VIGILANCE PRAEPOSTOR & CONSCIOUSNESS ANALYZER

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Submitted to the faculty of Department of Computer Software Engineering,
Military College of Signals, National University of Sciences and Technology, Islamabad,
in partial fulfillment for the requirements of B.E Degree in Software Engineering.

29 May 2022

IN THE NAME OF ALLAH, THE MOST BENEVOLENT, THE MOST COURTEOUS

CERTIFICATE OF CORRECTNESS AND APPROVAL

This is to officially state that the thesis work contained in this report
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under my supervision and that in my judgment, it is fully ample, in scope and excellence, for the degree of Bachelor of Software Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

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DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

ACKNOWLEDGEMENTS

Allah Subhan'Wa'Tala is the sole guidance in all domains.

Our parents, colleagues, and most of all our supervisor, Col Dr Asim Dilawar Bakhshi without your guidance.

The group members, who through all adversities worked steadfastly.

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ABSTRACT

This thesis is focused on driver vigilance detection and the objective of this thesis is to recognize driver's state with high performance. Drowsy driving is one of the main reasons of traffic accidents in which many people die or get injured. Driver vigilance detection is based on method focusing on driver's state. Furthermore, methods focusing on driver's state are divided into two groups: methods using physiological signals and methods using computer vision. In this thesis, driver data are pictures captured by a camera and the method proposed belongs to the group that uses computer vision to detect driver's state. There are two main states of a driver, those are vigilant and drowsy states. Pictures captured are analyzed by making use of image processing techniques. Eye regions are detected, and those eye regions are input to right and left eye region classifiers, which are implemented using artificial neural networks. The neural networks classify the right and left eye as open or closed eye and yawning state. The eye and yawning states along the pictures are fused and the driver's state is predicted as vigilant or drowsy. The proposed method is tested on pictures. The accuracy of the driver's state recognition method is 99.1% and the accuracy of our eye state recognition method is 94%. Those results are comparable with the results in literature.

TABLE OF CONTENTS

CONTENTS

..... PAGE

LIST OF FIGURES

CHAPTER # 1

1. INTRODUCTION

Drowsiness is the state where person have strong desire to sleep. It is the state where person has the high desire to sleep. It has two definite meanings, referring both to the state foregoing falling asleep and chronic condition referring to being in that state independent of the daily rhythm. While performing the tasks that needed the constant concentration such as driving can be dangerous if it is done in a drowsiness state. Person could experience drowsiness if they had a sufficient fatigue, and this can leads to road accidents.

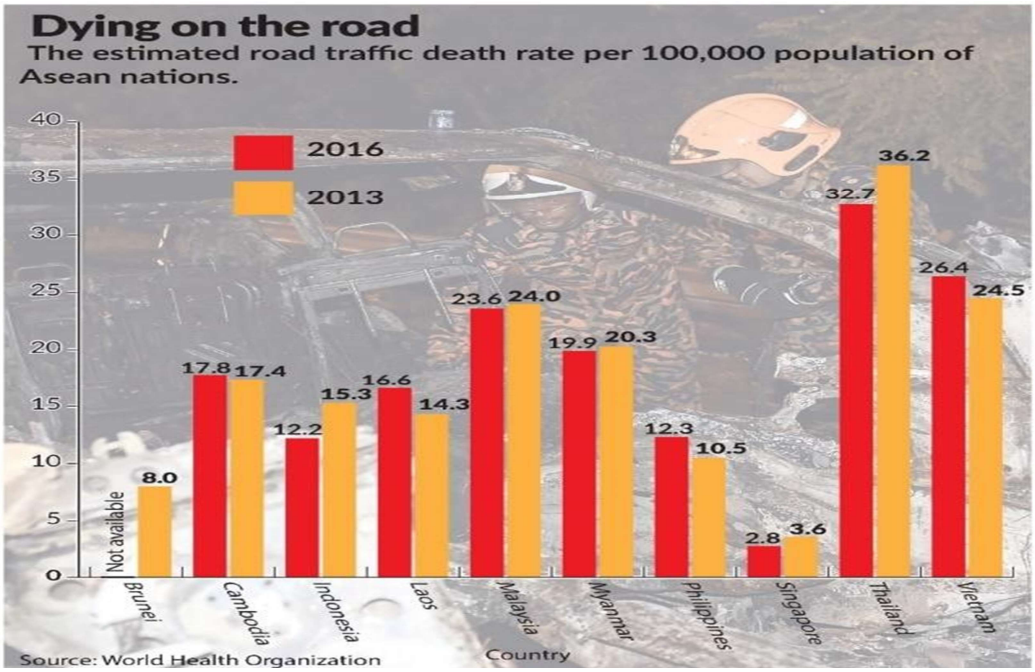


Figure 1: The statistic of road accidents of Asean Nations in 2013 and

The major challenge in the field of accident-avoidance system faced by the developer and researcher is in developing the technologies for detecting or preventing drowsiness among the drivers. Solutions need to be done to counter act the presence hazards of drowsiness on a road.

The purpose of this project is to develop the simulation of drowsiness detection system. The focus of the project is to design a system that will detect the drowsiness by detecting the closed eyes of the driver. By monitoring the state of the eyes, it is believed can detect the early symptom of the driver's drowsiness, to avoid car accidents. The process of detecting the drowsiness between drivers is to detect the open and closed of the eyes.

Figure 2: Example of drowsiness condition while driving

Sometimes, people need an alertness and warn to prevent them from sleeping while driving. There is plenty driver drowsiness detection system were developed by many researchers. One of the examples is the use a computer vision or OpenCV to detect image or video processing. This alternative will help developer to developed computer vision-based system.

The purpose of the project is to design the simulation of drowsiness detection system. The system will accurately monitor the state of driver's eyes whether it is open or closed. The road accidents believed can be avoided by monitoring the early stage of drivers' drowsiness.

Face recognition is one of the applications besides human identification and tracking for security systems becomes popular research area by analyzing the face images. This project is focused on the localization of the eyes, which involves the both eyes and face by applying the existed image- processing algorithm. The detection of the drowsiness will be determined once the position of the eyes located.

1.1 PROBLEM STATEMENT

The problem that occurs and make this project developed are:

a. Current drowsiness detection caused a problem to the driver because it is so troublesome because of its size such as Electroencephalography (EEG) and Electrocardiography (ECG).
b. It is also need complex algorithm to be developed by the developer
c. The increases of the road accidents caused by the drowsy driver while driving.

1.2 OBJECTIVE

a. To study on pattern recognition methods in detecting drowsiness from the collected variables.
b. To investigate the feasibility of classification of the alert states of drivers.
c. To develop a system which can detect on driver drowsiness using closed eyes as an indicator.

