DRIVE SAFE SYSTEM

PROJECT REPORT

FOUNDATION OF DATA SCIENCE (19CSE304 FDS)

BY GROUP 13

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Abstract

This document is a report on the research conducted in the field of computer engineering to develop a system for driver drowsiness detection to prevent accidents from happening because of driver fatigue and sleepiness. The novel proposed the results and solutions on the limited implementation of the various techniques that are introduced in the thesis-es on the topic.

The document discusses the many solutions available for detecting fatigue and their efficacy in preventing accidents in the current state of traffic. Furthermore, the paper states the overview of the observations made by the authors in order to help further optimization in the mentioned field to achieve the utility at a better efficiency for a safer road.

Now-a-days, road accidents have become one of the major issues. The major road accidents are caused due to drowsiness, drunken and rash driving. This is the reason, every year the number of road accidents is increasing especially by cars. Due to drowsiness, drivers become less active while driving.

This paper is to build a system for Drowsiness detection and Warning for automobile safety and accident prevention. We are using eye detection, drowsiness detection and eye blinking pattern detection with the help of machine vision-based concepts. In order to detect fatigue or drowsiness, a web camera has been used which points directly towards the driver’s face and detects the eye movement of the driver.

Keywords—Driver drowsiness; eye detection; yawn detection; blink pattern; fatigue.

Introduction

1.1 PURPOSE

1.1.1 HUMAN PSYCHOLOGY WITH CURRENT TECHNOLOGY

Humans have always invented machines and devised techniques to ease and protect their lives, for mundane activities like traveling to work, or for more interesting purposes like aircraft travel. With the advancement in technology, modes of transportation kept on advancing and our dependence on it started increasing exponentially.It has greatly affected our lives as we know it. Now, we can travel to places at a pace that even our grandparents wouldn't have thought possible. In modern times, almost everyone in this world uses some sort of transportation every day. Some people are rich enough to have their own vehicles while others use public transportation. However, there are some rules and codes of conduct for those who drive irrespective of their social status. One of them is staying alert and active while driving.

Neglecting our duties towards safer travel has enabled hundreds of thousands of tragedies to get associated with this wonderful invention every year. It may seem like a trivial thing to most folks but following rules and regulations on the road is of utmost importance. While on road, an automobile wields the most power and in irresponsible hands, it can be destructive and sometimes, that carelessness can harm lives even of the people on the road. One kind of carelessness is not admitting when we are too tired to drive. In order to monitor and prevent a destructive outcome from such negligence, many researchers have written research papers on driver drowsiness detection systems. But at times, some of the points and observations made by the system are not accurate enough. Hence, to provide data and another perspective on the problem at hand, in order to improve their implementations and to further optimize the solution, this project has been done.

1.1.2 FACTS & STATISTICS

Our current statistics reveal that just in 2020 in India alone, 151,113 people died due to car related accidents. Of these, at least 21 percent were caused due to fatigue causing drivers to make mistakes. This can be a relatively smaller number still, as among the multiple causes that can lead to an accident, the involvement of fatigue as a cause is generally grossly underestimated. Fatigue combined with bad infrastructure in developing countries like India is a recipe for disaster. Fatigue, in general, is very difficult to measure or observe unlike alcohol and drugs, which have clear key indicators and tests that are available easily. Probably, the best solutions to this problem are awareness about fatigue-related accidents and promoting drivers to admit fatigue when needed. The former is hard and much more expensive to achieve, and the latter is not possible without the former as driving for long hours is very lucrative. When there is an increased need for a job, the wages associated with it increases leading to more and more people adopting it. Such is the case for driving transport vehicles at night. Money motivates drivers to make unwise decisions like driving all night even with fatigue. This is mainly because the drivers are not themselves aware of the huge risk associated with driving when fatigued. Some countries have imposed restrictions on the number of hours a driver can drive at a stretch, but it is still not enough to solve this problem as its implementation is very difficult and costly.

