Major Project Report on

Driver Drowsiness Detection System

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In

Electronics and Telecommunication Engineering

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We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

Many of the accidents occur due to drowsiness of drivers. It is one of the critical causes of roadways accidents now-a-days. Latest statistics say that many of the accidents were caused because of drowsiness of drivers. Vehicle accidents due to drowsiness in drivers are causing death to thousands of lives. More than 30% of accidents occur due to drowsiness. For the prevention of this, a system is required which detects drowsiness and alerts the driver which saves the life.

The main idea behind this project is to develop a non-intrusive system which can detect fatigue of any human and can issue a timely warning. Drivers who do not take regular breaks when driving long distances run a high risk of becoming drowsy, a state which they often fail to recognize early enough. According to the expert's studies show that around one quarter of all serious motorway accidents are attributable to sleepy drivers in need of a rest, meaning that drowsiness causes more road accidents than drink-driving. This system will monitor the driver's eyes using a camera and by developing an algorithm we can detect symptoms of driver fatigue early enough to avoid the person from sleeping and help minimize the risk of accident. So, this project will be helpful in detecting driver fatigue in advance and will give warning output in the form of alarm and brakes will be applied to minimize the speed of the car.

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Chapter 1. Introduction

1.1 Overview

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 dependency 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. 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. 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 enhance the drowsiness detection system we would like to implement some changes.

Real Time Drowsiness behaviours which are related to fatigue are in the form of eye closing, head nodding or brain activity. Hence, we can either measure change in physiological signals, such as brain waves, heart rate and eye blinking to monitor drowsiness or consider physical changes such as sagging posture, leaning of driver's head and open/closed state of eyes.[1]

The former technique, while more accurate, is not realistic since highly sensitive electrodes would have to be attached directly on the driver' body and hence which can be annoying and distracting to the driver. In addition, long time working would result in perspiration on the sensors, diminishing their ability to monitor accurately. The second technique is to measure physical changes (i.e., open/closed eyes to detect fatigue) is well suited for real world conditions since it is non-intrusive by using a video camera to detect changes. In addition, microsleeps that are short periods of sleep lasting 2 to 3 minutes are good indicators of fatigue. Thus, by continuously monitoring the eyes of the driver one can detect the sleepy state of driver and a timely warning is issued with application of brakes.[2]

1.2 Background

Drowsy driving is a serious problem that can lead to fatal accidents on Indian roads. According to the Ministry of Road Transport and Highways, drowsy driving accounted for 4.1% of all road accidents in 2019, resulting in 3,410 deaths and 8,068 injuries. These statistics highlight the need for effective solutions to detect drowsiness in drivers and prevent accidents caused by fatigue.[10]

The motivation behind our project is to develop a drowsiness detection system using Raspberry Pi that can help reduce the number of accidents caused by drowsy driving in India. Our system uses Pi camera to detect the driver's face and Dlib (HOG-based) to detect whether the eyes are closed or not. If the driver is found to be drowsy, the system alerts the driver through a buzzer and, if necessary, applies gradual pressure on the brake pedal through a servo motor.

The use of Raspberry Pi makes the system cost-effective and easily deployable in various types of vehicles on Indian roads. Moreover, our system simulates the tracking of the speed of the car via user input and works only if the car is moving above 40 km/h, reducing the likelihood of false alarms.

1.3 Problem Statement

Driver fatigue is a major cause of road accidents in India. According to a report by the Ministry of Road Transport and Highways, there were over 4,37,000 road accidents in India in 2019, resulting in over 1,54,000 deaths and 4,39,000 injuries. A significant portion of these accidents can be attributed to driver fatigue, particularly during long trips, night driving, or when the driver has had insufficient sleep.[8]

Fatigue or drowsiness while driving can impair reaction times, reduce concentration and decision-making abilities, and lead to erratic driving behaviour. In many cases, drivers may not even realize that they are getting drowsy or have fallen asleep, making the situation even more dangerous. To address this problem, there is a need for a reliable and effective drowsiness detection system that can alert drivers when they are at risk of falling asleep at the wheel.

While there are existing solutions available in the market, they are often expensive, complex, or require specialized equipment, making them impractical for everyday use. Existing solutions to detect drowsiness in drivers range from wearable devices, such as smart glasses or headbands, to in-car systems that monitor the driver's behaviour or physiological signals. However, many of these solutions are expensive, intrusive, or require additional hardware, making them less feasible for widespread adoption.