1.3 SCOPE OF STUDY

In the project, the main focused will be based on:

a. Concept of drowsiness detection system.

b. Determine drowsiness from these parameters:

    i. Blink eye.

    ii. Eye of Ratio (EAR).

    iii. Mouth of Ratio (MAR).

c. Coding development and testing.
d. Complete testing and improvement.

1.4 LIMITATION OF WORK

There are some limitations during the research:

a. The system cannot detect the driver's eyes that wearing sunglasses while driving
b. The low light condition in the car can be the limitation to system to detect the position of the driver's eyes

CHAPTER # 2

2. LITERATURE REVIEW

There are many research papers that focusing on detecting the drowsiness among the drivers that developer can refer to develop the drowsiness detection system. Literature review focusing on what have been done by other authors.

2.1 RESEARCH OF STUDIES

2.1.1 Automatic Driver Drowsiness Detection and Accident Prevention System using Image Processing.

In this article, sleep is a primary human need. Basically, human needs to sleep at least eight hours a day by schedule for the day. If someone needs adequate relief the frame does not have a proper characteristic (function). The first to do so drivers all need enough sleep to boost their work. If we don't sleep enough, we might get drowsy and fall asleep. A few seconds of drowsiness will also cost lives for both drivers and travelers. This gadget gives you a vibrant monitoring assistant who analyses blinking of the drivers' eyes action and, in addition, portion of the mouth examining whether driving is yawning.

2.1.2 Understanding of a Convolutional Neural Network

In this paper [1], deep learning or deep neural network refers to Artificial Neural Networks (ANN) with multiple layers. It has been considered one of the most recent decades. Most efficient devices and has been very popular literature as its capable of processing a large volume of data. This is the interest in having deeper hidden layers has recently begun. Surpass the performance of classical methods in different fields, especially in recognition of patterns.

One of the deepest, most popular the neural networks are the Convolutional Neural Network (CNN). Taking its name from the mathematical linear operation between matrixes are called convolution. CNN has several layers, like a coevolutionary layer, a non-linear layer, a pooling layer and a completely connected layer. Coevolutionary and fully connected layers have parameters but there are no pooling and non-linear layers its' parameters. CNN has an outstanding computer efficiency thing of learning.

Applications dealing with image data, such as the largest image classification data set (Image Net), computer vision and natural language processing (NLP) and the results obtained have been very wonderful. This paper discusses and describes all the elements and issues of significance related to CNN, and how it works. In addition, we are this will also state the parameters that have an impact on CNN performance. This paper assumes that readers have sufficient knowledge of both machine learning and artificial neural networks.

2.1.3 A Survey Paper on Drowsiness Detection & Alarm System for Drivers

In this research paper [2], our priority is safety while traveling or driving. A driver's mistake can lead to a serious mistake. Physical injury, mortality, and major economic losses. There are several applications available on the market today, such as navigation devices, multiple sensors, etc. Easy to work. There are numerous reasons, particularly human's faults that give rise to road accidents. Studies say that there is a huge rise in the number of road accidents in our country has been in existence for the last few years. The key explanation that is happening on the highway injuries are somnolence and sleepiness driver as he's driving.

2.1.4 Real-time Drowsy Driver Detection using Haar Cascade Samples

In this paper, with population increase, car injuries have also occurred growth. A thorough study reveals that there are over half of a million incidents in India per year. However, owing to driver exhaustion, about 60 percent of such injuries are induced. Tired rider influences driving skill in the following 3 regions, (a) hinder balance, (b) affect slower driving ability's reaction cycles, and c) Perception loss. We have a real-time via this paper monitoring device of image recognition technologies, facial / head identification. Even, to ensure real-time computation, Haar Cascade tests are used to discern between a blink of the eye and detection in drowsiness / exhaustion.

2.1.5 Real-Time System for Driver Fatigue Detection Based on a Recurrent Neuronal Network.

This research paper [3], the growth in car crash deaths has risen rapidly across the world in recent years. Nevertheless, road security has been a global problem and a complex topic that needs to be tackled. Deaths from traffic accidents are also on the rise and are deemed a major general medical issue. The most recent advances in promoting research

and information Vehicle skills, allowing drivers to see and analyses conditions in the streets to prevent collisions and secure travelers. Analyzing driver activities on the road has therefore been one of the leading research topics in recent years, particularly somnolence, as it provides the highest mishaps impact and is the main cause of death on the highways. This paper includes an overview and predict driver drowsiness by running a Recurrent Neural Network over a sequence frame eye to the rider. We used a dataset to mold and authorize our concept and provide repeated implementations Neural Network Multi-Layer 3D Coevolutionary Networks for Driver Detection Drowsiness. The accuracy of acceptance rate is 92% after the training session.

2.1.6 An Efficient K–NN Approach for Automatic Drowsiness Detection Using Single–Channel EEG Recording.

The author said [4], drowsy driving is a major source of many traffic accidents. The purpose of this research is the automated creation of detection method for drowsiness use an effective k-nearest neighbors (K-NN) algorithm. Next, power distribution in time-frequency space was computed using short-term Fourier transform (STFT), and then the mean power value was determined for each EEG sub band across time-segments of 0.5 second. In addition, the time- domain was calculated for standard deviation (SD) and Shannon entropy linked to increasing time-segment. Ultimately, they removed 52 elements. Random forest algorithm was added to the extracted data to pick the most helpful apps sub package. To identify drowsiness and alertness a minimum of 11 apps have been chosen. Kd-trees are used as a search algorithm for nearest neighbors to provide a fast classifier. The experimental findings demonstrate that the techniques and materials introduced in this paper can be used to reliably diagnose drowsiness with 91% precision.

2.1.7 Target Recognition in Infrared Circumferential Scanning System via Deep Convolutional Neural Networks.

In this article [5], with an IRCSS (Infrared Circumferential Scanning System) we will realize long-term oversight over a wide field of vision. Automatically identifying goals inside the field of vision is a critical part of increasing environmental consciousness in the computerization cycle, particularly with the framework of protection. Recognition of objectives consists of two subtasks: identification and identification, which refers to the goal location and type, respectively. In the analysis, we

propose a Deeply Coevolutionary Neural Network (DCNN)-based method for end-to - end realization recognition of goal in IRCSS. Current DCNN-based approaches need a broad data collection, annotated for instruction, while public infrared databases are often used to monitor objectives. Hence, we create an infrared object recognition dataset to both solve data limitations and boost the algorithm's adaptability in various scenes. We can use data raise and take advantage of optimum cross- domain software transition technique for Network Learning. Within this step we implement the smoother L1 as the loss function for improved localization efficiency within bounding box regression. The proposed approach obtained 82.7 map in the tests, achieving end-to - end identification of the infrared target with high efficiency on accuracy.