1.2 DOCUMENT CONVENTIONS

Main Heading Font size: 16 (bold fonts)
Sub-headings Font size: 14 (bold fonts)
Sub-headings Content Font size: 12 (normal fonts)

1.3 PRODUCT SCOPE

There are many products out there that provide the measure of fatigue level in the drivers which are implemented in many vehicles. The driver drowsiness detection system provides similar functionality but with better results and additional benefits. Also, it alerts the user on reaching a certain saturation point of the drowsiness measure.

1.4 PROBLEM DEFINITION

Fatigue is a safety problem that has not yet been deeply tackled by any country in the world mainly because of its nature. Fatigue, in general, is very difficult to measure or observe unlike alcohol and drugs, which have clear key indicators and tests that are available easily. Probably, the best solutions to this problem are awareness about fatigue-related accidents and promoting drivers to admit fatigue when needed. The former is hard and much more expensive to achieve, and the latter is not possible without the former as driving for long hours is very lucrative.

BROAD CONTEXT

"1 in 25 adult drivers report that they have fallen asleep at the wheel in the past 30 days"

- If you have driven before, you've been drowsy at the wheel at some point. It's not something we like to admit but it's an important problem with serious consequences that needs to be addressed. 1 in 4 vehicle accidents are caused by drowsy driving and 1 in 25 adult drivers report that they have fallen asleep at the wheel in the past 30 days. The scariest part is that drowsy driving isn't just falling asleep while driving.

- Drowsy driving can be as small as a brief state of unconsciousness when the driver is not paying full attention to the road. Drowsy driving results in over 71,000 injuries, 1,500 deaths, and $12.5 billion in monetary losses per year. Due to the relevance of this problem, we believe it is important to develop a solution for drowsiness detection, especially in the early stages to prevent accidents.

2.1 FACTORS CAUSING DROWSY DRIVER

Humans tend to ignore fatigue as a constraint of their under-performance. This can lead to many dangerou situations especially when drivers are responsible for their life as well as the life of other people on the road. Driver drowsiness is a dangerous mixture of driving while fatigued and sleepy.

Some of the factors that lead to fatigue are:

1. Driver fatigue generally happens when the driver has not slept well in the past 24 hours. An average human should sleep at least 7 hours every day for better health.
2. Other factors such as sleep disorders like insomnia, Sleep Apnea and Shift work sleep disorder (SWSD) which can occur because of irregular hours at work.
3. Too much work pressure can cause stress and anxiety which often leads to loss of sleep during normal hours.
4. According to a study, people who drive commercial vehicles, especially trucks, suffer from drowsy driving more regularly than non-transport drivers . This is mainly because of increased demand for workers and higher pay for greater work hours at odd times of the day.
5. The human brain is trained to relate to sleep and night hours. However, this is the time when most transport vehicles are on the move. This leads to an increase in the number of cases of drowsy driving as the drivers fall asleep easily while driving at night compared to the day.
6. Another factor is medication, alcohol and drugs. Consumption of these in many cases can cause even a perfectly healthy person to fall asleep in front of the wheel and cause an accident

Literature Survey

3.1 SYSTEM REVIEW

This survey is done to comprehend the need and prerequisite of the general population, and to do as such, we went through different sites and applications and looked for the fundamental data. Based on these data, we made an audit that helped us get new thoughts and make different arrangements for our task. We reached the decision that there is a need for such an application and felt that there is a decent extent of progress in this field too.

3.2 TECHNOLOGY USED

a. PYTHON - Python is an interpreted, high-level, general-purpose programming language. Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed AND supports multiple programming paradigms, including procedural, object-oriented, and functional programming.

b. JUPYTER Lab - Project Jupyter is a nonprofit organization created to develop open-source software, open-standards, and services for interactive computing across dozens of programming languages.

c. IMAGE PROCESSING - In computer science, digital image processing is the use of computer algorithms to perform image processing on digital images.

d. MACHINE LEARNING - Machine learning is the scientific study of algorithms and statistical models that computer systems use in order to perform a specific task effectively without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence. Machine learning algorithms build a mathematical model based on sample data, known as "training data", in order to make predictions or decisions without being explicitly told.