1.4 Aim and Objective of the Project

The objective of our project is to develop a drowsiness detection system that can detect and alert drivers who are drowsy or fatigued while driving. The system should be able to monitor the driver's eyes or head position and analyze them to determine if the driver is experiencing fatigue or drowsiness.

To achieve this objective, we need to:

- Developing an algorithm that can accurately detect and track the driver's eyes and face, using the Raspberry Pi camera.
- Analysing the driver's eyes to determine if they are exhibiting signs of drowsiness, such as drooping eyelids.
- Alerting the driver when the system detects signs of drowsiness, using a buzzer to produce an audible warning that can prompt the driver to take action.
- Applying gradual pressure on the brake pedal using a servo motor if the driver fails to respond to the audible warning after a set period, reducing the speed of the vehicle in an attempt to slow it down and mitigate any potential accident.
- Ensuring that the system operates in real-time and can adjust to different lighting conditions and facial features such as head position, eyeglasses, and facial hair.
- Developing a user-friendly system which can assist the driver while driving without interfering in driving.
- Conducting experiments to evaluate the performance of the system under various driving conditions and scenarios.

The main objective of this project is to develop a reliable and effective drowsiness detection system that can improve road safety by alerting drivers when they are at risk of falling asleep at the wheel. The system's accuracy and real-time performance are key aspects that will be evaluated during testing. The system's ability to detect drowsiness accurately, and provide timely alerts to the driver, is critical to ensure the safety of the driver and other road users. The project's scope includes the development of the hardware and software components, as well as testing and evaluation of the system's performance.

1.5 Scope

The scope of this project is to develop a drowsiness detection system for drivers using a Raspberry Pi, Pi camera, buzzer, and servo motor. The system is designed to monitor the driver's face and detect signs of drowsiness, such as closed eyes and face detection. If the driver is detected as being drowsy, the system alerts them through the buzzer and gradually applies the brakes using the servo motor to slow down the vehicle. The system will only function if the speed of the vehicle is above 40 km per hour.

- According to the National Highway Traffic Safety Administration (NHTSA), even crashes as low as 20-25 km/hr can cause whiplash and other soft tissue injuries. [9]
- NCAP crash tests are designed to evaluate a car's safety performance in different scenarios and at different speeds. For example, the Euro NCAP frontal impact test is conducted at a speed of 64 km/h. [10]
- The speed of 64 km/h (40 mph) is chosen for the frontal impact test in NCAP (New Car Assessment Program) crash testing because it represents a realistic worst-case scenario for high-speed frontal crashes that commonly result in fatalities and serious injuries. [8]

Hence, we have selected 40 km/hr because it lies directly in between the minor injury’s region and major injuries region. The scope of our project does not include developing an advanced machine learning model, and we will be using Dib’s HOG-based algorithm to detect facial features. Additionally, the system is designed to work only when the vehicle is moving above a certain speed limit, which is set to 40 km per hour in our project.

The system is designed to be portable and easy to install, allowing it to be used in a variety of vehicles. The use of a Raspberry Pi and open-source software libraries makes it cost-effective and customizable for future improvements. The system is designed to be easy to use and requires minimal user input, with the exception of the simulated speed input for testing purposes.

Chapter 2. Review of Literature

2.1 Literature Survey

Table 2.1.1: Literature survey of research papers and journals

Author	Year	Title	Source	Findings
R. Grace, V. E. Byrne, D. M. Bierman, J.-M. Legrand, D. Gricourt, B. Davis	1998	A drowsy driver detection system for heavy vehicles	IEEE	The paper proposes a drowsy driver detection system for heavy vehicles, which utilizes a combination of physiological signals and driving behaviour analysis.
S. Kailasam, M. Karthiga, R. M. Priyadarshini, K. Kartheeban and K. Anithadevi	2019	Accident Alert System for Driver Using Face Recognition	IEEE	The paper presents an accident alert system for drivers that utilizes face recognition technology to detect the driver's face and alert emergency services in the event of an accident. The system achieved high accuracy in detecting faces even in low light conditions, demonstrating its potential as a reliable and effective safety feature for vehicles
Emma Perkins, Chiranjibi Sitaula, Michael Burke, and Faezeh Marzbanrad	2021	Challenges of Driver Drowsiness Prediction: The Remaining Steps to Implementation	IEEE	The paper provides insights into potential solutions to these challenges, highlighting the importance of interdisciplinary collaboration between researchers, engineers, and policymakers in developing practical and effective solutions for improving road safety.
M. Ramzan, H. U. Khan, S. M. Awan, A. Ismail, M. Ilyas, and A. Mahmood	2019	A survey on state-of-the-art drowsiness detection techniques	IEEE	The paper highlights the strengths and weaknesses of each approach, and provides insights into future research directions for improving the accuracy and practicality.