2.1.8 An Investigation of Early Detection of Driver Drowsiness Using Ensemble MachineLearning Based on Hybrid Sensing.

What can I conclude from this paper [6], drowsy driving is one of the most important sources of road collisions, reducing these injuries, it is essential to detect drowsy driving early? It has been demonstrated, in previous research, that driver drowsiness impacted driving performance, conduct indices and physiological indices. This is for the purpose the research would investigate the feasibility of classifying driver warning systems, the slightly somnolent, dependent on engine, behavioral, and physiological hybrid sensing indicators of concern for the analysis of such identification setup. Next, we assessed the degree of drowsiness, driving efficiency and physiological signal (From the analysis of electroencephalograms and electrocardiograms) and the conductor's behavioral measures driving simulator and control panel for passengers. Therefore, driver alarm and drowsy conditions have been established using machine learning algorithms and constructing a catalogue of the indices derived from a duration 10 s. Ultimately, description of the ensemble algorithms was used. Reports suggested the ensemble algorithm will achieve 82.4 per cent classification accuracy using hybrid warning recognition methods yet mildly somnolent, 95.4 percent precision classifying alarm and somewhat drowsy.

2.1.9 Non-Intrusive driver drowsiness detection system.

The main contribution of this study is a novel algorithm for drowsiness detection and tracking, which is based on the incorporation of information from a road vision system and vehicle performance parameters. Refinement of the algorithm is more specifically identified the degree of drowsiness by the implementation of a service computer vector detection with a reliable and effective alarm method with drowsiness. By utilizing non-intrusive devices with regular equipment sensors, the Support Vector Machine (SVM) detection methodology decreased drowsiness level to eliminate such road injuries triggered by drowsiness users. It identification device includes a non-contact tool for assessing various forms of driver alertness rates and enables early identification of a decrease in driving alertness. The findings reported are focused on a collection of somnolence databases which cover approximately 60 hours driving hours to assess data collection. Everything system parameters derived data on parameters are obtained in a driving simulator. A true car with all the equipment, a model for detecting drowsiness in SVM is being developed. The grouping, after many changes for certain methods, the findings gave a very strong sign of drowsiness.

2.1.10 Prediction of Drowsy Driver Detection by Using Soft Computing Technique.

This research [7] defines a system for automated drowsy drivers and crash avoidance focused on adjustments in the facial expressions. The central character the explanation for the road injuries may be the number of years of driving. Face expression check will include the driver's drowsiness assessment to insure the driver is vigilant. Hence, the research discusses the solution to recognize vehicle drowsiness. We realize our methodology by taking the driver's face picture, searching for facial features by handling images and using hybrid strategy for assessing the degree of driver drowsiness.

CHAPTER # 3

3. METHODOLOGY

The research methodology is essential to ensure the research objectives can be achieved. This chapter will explain in detail regarding the methods used during conducting this project. To make sure the project is in the right path; methodology plays an important role as a guide for the project to complete and working well as planned. This project is involving many software such as Anaconda Navigator, Sublime text editor etc.

A video transfer will be reliably procured from the driver's appearances and feed into a miniature regulator for getting ready. Classifiers will at that point be used to bunch the state of the driver's eye, mouth, and head. If a languid driver is perceived an alert will be raised, until the system sees the driver is ready.

3.1 The interaction includes the accompanying advances:

3.1.1 IMAGE CAPTURE.

Using a web camera showed inside the vehicle we can get the image of the driver. Notwithstanding the way in which that the camera makes a video cut, we need to apply the computation on each edge of the video stream to get the edges for the further technique.

3.1.2 PARTITIONING INTO FRAMES.

It is sorted out some way to get the predictable circumstance where video is recorded and ought to be prepared. Be that as it might, the video isn't which is used at the same time, so it is changed over into picture. Henceforth the video should be divided into edges for investigating.

3.1.3 FACE RECOGNITION.

In this stage it is perceived that the district containing the pith of the driver. A predefined tally is for space of face in each bundling. By face affirmation we surmise that discovering the face in an edge or continuously end discovering zone of facial characters through a sort of progression with the utilization of PC. The bundling might be any emotional bundling. Essentially facial related constructions or highlights are perceived and all other kinds of articles like structures, tree, bodies are disregarded.

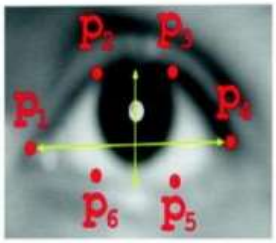
3.1.4 EYE DETECTION.

After affirmation of face eye should be recognized for additional dealing with. In the strategy eye is the choice boundary for discovering the condition of driver. Despite the way that conspicuous verification of eye might be less mind boggling to find, in any case it's angled. By and by it plays out the space of eye in the required unequivocal area with the utilization of affirmation of a few highlights. Everything considered Eigen approach is utilized for this approach.

3.1.5 EYE PERSPECTIVE PROPORTION (EAR).

From the eye corner focuses, the eye perspective proportion is determined as the proportion of stature and width of the eye as given by:

EAR Formula:

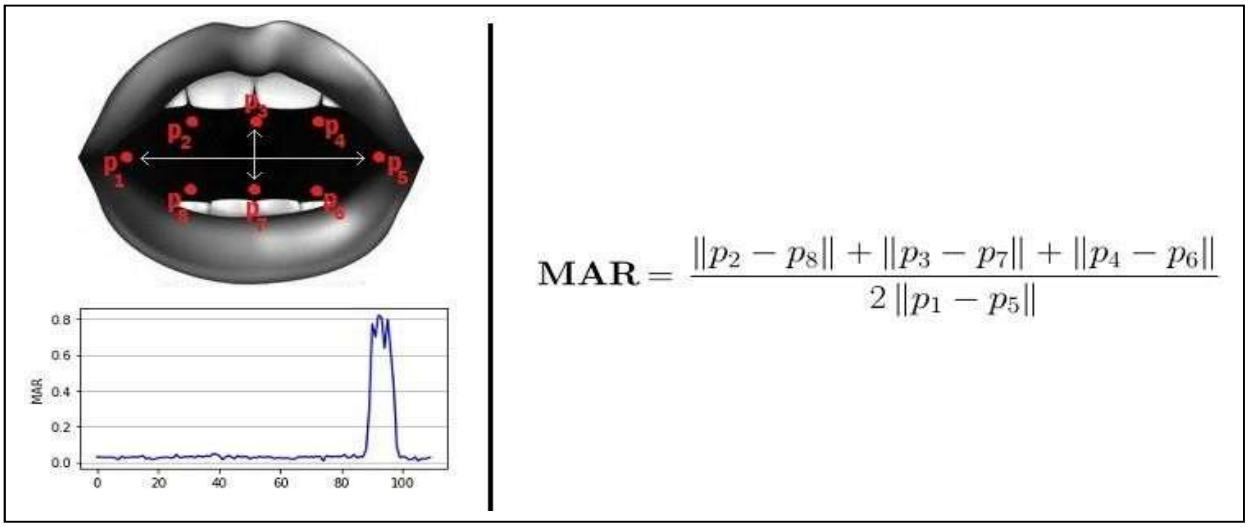


$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

Similarly, the actions are taken from the Mouth that is by utilizing Mouth Opening Ratio (MOR), and furthermore the head gesturing is determined. In the wake of recognizing the facial milestones.