Software Requirements Specification

4.1 Python:

• Python 3

4.2 Libraries

- Numpy
- Scipy
- Playsound
- Dlib
- Imutils
- opencv, etc.

4.3 Operating System

• Windows or Ubuntu

Hardware Requirements Specification

I. Laptop with basic hardware.

II. Webcam

Requirement Analysis

6.1 Python

Python is the basis of the program that we wrote. It utilizes many of the python libraries.

6.2 Libraries

- Numpy: Prerequisite for Dlib

- Scipy: Used for calculating Euclidean distance between the eyelids.
- Playsound: Used for sounding the alarm
- Dlib: This program is used to find the frontal human face and estimate its pose using 68 face landmarks.
- Imutils: Convenient functions written for Opencv.
- Opencv: Used to get the video stream from the webcam, etc.

6.3 OS

Program is tested on Windows 10 build 1903 and PopOS 19.04 4.3
Laptop: Used to run our code.

6.4 Webcam

Used to get the video feed

Study System

Various techniques have been advised by different authors of various research papers for detecting fatigue in drivers effectively. The OpenCV library from Python can be used to detect faces and eyes accurately for detecting fatigue. This makes the system very easy to implement however, it makes the process of detecting faces very slow. Various techniques like comparing changes in consecutive frames to detect face and eyes can make this process at least twenty times faster . A method for detection of the human eye that uses Circular Hough Transform (CHT) for accurate iris detection can make the whole drowsiness detection process much more reliable . CHT is used to calculate the center and radius of the iris which is important for calculating the gap between eyelids.

Another system uses video input to analyze both the eyes and mouth for eye tracking and mouth to better predict the drowsiness of the driver. Since faces with different complexions is distinguished by only brightness, YCbCr which is made of two components Luminance (EyeMapL) and Chrominance (EyeMapC) can help in detecting faces with different complexions better as after the removal of luminance from the Eye Map faces with different complexions can easily be identified. Color space like HSV graph is used to identify the state of eyes i.e. open or close which can be used for calculating PERCLOS parameters to judge drowsiness.

Structural Similarity Measure (SSIM) can be used for eye detection as it has better performance than any of the conventional measures. Combining yawn detection with this result gives insight that helps to decide if the alarm should be triggered by checking drowsiness levels.

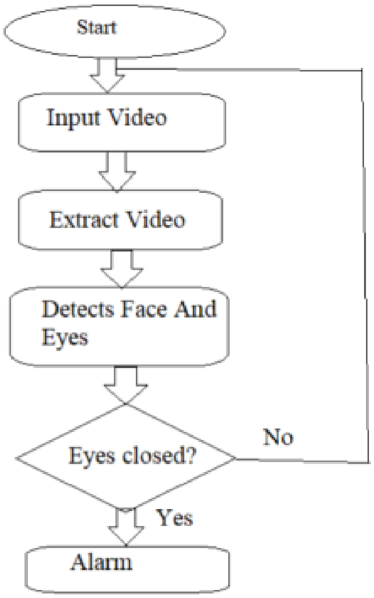
- Drowsiness and Fatigue of drivers are amongst the significant causes of road accidents. Every year, they increase the amount of deaths and injuries globally. In this project, a drowsy driver alert system is presented to reduce the number of accidents due to drivers fatigue and hence increase the transportation safety.

- This system deals with automatic driver drowsiness detection based on visual information. We propose an algorithm to locate, track, and analyze both the drivers face and eyes to measure drowsiness associated with slow eye closure.