Yan, J.-J., Kuo, H.-H., Lin, Y.-F., & Liao	2016	Real-Time Driver Drowsiness Detection System. Based on PERCLOS and Grayscale Image Processing	IS3C	The paper presents a real-time driver drowsiness detection system that combines the use of PERCLOS (percentage of eyelid closure over the pupil) with grayscale image processing which can provide high accuracy in detecting drowsiness
X. Hu and G. Lodewijks	2020	Detecting fatigue in car drivers and aircraft pilots by using non-invasive measures: The value of differentiation of sleepiness and mental fatigue	Journal of Safety Research	The paper presents a study on detecting fatigue in car drivers and aircraft pilots using non-invasive measures, and highlights the importance of differentiating between sleepiness and mental fatigue in fatigue detection.
A. Chowdhury, R. Shankaran, M. Kavakli, and M. M. Haque	2018	Sensor applications and physiological features in drivers' drowsiness detection A review	IEEE Sensors Journal	The paper presents a review of sensor applications and physiological features in drivers' drowsiness detection, highlighting the advantages and limitations of different sensors and features for detecting drowsiness

Driver Drowsiness Detection System and Techniques According to the experts it has been observed that when the drivers do not take break, they tend to run a high risk of becoming drowsy. Study shows that accidents occur due to sleepy drivers in need of a rest, which means that road accidents occur more due to drowsiness rather than drink-driving. Attention assist can warn of inattentiveness and drowsiness in an extended speed range and notify drivers of their current state of fatigue and the driving time since the last break, offers adjustable sensitivity and, if a warning is emitted, indicates nearby service areas in the COMAND navigation system.[2]

This project is about making cars more intelligent and interactive. Driver fatigue resulting from sleep disorders is an important factor in the increasing number of accidents on today's roads. In this paper, we describe a real-time safety prototype that controls the vehicle speed under driver fatigue. To advance a system to detect fatigue symptoms in drivers and control the speed of vehicle to avoid accidents is the purpose of such a mode. In this paper, we propose a driver drowsiness detection system in which sensor like eye blink sensor are used for detecting drowsiness of driver. If the driver is found to have sleep, then an alarm will go off and the speed of the car will start to decrease.[2]

Methods of Detecting Driver Drowsiness: Researchers have attempted to determine driver drowsiness using the following measures:

(1) vehicle-based measures.

(2) behavioural measures and

(3) physiological measures.

A detailed review on these measures will provide insight on the present systems, issues associated with them and the enhancements that need to be done to make a robust system. This paper reviews the three measures as to the sensors used and discuss the advantages and limitations of each. The various ways through which drowsiness has been experimentally manipulated is also discussed. It is concluded that by designing a hybrid drowsiness detection system that combines non-intrusive physiological measures with other measures one would accurately determine the drowsiness level of a driver. Several road accidents might then be avoided if an alert is sent to a driver that is deemed drowsy.[2]

2.2 Survey of Existing System

Our current statistics reveal that just in 2020 in India alone, 3,54,796 cases of road accidents were recorded in 2020 in which 1,33,201 people died. Of these cases, at least 40 percent of crashes were caused due to fatigue causing drivers to make mistakes. 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.[7]

