.blobFromImage(frame, 1.0, (224, 224), (104.0, 177.0, 123.0))`.
- Passing the blob through the network and obtaining the face detections and saving to our model.



faceNet.setInput(blob) detections = faceNet.forward()

- Filter out weak detections by ensuring the confidence is greater than the minimum confidence ie, compute the (x, y)-coordinates of the bounding box for the object and ensure the bounding boxes fall within the dimensions of the frame
- Extract the face ROI, converting it from BGR to RGB channel, ordering, resizing it to 224x224, and preprocessing it.
- *Alarming the driver if drowsy*

By placing a count value and increasing if the output is drowsy and decrease the count if awake. if the count value increases more than a threshold at a particular time limit the system will warn the driver by giving alarm that its time to take rest .

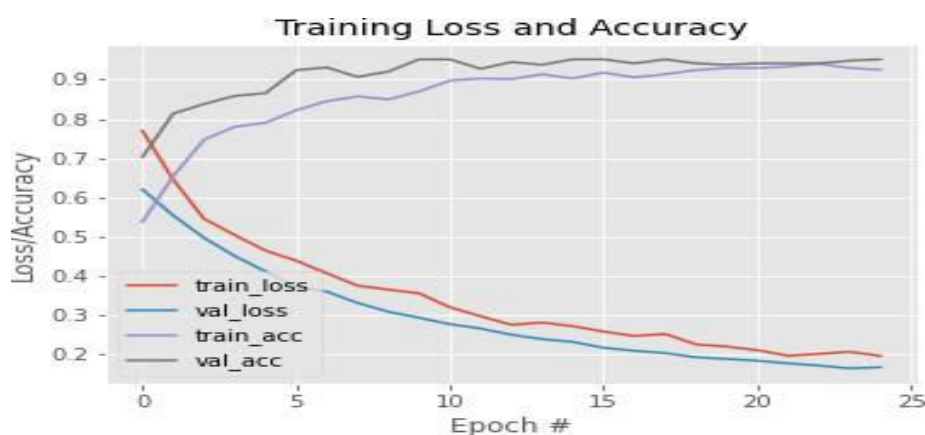


Figure 6: ACCURACY PLOT

## V. CONCLUSION

The paper proposed a deep learning-based method which uses adaptive deep neural networks with the transfer learning approach for drowsiness detection. We designed and perfected these networks developed on the advanced networks of MobileNet-V2, which are more efficient in terms of memory and complexity. The proposed networks are very good feature extractors, since they can capture and learn relevant features of drowsiness automatically. The use of a transfer learning approach to well solve the problem of fast training, a small training dataset and accuracy improvement. Since the caffe model is used in capturing the driver's face it has its own advantages like Expressive architecture, Speed for capturing frames per second, in built extensible code. This method develops 95% accuracy on predicting the result. The proposed method is useful for monitoring the fatigue of drivers, to give early warning of falling asleep, and thereby avoiding unfortunate traffic accidents.

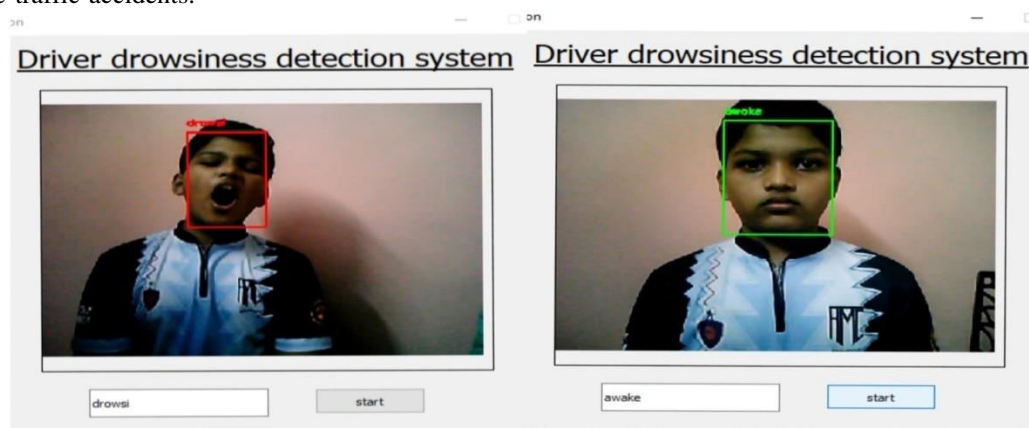


Figure 7: AWAKE OR DROWSY DETECTION



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