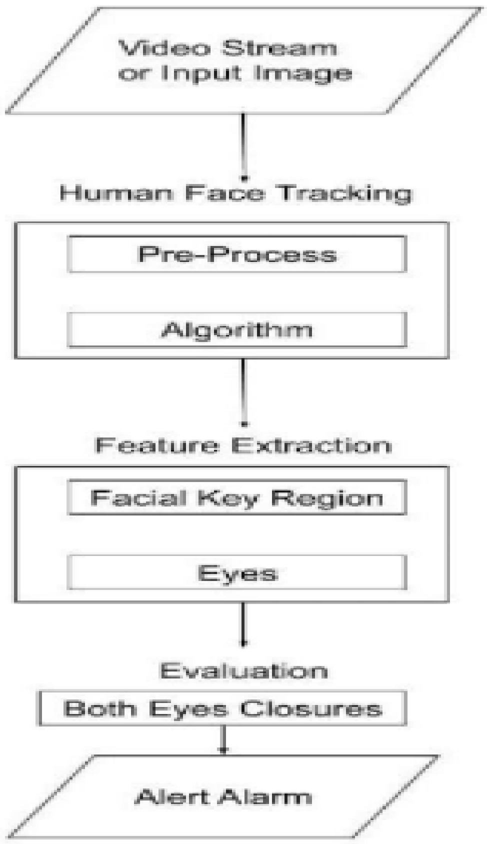
- The project presents a study regarding the possibility to develop a drowsiness detection system for car drivers.

- In this project we will be using the pythonLanguage. We examine the visuals and look for signs of drowsiness. To do so, we must follow the steps below.
    - Data Source and Preprocessing
    - Feature Extraction
    - Basic Classification Methods and
    - Results

Flow chart



Block Diagram



Dataset and Methods

- The Real life drowsiness dataset consists of around 30 hours of RGB videos of 60 healthy participants. For each participant we obtained one video for each of three different classes: alertness, low vigilance, and drowsiness, for a total of 180 videos.

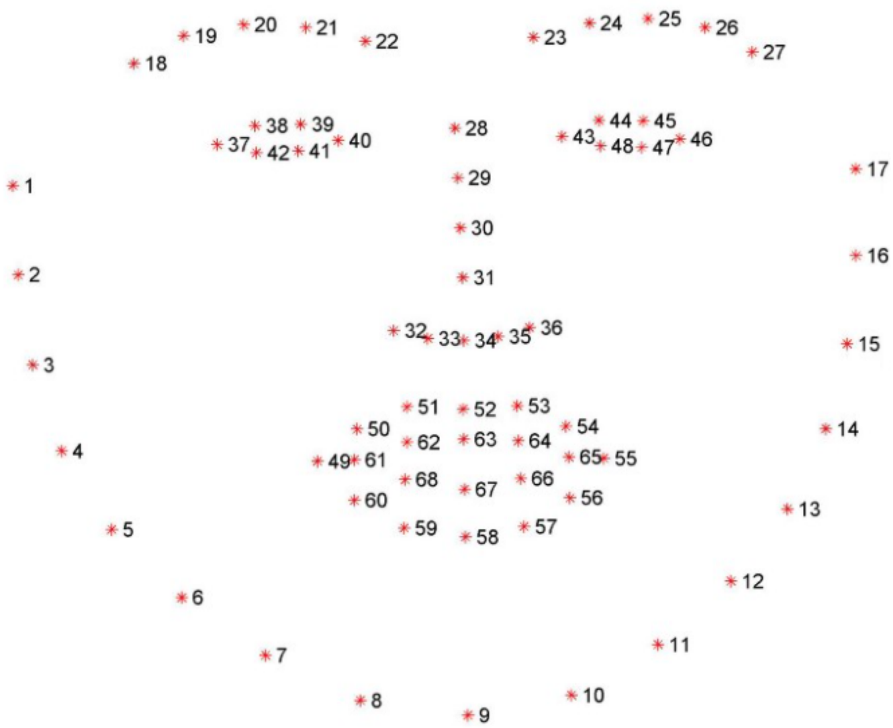
- Subjects were undergraduate or graduate students and staff members who took part voluntarily or upon receiving extra credit in a course. All participants were over 18 years old. There were 51 men and 9 women, from different ethnicities and ages (from 20 to 59 years old). The subjects wore glasses in 21 of the 180 videos, and had considerable facial hair in 72 out of the 180 videos.