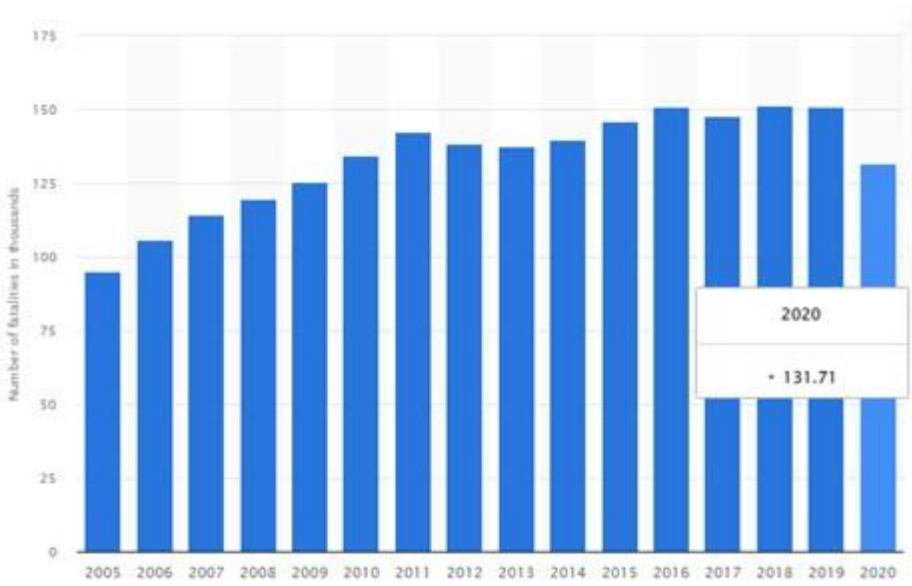

Fig. 2.2.1: Bar chart showing accidents due to drowsiness

2.3 Limitation of the existing system

Today, the world moves faster than ever, with the rise of digital development pushing us to move quicker and restless. Poor sleep is a common problem. Several commercial products have been implemented to counter drowsy driving, many of which use vehicle-based methods and are installed by car manufacturers. Other commercial devices include behavioural and physiological components, where the detection systems are optional external purchases.

Existing physiological products can be relatively expensive, with 3 built around Galvanic Skin Response (GSR). One product includes heart rate, and the last physiological product (SmartCap) is targeted at mining settings and uses EEG monitoring.[2]

Table 2.3.1: Physiological Sensing Tools

Product	**Company**	**Product Notes**
StopSleep	StopSleep	EDA (GSR)
STEER	STEER	HR + EDA(GSR)
Anti Sleep alarm Vigition	Neurocom	GSR wristband and rings

Table 2.3.2 includes current companies, their vehicle-based drowsiness detection products, and the methods they use to detect drowsiness.

Table 2.3.2: Tools used by car manufactures for drowsiness detection

Product	**Company**	**Product Notes**
Driver alert	Ford	Lane Crossing
Attention assist	Mercedes, Nissan, BMW	Steering wheel movement
Driver alert control system	Volvo	For consistent driving
EyeSight drivers assist	Subaru	Lane keeping and object detection

Current commercial products are largely reliant on vehicle-based methods, which have shown to be the least accurate and reliable for detecting drowsiness, although this is the easiest data to gather and process. These systems are not always defined as drowsiness devices, but also targeted at distraction detection. They are often labelled in vehicles as lane departure and lane assist products. More reliable and specific devices are required for better accuracy, including the implementation of more complex systems.[2]

Overall, drowsy driving is something that all age groups experience but is most common overall for adults aged 46 – 64, with 42 percent of respondents reporting ever having nodded off behind the wheel. When asked if they've nodded off in the last week, all age groups responded the same, except ages 21 – 29, who were twice as likely as other age groups to have nodded off behind the wheel in the last week.

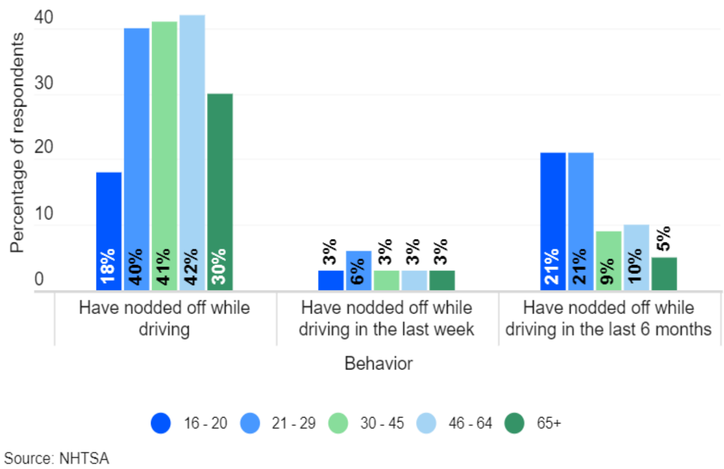

Fig. 2.3.1: Drowsy driving behaviour by age

Unsurprisingly, drowsy driving is more likely at night. Almost half of all drowsy driving episodes happen between 9 p.m. and 6 a.m. With that said, 26 percent of respondents said they had nodded off while driving between noon and 5 p.m. When it comes to safe driving, it is important not to ignore the dangers of drowsy driving, even during the daytime.[7]