3.1.6 Mouth opening proportion (MAR):

Mouth opening proportion is a boundary to recognize yawning during sleepiness. Like MAR, it is determined as:



$$\mathbf{MAR} = \frac{\|p_2 - p_8\| + \|p_3 - p_7\| + \|p_4 - p_6\|}{2\,\|p_1 - p_5\|}$$

3.2 ALGORITHM.

In earlier stages of this final year project, it has been intended to use OpenCV to develop the algorithm for the system. Using OpenCV, the software has been used to ease the process of writing the codes. In the experimentation result, eyes and mouth has been done.

HOG + Linear SVM (Using Dlib)

Dlib is a general-purpose cross-platform software library written in the programming language C++ as well as Python. Its design is heavily influenced by ideas from design by contract and component-based software engineering. Thus, it is first and foremost, a set of independent software components. It is opensource software released under a Boost Software License.

Since development began in 2002, Dlib has grown to include a wide variety of tools. As of 2016, it contains software components for dealing with networking, threads, graphical user interfaces, data structures, linear algebra, machine learning, image processing, data mining, XML and text parsing, numerical optimization, Bayesian networks, and many other tasks. In recent years, much of the development has been focused on creating a broad set of statistical machine learning tool.

The pre-trained facial landmark detector inside the dlib library is used to estimate the location of 68 (x, y) coordinates that map to facial structures on the face.

3.2.1 EUCLIDEAN ALGORITHM.

It is only a distance measure between a couple of tests p and q in a n-

dimensional element space:

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \cdots + (q_n - p_n)^2}$$

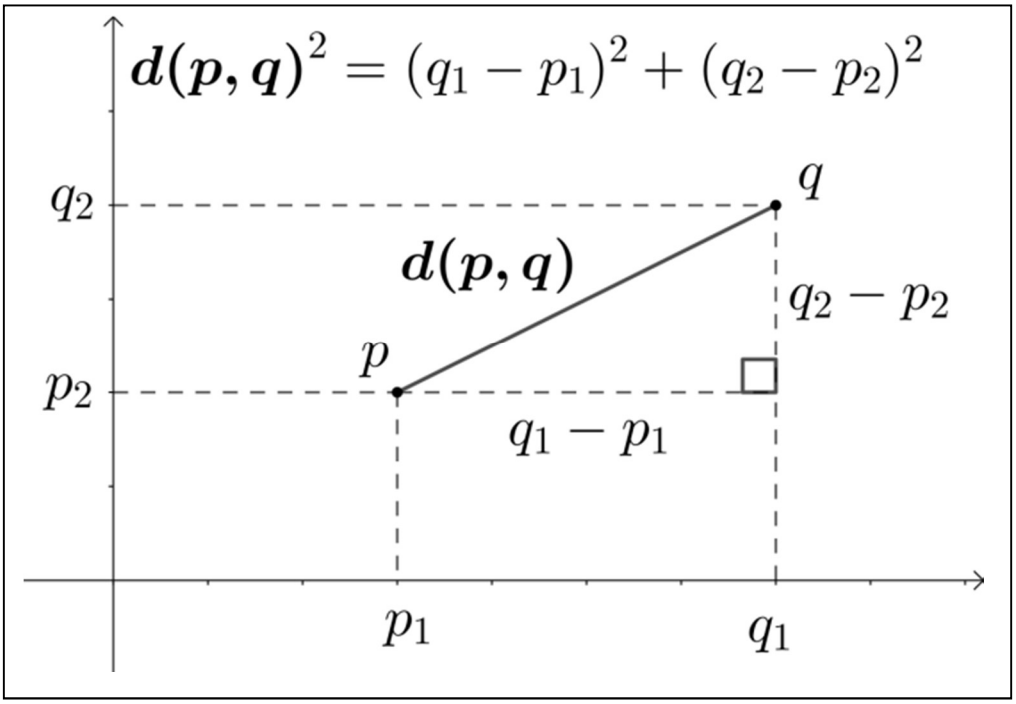
$$= \sqrt{\sum_{i=1}^{n} (q_i - p_i)^2}.$$

Concerning Euclidean calculation, an assessment is made in one assessment by fixing two on a line, and picking one to be the root.

The length of the line part between these centers portrays the unit of bundle and the heading from the inspiration to the subsequent point is depicted as the positive bearing. This line section may be made an explanation of along the line to manufacture longer divides whose lengths identify with eventual outcomes of the unit isolated.

The subsequent point is then astoundingly picked as the point on hold that is at a unit of one certain unit from the soonest beginning stage put together.

The division between any two on the certified line is the firm assessment of the mathematical difference of their direction. It is completely expected to see the name of a point with its Cartesian help.



3.2.2 KCF ALGORITHM.

Focusing on the issue that the customary bit relationship channel (KCF) following calculation can't re-recognize the objective, when the objective is absent because of brightening variety, extreme impediment, and out of view, this paper prompts the oddity discovery technique as the objective misfortune cautioning instrument dependent on KCF, and simultaneously, an objective misfortune re-location system is proposed. This strategy distinguishes the pinnacle worth of the reaction of each casing. On the off chance that the strange pinnacle esteem is discovered, the objective is lost or will be lost. At that point, the admonition component cautions, the objective format update is halted, the objective misfortune re-identification instrument is begun and tracks the objective in full edge search. The test results show that the accuracy of the improved calculation is 0.751, and the achievement rate is 0.579, which is 5.77% and 12.43% higher than that of the customary KCF following calculation, separately. This tackles the issue that the KCF tracker can recuperate the objective to continue to follow the objective is lost, the exhibition of the following calculation is improved, and the drawn-out following is figured it out.

3.3 SYSTEM REQUIREMENT AND SPECIFICATION.

System requirement is needed to accomplish this project and assist the development of the project that involves system requirement in hardware and software. Each of the requirement is related to each other to make sure that the system can be done smoothly.

3.3.1 HARDWARE.

No	Hardware	Description
1	Laptop	Processor: Intel Core i5 or Higher
		RAM: 4 GB (min)
		OS Version: Windows 32/64 bit
2	Webcam	Built-in webcam

Table 1: Hardware

3.3.2 SOFTWARE.

No.	Software	Description
1.	Microsoft Word 2016	Microsoft Word used for word processing, such as crating and editing report and thesis documentation.
2.	Microsoft PowerPoint2016	To present the result and the findings of this project.
3.	Snipping Tool	Capture and screenshot images
4.	Anaconda Navigator	Launch applications and easily manage conda packages, environments, and channels without using command-line commands.
5.	Python 2.7 or Higher	High-end language interpreter to program the project
6.	WinZip	To extract the zipped data

Table 2: Software

3.4 FRAMEWORK.

The core of this research is to develop an algorithm that can be used in a software system based on driver drowsiness detection system.