- Videos were taken from roughly different angles in different real-life environments and backgrounds. Each video was self-recorded by the participant, using their cell phone or web camera. The frame rate was always less than 30 fps, which is representative of the frame rate expected of typical cameras used by the general population.

- **Alert :** One of the first three states highlighted in the KSS table in Table 1. Subjects were told that being alert meant they were completely conscious so they could easily drive for long hours.
- **Low Vigilant :** As stated in level 6 and 7 of Table 1, this state corresponds to subtle cases when some signs of sleepiness appear, or sleepiness is present but no effort to keep alert is required. While subjects could possibly drive in this state, driving would be discouraged.
- **Drowsy :** This state means that the subject needs to actively try to not fall asleep.
- **Model 1** Facial Feature Engineering (FFE)
- In this approach, we propose using the position of key facial features, including the eyes, nose, mouth, and chin, as well as the eye-aspect ratio (EAR), and mouth-aspect ratio (MAR) to detect drowsiness.
- **Model 2**: CNN-LSTM
- The second approach serves to extend this idea further and allow a model to learn only the sequence of extracted features, but a temporal sequence of images.

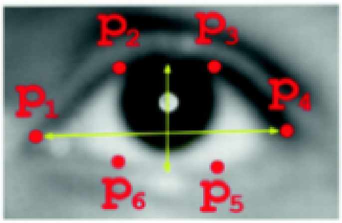
Implementation

- In our program we used Dlib, a pre-trained program trained on the HELEN dataset to detect human faces using the predefined 68 landmarks.
- After passing our video feed to the dlib frame by frame, we are able to detect left eye and right eye features of the face.
- Now, we drew contours around it using OpenCV.



Facial Landmarks from OpenCV

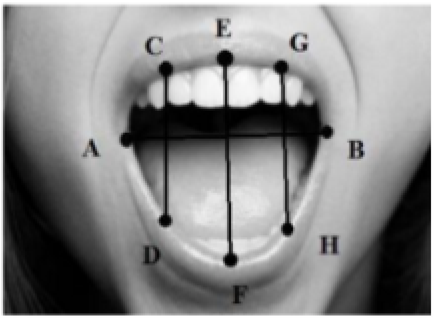
- Using Scipy's Euclidean function, we calculated the sum of both eyes' aspect ratio which is the sum of 2 distinct vertical distances between the eyelids divided by its horizontal distance.
- Eyes with horizontal and vertical distance marked for **Eye Aspect Ratio** calculation.



$$\text{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

Eye Aspect Ratio (EAR)

- Now we check if the aspect ratio value is less than 0.25 (0.25 was chosen as a base case after some tests). If it is less, an alarm is sounded and the user is warned.
- Mouth Aspect Ratio (MAR)Computationally similar to the EAR, the MAR, as you would expect, measures the ratio of the length of the mouth to the width of the mouth.
- Our hypothesis was that as an individual becomes drowsy, they are likely to yawn and lose control over their mouth, making their MAR to be higher than usual in this state.



$$\text{MAR} = \frac{|EF|}{|AB|}$$

Mouth Aspect Ratio (MAR)

- Pupil Circularity (PUC)PUC is a measure complementary to EAR, but it places a greater emphasis on the pupil instead of the entire eye.

$$Circularity = \frac{4 * \pi * Area}{perimeter^2} \qquad Area = \left(\frac{\text{Distance}(\text{p2}, \text{p5})}{2}\right)^2 * \pi$$

$$Perimeter = Distance(p1, p2) + Distance(p2, p3) + Distance(p3, p4) + Distance(p4, p5) + Distance(p5, p6) + Distance(p6, p1)$$