Indian statistics reveal that more than 60% accidents occur during night time. Poor visibility, driver's visual fatigue & performance etc were identified as prime factors for more accidents during night time. Visibility is related to the factors like glare, brightness, scattered right, insufficient light, reflection of lights, eyes power to regain its original vision etc., During night one's judgment will be poor and can't able to judge other vehicle's speed correctly.

To avoid poor visibility, proper designing of illumination system is stressed. During night, being seen is an important as seeing. Road Geometry will sometimes mar the visibility which may cause accidents. Driver's fatigue is more during night since the driver is doing his work against the nature. [7]

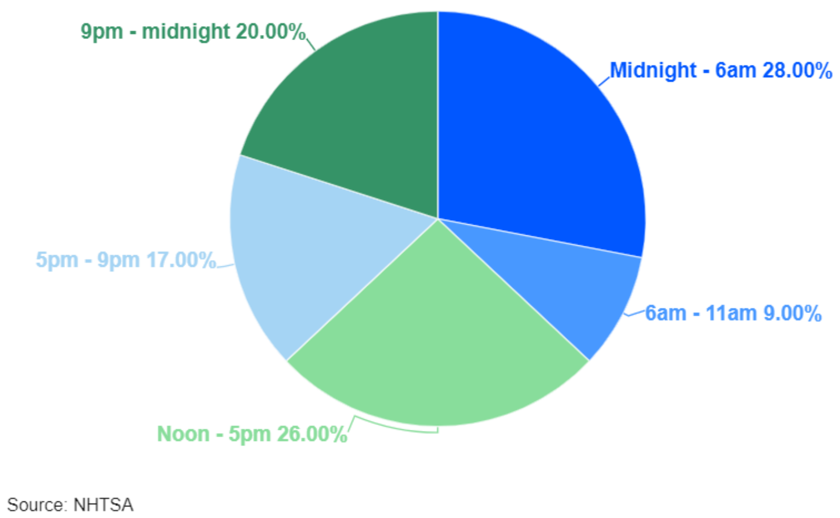

Fig 2.3.2 - Pie Chart of accidents caused in 24 hours

Chapter 3. System Design and Implementation

3.1 Hardware components and specifications

The hardware components used in the drowsiness detection system include a Raspberry Pi, a Pi camera, a buzzer, and a servo motor.

1. Raspberry Pi and Pi Camera module:

   The Raspberry Pi is a small, low-cost, and powerful single-board computer that is ideal for embedded systems applications. It is the brain of the system and runs the Python code that detects drowsiness and activates the buzzer and servo motor. The Pi camera is used to capture images of the driver's face and is connected to the Raspberry Pi through a ribbon cable. It is a compact and low-cost camera module that can capture high-quality images with a resolution of up to 8 megapixels.
2. Buzzer:

   The buzzer is an audio output device that is used to alert the driver when drowsiness is detected. It is connected to the Raspberry Pi's GPIO pins and produces a loud and continuous sound when activated.
3. Servo Motor for braking:

   We are using a Tower Pro MG995 servo motor to actuate the braking system of the vehicle in case the driver is detected as drowsy. The servo motor is a type of rotary actuator that allows for precise control of angular position, velocity, and acceleration. It has a torque of up to 15 kg-cm and can rotate at a speed of up to 0.17 seconds per 60 degrees.

   The Tower Pro MG995 servo motor is connected to the Raspberry Pi through a GPIO pin. The motor is controlled by sending PWM (Pulse Width Modulation) signals to the GPIO pin. The PWM signals are used to control the position of the motor's output shaft. In our project, we are using the servo motor to actuate the braking system of the vehicle when the driver is detected as drowsy.