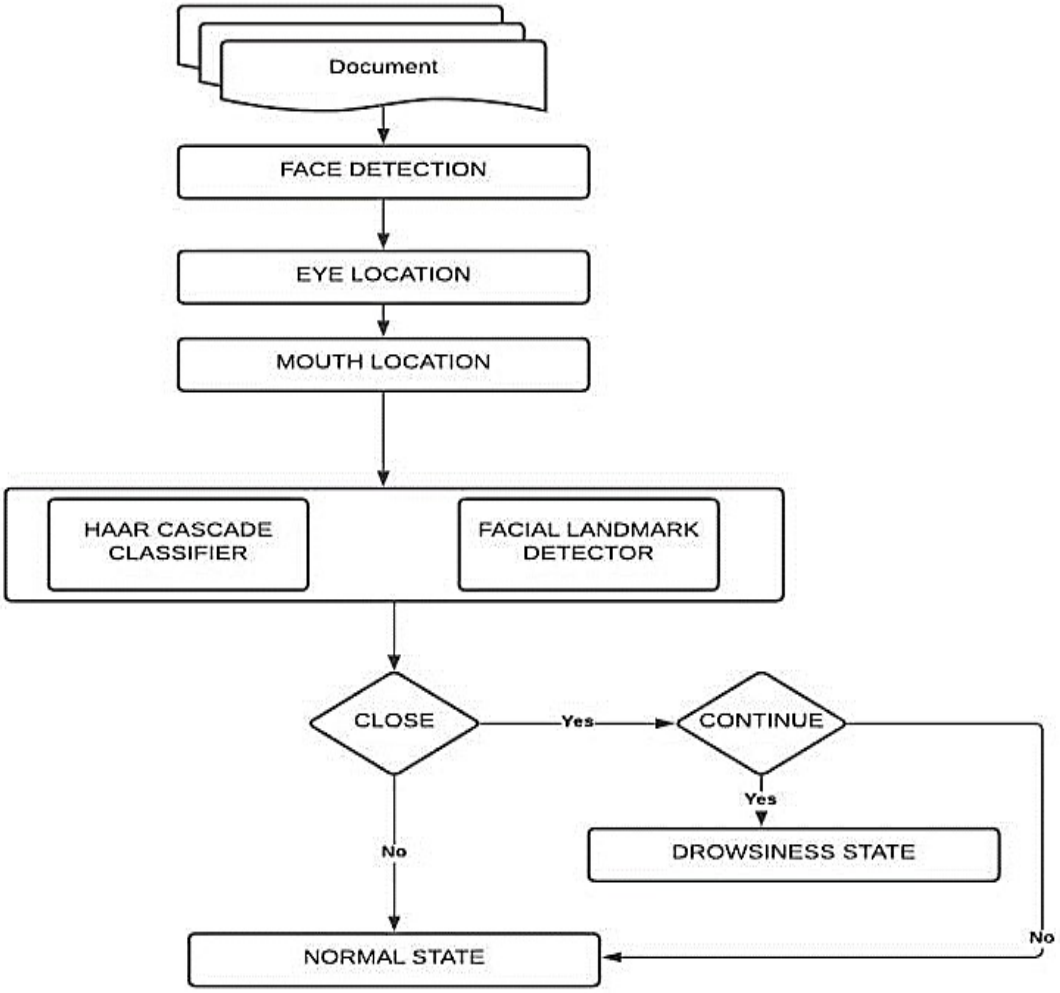


Figure 3: Flow chart of the process model

3.5 DATA SOURCE.

Data source is the location where we can get data that has been accessible to others and that has been provided by a trustworthy platform based on the computer science. The primary database source is the database that can be located on a disk or remote server in a database management system. I use the collected data that has been uploaded into the trustworthy website.

CHAPTER # 4

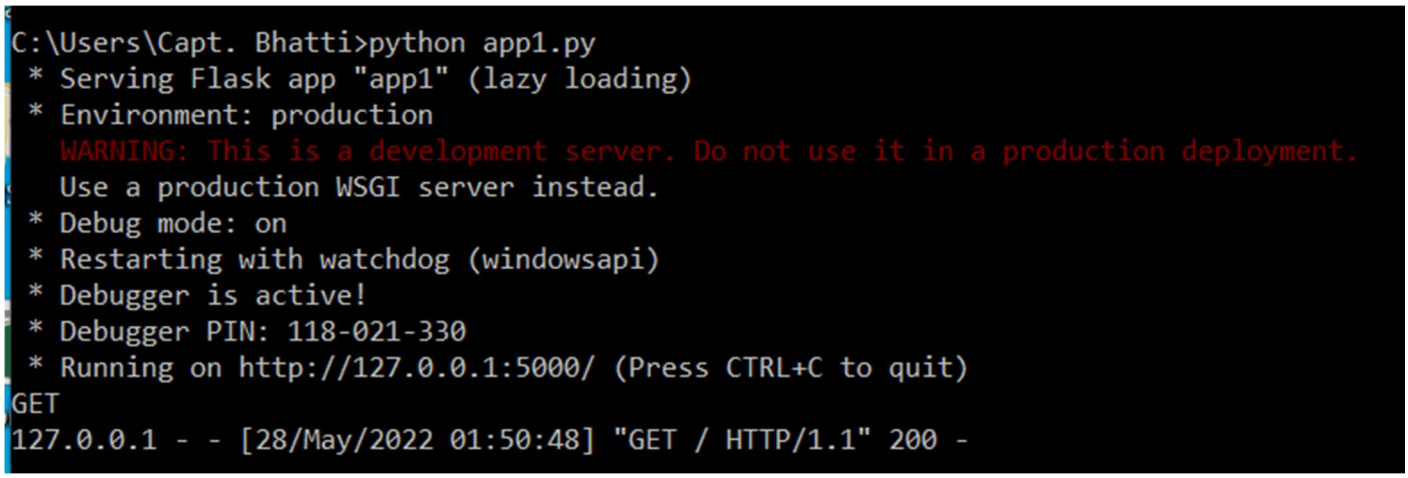
4. IMPLEMENTATION AND RESULT.

This chapter will discuss about the project implementation and testing. Both implementation and testing result are the last stage of the project development. Implementation is necessary to verify that the project development of the trained model meet the requirement. Testing result is the process of showing the result of the testing that have been done to ensure its functionality. At this phase, it will show the model is well functioned and identify any weaknesses to be improved later. So, this chapter will generally discuss the implementation, deployment, and testing of the entire project after being developed.