Pupil Circularity

- For example, someone who has their eyes half-open or almost closed will have a much lower pupil circularity value versus someone who has their eyes fully open due to the squared term in the denominator. Similar to the EAR, the expectation was that when an individual is drowsy, their pupil circularity is likely to decline.
- Mouth aspect ratio over Eye aspect ratio (MOE)Finally, we decided to add MOE as another feature. MOE is simply the ratio of the MAR to the EAR.

$$MOE = \frac{MAR}{EAR}$$

- Mouth Over Eye Ratio (MOE)The benefit of using this feature is that EAR and MAR are expected to move in opposite directions if the state of the individual changes. As opposed to both EAR and MAR, MOE as a measure will be more responsive to these changes as it will capture the subtle changes in both EAR and MAR and will exaggerate the changes as the denominator and numerator move in opposite directions. Because the MOE takes MAR as the numerator and EAR as the denominator, our theory was that as the individual gets drowsy, the MOE will increase.
- While all these features made intuitive sense, when tested with our classification models, they yielded poor results in the range of 55% to 60% accuracy which is only a minor improvement over the baseline accuracy of 50% for a binary balanced classification problem. Nonetheless, this disappointment led us to our most important discovery: the features weren't wrong, we just weren't looking at them correctly.

Feature Normalization

When we were testing our models with the four core features discussed above, we witnessed an alarming pattern. Whenever we randomly split the frames in our training and test, our model would yield results with accuracy as high 70%, however, whenever we split the frames by individuals (i.e. an individual that is in the test set will not be in the training set), our model performance would be poor as alluded to earlier.

This led us to the realization that our model was struggling with new faces and the primary reason for this struggle was the fact that each individual has different core features in their default alert state. That is, person A may naturally have much smaller eyes than person B. If a model is trained on person B, the model, when tested on person A, will always predict the state as drowsy because it will detect a fall in EAR and PUC and a rise in MOE even though person A was alert. Based on this discovery, we hypothesized that normalizing the features for each individual is likely to yield better results and as it turned out, we were correct.

To normalize the features of each individual, we took the first three frames for each individual's alert video and used them as the baseline for normalization. The mean and standard deviation of each feature for these three frames were calculated and used to normalize each feature individually for each participant. Mathematically, this is what the normalization equation looked like:

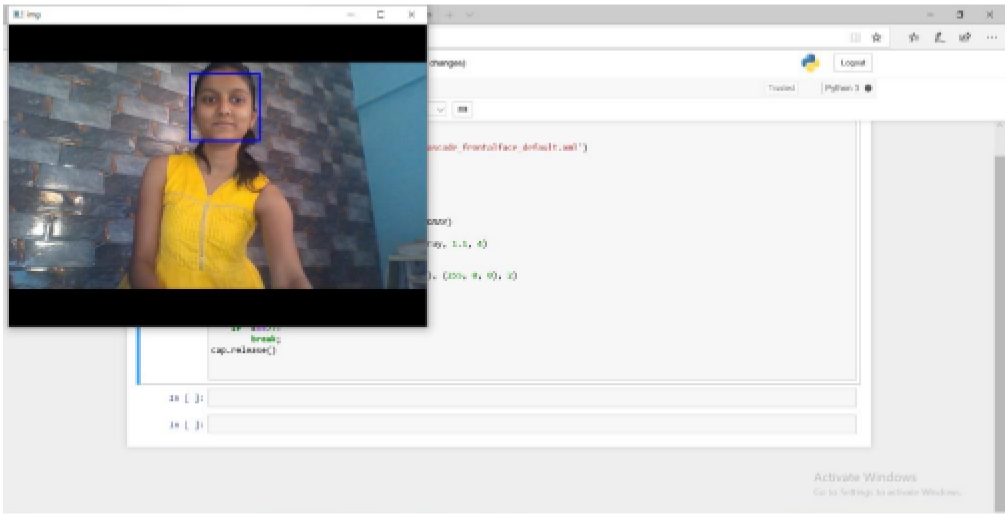
$$\textit{\textbf{Normalised Feature}}_{n,m} = \frac{\textit{\textbf{Feature}}_{n,m} - \boldsymbol{\mu}_{n,m}}{\boldsymbol{\sigma}_{n,m}}$$

where:
n is the feature
m is the person
$\mu_{n,m}$ *and* $\sigma_{n,m}$ *are taken from the first 3 frames of the "Alert" state*