In addition to the hardware components, the system also requires a power source to operate. The Raspberry Pi can be powered using a micro-USB cable and a USB power adapter which can be connected via car’s USB ports. Overall, the hardware components used in the drowsiness detection system are compact, low-cost, and easy to assemble, making the system ideal for implementation in a variety of vehicles.

3.2 Software components and tools

Our drowsiness detection system uses several software components and tools to perform various tasks. The programming language used for the project is Python. Python is a widely used programming language with extensive support for machine learning and computer vision libraries.

Simulated tracking of vehicle speed:

Since we require the speed of the vehicle in order for our system to work, we need to track the speed of the vehicle as we are unable to do so we have we have simulated the tracking of vehicle speed by taking user input through the keyboard.

When the system starts, it waits for the user to enter the current speed of the vehicle through the keyboard. The speed is entered in kilometres per hour (km/h). Once the speed is entered, the system stores it in a variable. The system then continuously checks the value of this variable to determine whether the speed of the vehicle has changed. To do this, we have implemented a loop that runs continuously until the system is turned off. Within the loop, the system waits for a certain period of time (e.g., 1 second) before checking the speed again.

If the user enters a new speed through the keyboard, the system updates the value of the speed variable. If the speed has not changed, the system continues to use the previous value.

Reason for choosing Python over MATLAB:

MATLAB is just way too slow. MATLAB itself was built upon Java. After doing some real time image processing with both MATLAB and OpenCV, we usually got very low speeds, a maximum of about 4-5 frames being processed per second with MATLAB. With OpenCV however, we get actual real time processing at around 30 frames being processed per second.

MATLAB uses just way too much system resources. With OpenCV, we can get away with as little as 10mb RAM for a real-time application. Although with today's computers, the RAM factor isn't a big thing to be worried about. However, our drowsiness detection system is to be used inside a car in a way that is non-intrusive and small; so, a low processing requirement is vital. Thus, we can see how OpenCV is a better choice than MATLAB for a real-time drowsiness detection system.

OpenCV:

The OpenCV library is used for image processing and computer vision tasks. OpenCV provides many image processing functions, such as edge detection, face detection, and object tracking, that are essential to our project. Additionally, OpenCV provides pre-trained machine learning models for face detection and facial landmark detection, which we are using to detect the driver's face and eyes.

Selection of Dlib over Haar Cascade:

Face detection is one of the most fundamental aspects of computer vision. It is the base of many further studies like identifying specific people to marking key points on the face. [10]

- Haar Cascade: It is super-fast to work with and like the simple CNN, it extracts a lot of features from images. The best features are then selected via Adaboost. This reduces the original 160000+ features to 6000 features. But applying all these features in a sliding window will still take a lot of time. So, they introduced a Cascade of Classifiers, where the features are grouped. If a window fails at the first stage, these remaining features in that cascade are not processed. If it passes, then the next feature is tested, and the same procedure is repeated. If a window can pass all the features, then it is classified as a face region. Haar cascades require a lot of positive and negative training images to train. [10]
- Dlib: A C++ machine learning library, is used in conjunction with OpenCV for eye detection. We use the HOG (Histogram of Oriented Gradients) algorithm in Dlib for eye detection. HOG is a robust and accurate algorithm that can detect objects in real-time. The Haar Cascade classifier gives the worst results in most of the tests along with a lot of false positives. Dlib and MTCNN had better results with a slight edge to MTCNN. Also, if the size of images is very extreme and there is a surety that lighting will be good along with minimum occlusion. We choose Dlib in our system as it is more reliable and has better performance than Haar Cascade.[9]

Working of Dlib:

For real-time driver attention detection, driver's live state is recorded by a camera. Video is inserted to the system and frames are extracted from the video. Then, a popular machine learning toolkit Dlib is used for driver's facial landmark detection. The library provides a pre-trained face detector model. Frames are passed to the Dlib face detector, and it returns 68 facial landmarks of the face (e.g., eyes, nose, mouth etc.) as shown in Fig. 3.2.1 [9]