4.1 IMPLEMENTATION.

All the implementation process of the vigilance detection by using computer vision project will be presented.

Create and activate the virtual environment for compatible version that support the all packages needed.



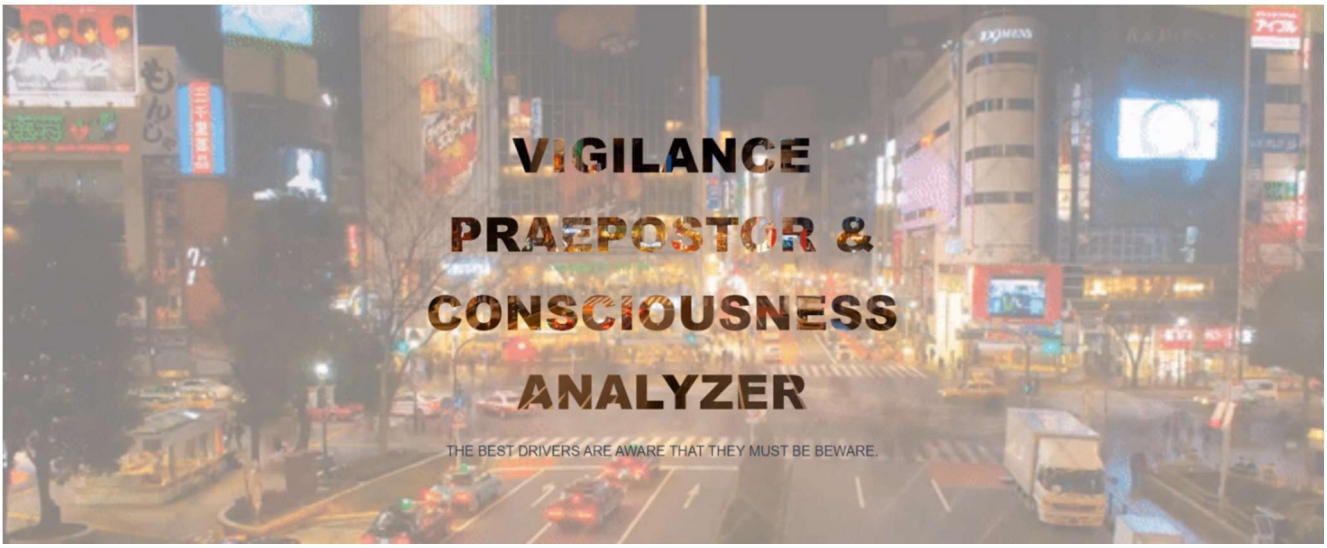


Figure 4: Front Display

Figure 5: Start Up Page

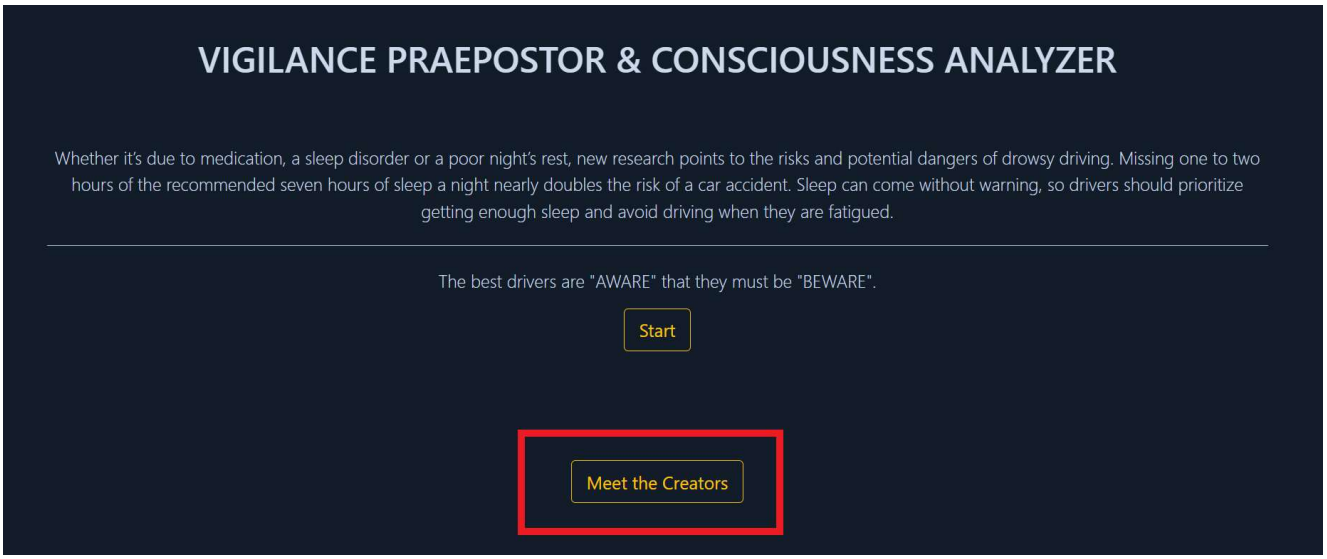


Figure 6: Menu Page

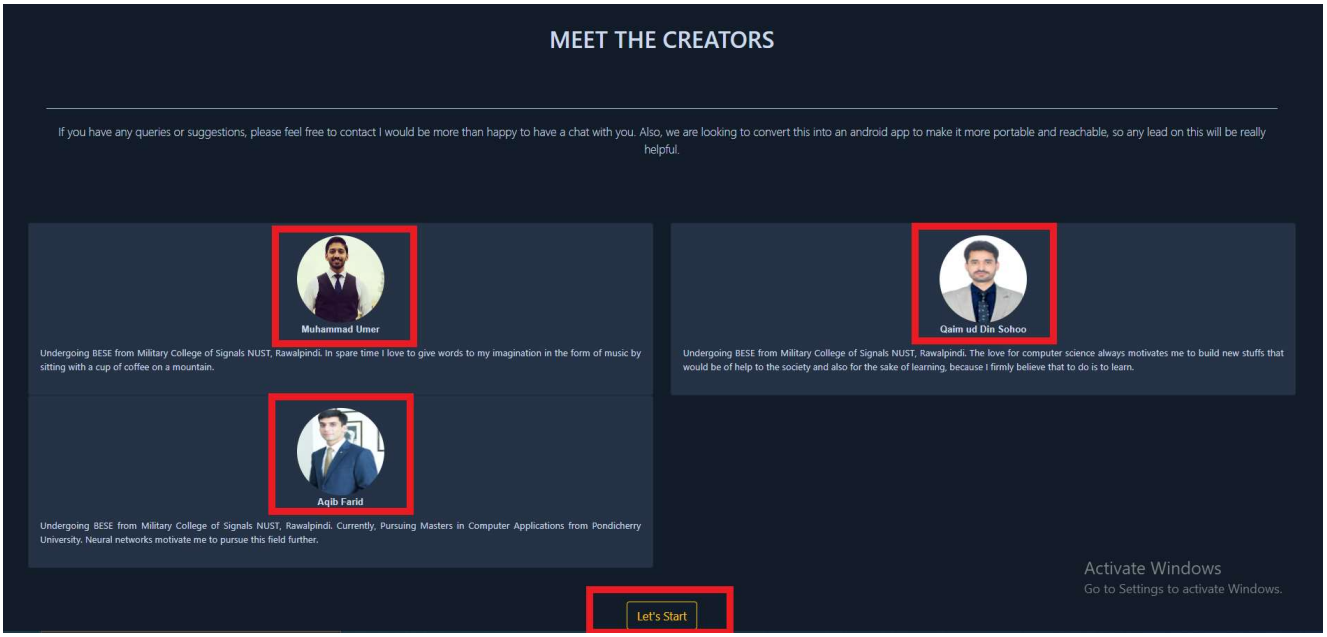


Figure 7: Creator Page

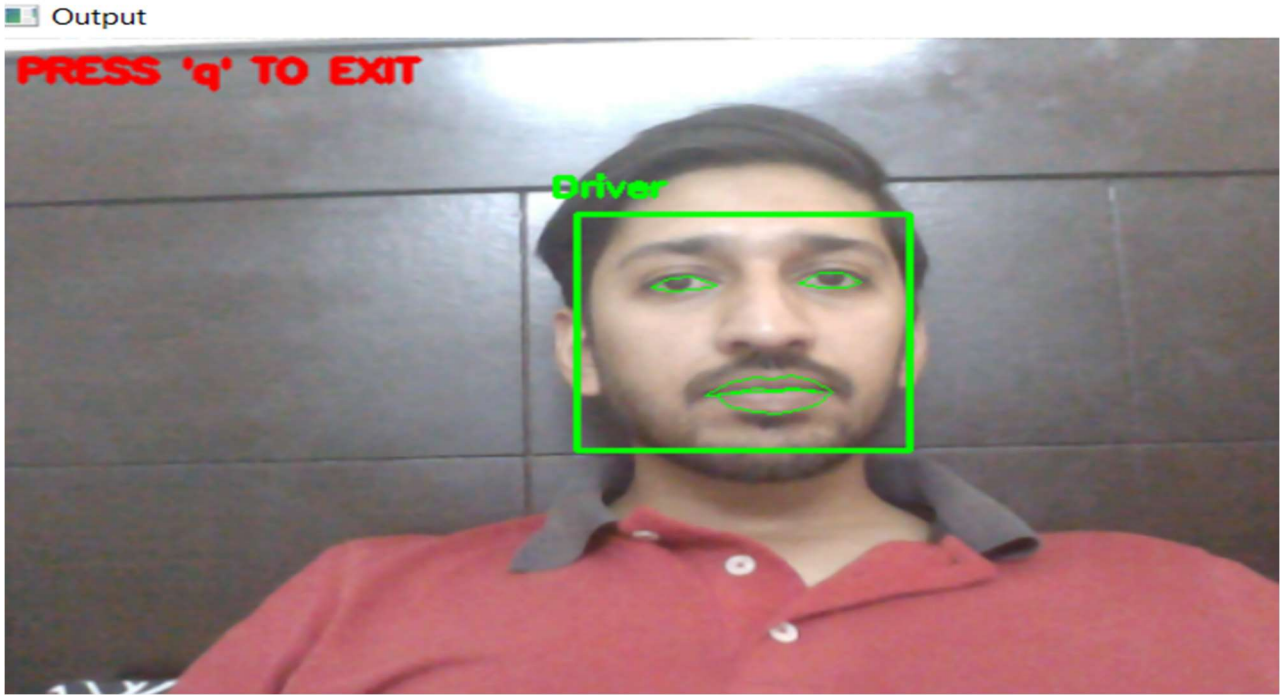


Figure 8: Shows Driver is Alert

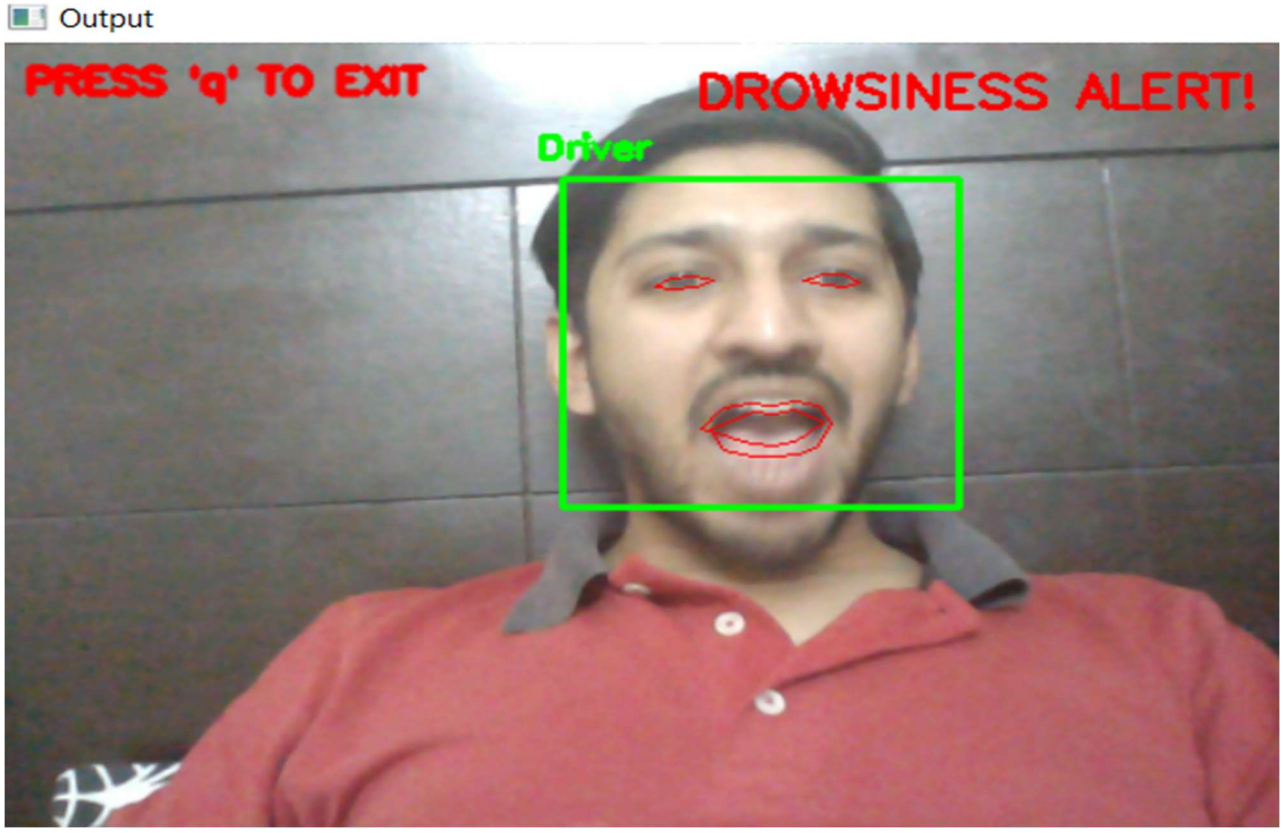


Figure 9: Detection of Yawning, It Shows Driver is Drowsy

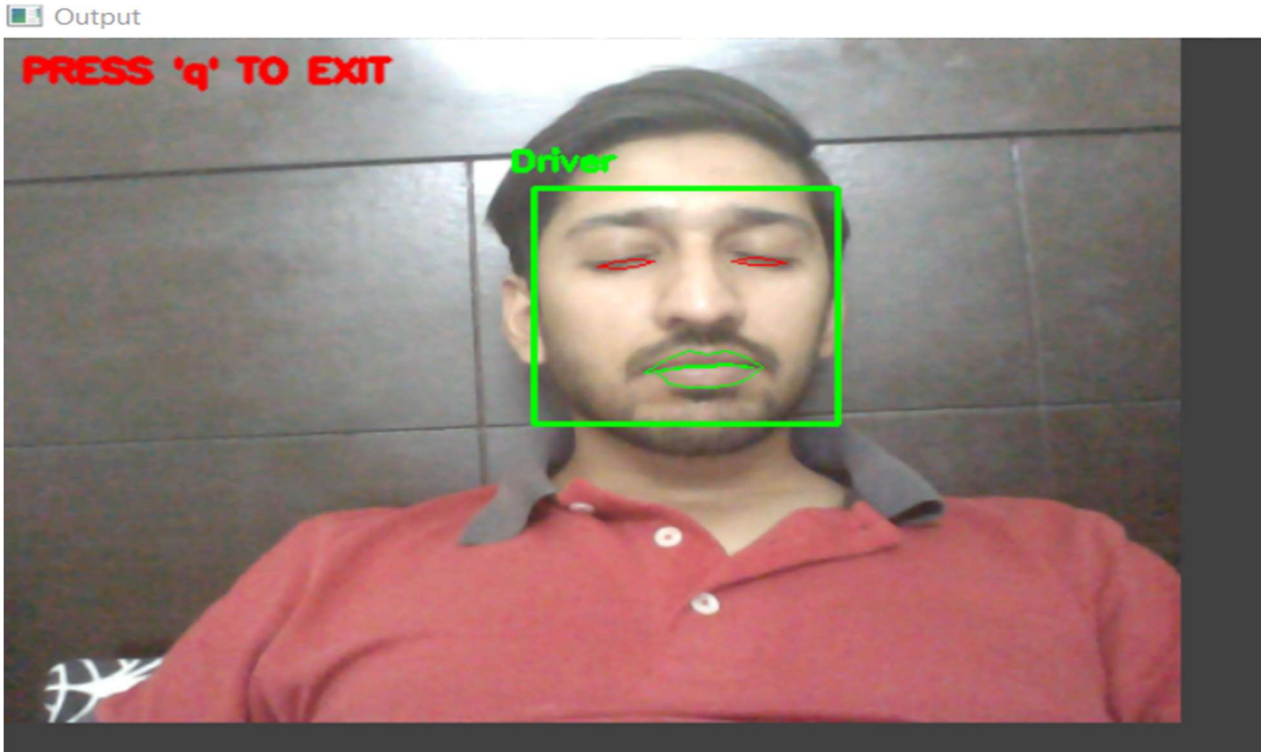


Figure 10: Detection of closed eyes, It Shows Driver is Sleeping

5. CONCLUSION.

In this chapter, the authors can conclude that, this project can be improved in the future to make it better and outstanding. Several techniques to develop the simulation system have been discovered. There are also other objectives that this project needs to achieve.

5.1 RESEARCH PHASE.

This project is divided into four phases in order to fulfil the objective. The first are the preliminary study and literature review that study the previous research or works.