Normalization Method

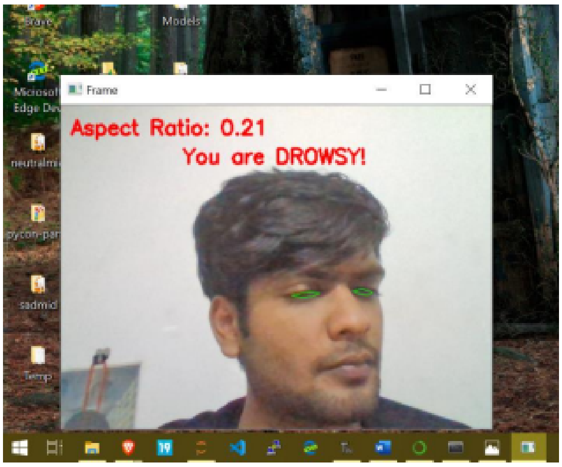
Now that we had normalized each of the four core features, our feature set had eight features, each core feature complemented by its normalized version. We tested all eight features in our models and our results improved significantly.

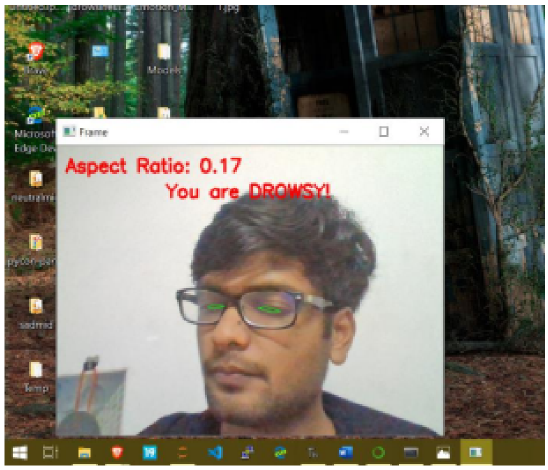
Screenshots of the project output



Non-drowsy Person

Different aspect ratio at drowsy state





Drowsy Person

WORK DIVISION:

NAME	WORK
Kode Dhanya	Coding part and Study system
Nimmagadda Monitha	Data set and model architecture
Pulivendula Reddy Gowtham	Implementing CNN and block diagram
Kotikalapudi chandrasekhar madan	Algorithm and its implementation
Thumati Sai Manichandana Devi	Feature normalisation and Conclusion

Conclusion

Captured video was divided into frames and each frame was analyzed. Successful detection of face followed by detection of eye. If the closure of the eye for successive frames were detected then it is classified as a drowsy condition, else it is regarded as normal blink and the loop of capturing image and analyzing the state of the driver is carried out again and again. In this implementation during the drowsy state the eye is not surrounded by a circle or it is not detected and a corresponding message is shown.Even though this implementation has some limitations.

Limitations :

Dependence on ambient light
Distance of camera from driver face
Multiple face problem
These are some factors which can affect the results.

14.2 Future Scope

The model can be improved incrementally by using other parameters like blink rate, yawning, state of the car, etc. If all these parameters are used it can improve the accuracy by a lot. We plan to further work on the project by adding a sensor to track the heart rate in order to prevent accidents caused due to sudden heart attacks to drivers. Same model and techniques can be used for various other uses like Netflix and other streaming services can detect when the user is asleep and stop the video accordingly. It can also be used in application that prevents user from sleeping