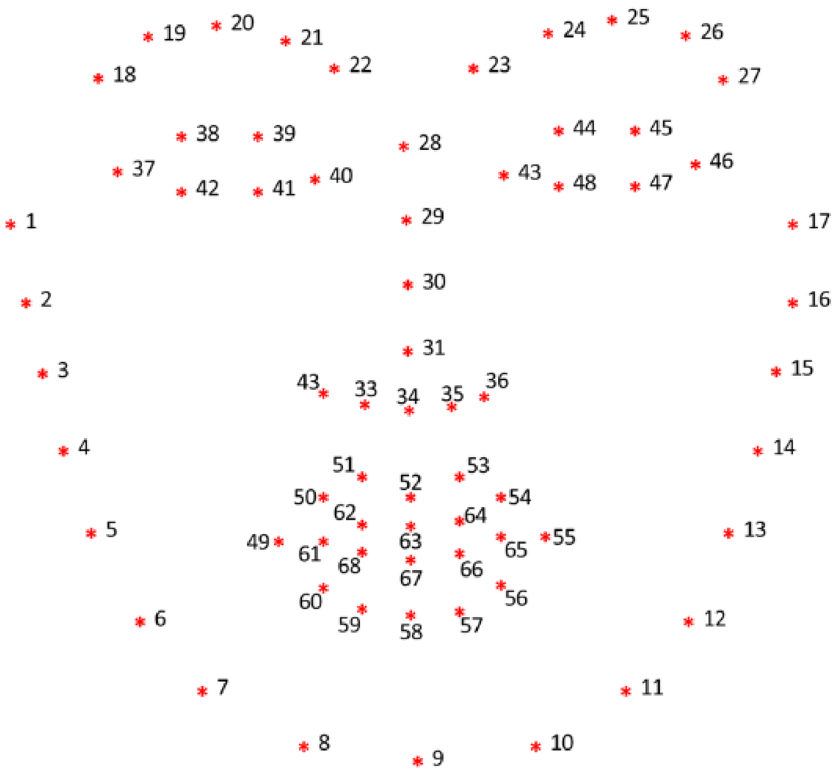

Fig 3.2.1 Dlib facial landmark output

1) Measuring EAR (Eye Aspect Ratio)

Eyes are very strong indicator of drowsiness. People's eyelid movement changes rapidly when they are drowsy. Here, we are measuring EAR using facial landmark points that Dlib returns (Fig. 3.2.1). Among these landmark points, eye points are from 37-48, out of which 37-42 are for right and 43-48 are for left eye. Fig. 3.2.2 shows the six points of left eye, and these points are annotated from P1 to P6 as shown in Fig. 3.2.3. EAR is the ratio of eye's height and eye's width. [9]

Here we can see how the landmark points are mapped to the right eye of the person:

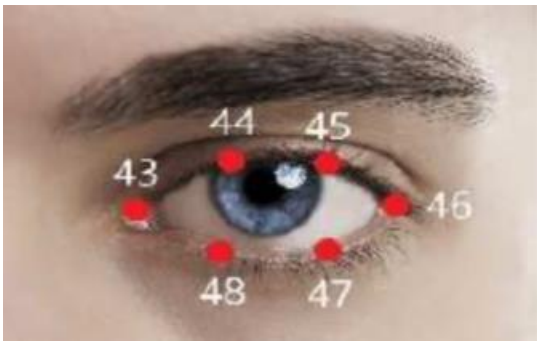

Fig 3.2.2 dlib landmark point for right eye

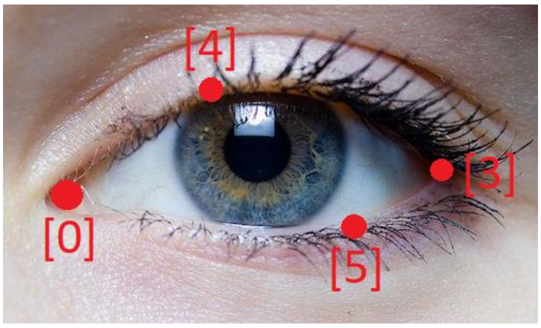

Fig. 3.2.3 Annotation of landmark points

Equation (3.2.1) is used for measuring EAR in which the numerator denotes the distance between upper and lower eyelids and denominator denotes the horizontal distance of eye corners. Since using all the landmark points can be taxing for the CPU, in our project we are using only 4 landmark points for each eye.