Next, the design and methodology phase which are system requirement, model and algorithm. The third phase is implementing, testing and expected result. Lastly, the conclusion of this project will be summarized that conclude the whole project.

5.2 FUTURE WORK AND RECOMMENDATION.

The main goal of this project is to detect the states of the drivers' eyes and mouth to determine they are in the state of vigilance or not. The system must meet certain requirement which is detecting vigilance and alert the driver as well accurately.

Improvement on the algorithms to detect eyes and mouth need to be done for future implementation. Luminance changes have to be encountered to ensure the detection of the gradient of eyes is sufficient to improve the detection results. The quality of the video or images used in detecting drowsiness affects the result of the detection. Therefore, a good quality and high frame rate of images (number of pixel) is one of the factors to get better detection. Better techniques can be used to compare which technique is more reliable in detecting drowsiness.

Thus, by making this project successful, the numbers of road accident can be reduced when this project is implemented in the vehicle to detect the drowsiness of the driver.

REFERENCES

[1] S. Albawi, T. A. Mohammed, and S. Al-Zawi, “Understanding of a convolutional neural network,” *Proc. 2017 Int. Conf. Eng. Technol. ICET 2017*, vol. 2018-Janua, no. April 2018, pp. 1–6, 2018.

[2] P. Choudhary, R. Sharma, G. Singh, S. Das, and S. G. Dhengre, “A Survey Paper On Drowsiness Detection & Alarm System for Drivers,” *Int. Res. J. Eng. Technol.*, pp. 1433–1437, 2016.

[3] Y. Ed-Doughmi, N. Idrissi, and Y. Hbali, “Real-time system for driver fatigue detection based on a recurrent neuronal network,” *J. Imaging*, vol. 6, no. 3, 2020.

[4] A. Jalilifard and E. B. Pizzolato, “An efficient K-NN approach for automatic drowsiness detection using single-channel EEG recording,” *Proc. Annu. Int. Conf. IEEE Eng. Med.Biol. Soc. EMBS*, vol. 2016-Octob, pp. 820–824, 2016.

[5] G. Chen and W. Wang, “Target recognition in infrared circumferential scanning systemvia deep convolutional neural networks,” *Sensors (Switzerland)*, vol. 20, no. 7, pp. 1–18,2020.

[6] J. Gwak, A. Hirao, and M. Shino, “An investigation of early detection of driver drowsiness using ensemble machine learning based on hybrid sensing,” *Appl. Sci.*, vol. 10, no. 8, 2020.

[7] M. P. Singh, G. Srivastava, and P. Kumar, “Internet traffic classification using machine learning,” *Int. J. Database Theory Appl.*, vol. 9, no. 12, pp. 45–54, 2016.