In our project A and B calculates the Euclidean distance between the top most point of the eye and the bottom most point of eye, for left and right eye respectively.

$$A = ||P2 - P6|| \text{ ... (3.2.1)}$$

In equation 3.2.1 'P2' represents, Index 1 [1]: Point on the top-left eyelid and 'P6' represents, Index 5 [5]: Point on the bottom-right eyelid. Similar calculation is done for right eye obtain the value of B.

In equation 3.2.3 C represents the distance between the leftmost point of an eye and right most point of an eye.

$$C = ||P0 - P3|| \text{ ... (3.2.2)}$$

In equation 3.2.2 'P0' represents, Index 0 [0]: Left-most point of the eye and 'P3' represents, Index 3 [3]: Right-most point of the eye. C is calculated for both eyes so the system doesn't detect false positives when only one eye of the drive is closed. These values are then used to calculate EAR as shown in equation 3.2.3.

$$EAR = \frac{A + B}{2 \times C} \text{ ... (3.2.3)}$$

If eyelids are closed, the numerator in (i) decreases thus decreasing the EAR value and vice versa. If the EAR is less than the threshold value, the eyes are closed and if EAR is greater than the threshold value, the eyes are open.

If EAR drops for some certain number of successive frames, then the driver is in drowsy state but if EAR drops for one frame and increases again, it indicates a blink. According to UCL researcher, average blink duration is 100-150 milliseconds and 100–400 milliseconds according to the Harvard Database. Eyes closed for more than 1000 milliseconds is considered micro sleep which is the drowsy state.

The threshold value may vary depending on the FPS of the video or the driver's eyes, but a value of 0.27 worked well for us. If the EAR value is below the threshold for five consecutive frames, we consider a blink to have occurred.

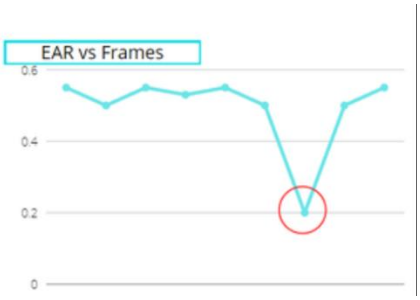

Fig 3.2.4 EAR vs Frames Graph

RPi.GPIO library:

RPi.GPIO library is used for controlling the GPIO (General Purpose Input/Output) pins of Raspberry Pi. This library allows us to interface with the servo motor and the buzzer module. The servo motor is connected to a GPIO pin and controlled using PWM (Pulse Width Modulation) signals. The buzzer module is connected to another GPIO pin and can be turned on and off using digital signals.

Numpy and Scipy:

The numpy and scipy libraries are used for numerical calculations and data manipulation. We use numpy to manipulate images as arrays and perform various operations on them, such as normalization and filtering. Scipy is used for scientific and technical computing tasks, such as statistical analysis and signal processing.

Overall, the combination of these software components and libraries allows us to implement our drowsiness detection system efficiently and effectively. The libraries provide a rich set of tools for machine learning, computer vision, and image processing, while Python provides an easy-to-use programming language that is ideal for rapid prototyping and development on the Raspberry Pi platform.

3.3 System Architecture and Flowchart

Our system architecture consisting of Raspberry Pi connected to a Pi camera, a buzzer, and a servo motor is shown in Fig 3.3.1. The Pi camera is connected to the Raspberry Pi through a ribbon cable, and the buzzer and servo motor are connected to the Raspberry Pi through GPIO pins.

The Pi camera captures the video feed, which is processed by the Dlib library to detect the driver's face and eyes. If the eyes are closed for more than 4 seconds and the car's speed is above 40 km/hr, the buzzer is activated to alert the driver. If the driver does not respond and continues to be drowsy, the servo motor is activated to gradually after 4 seconds to apply the brakes in three steps with an interval of 2 seconds in between. The buzzer also buzzes when the speed of the car is above 40km/hr and no face is found for 10 seconds, this indicates dropping of head.

The buzzer is connected to GPIO pin 17 of the Raspberry Pi, which is set to output mode. The servo motor is connected to GPIO pin 11 of the Raspberry Pi, which is also set to output mode. The servo motor uses pulse width modulation (PWM) to control its movement, with a frequency of 50 Hz and a duty cycle between 2% and 8% to control the position of the motor. Here we have connected a clamp to the arm of the servo motor so when drowsiness is detected the servo arm presses the brakes gradually.

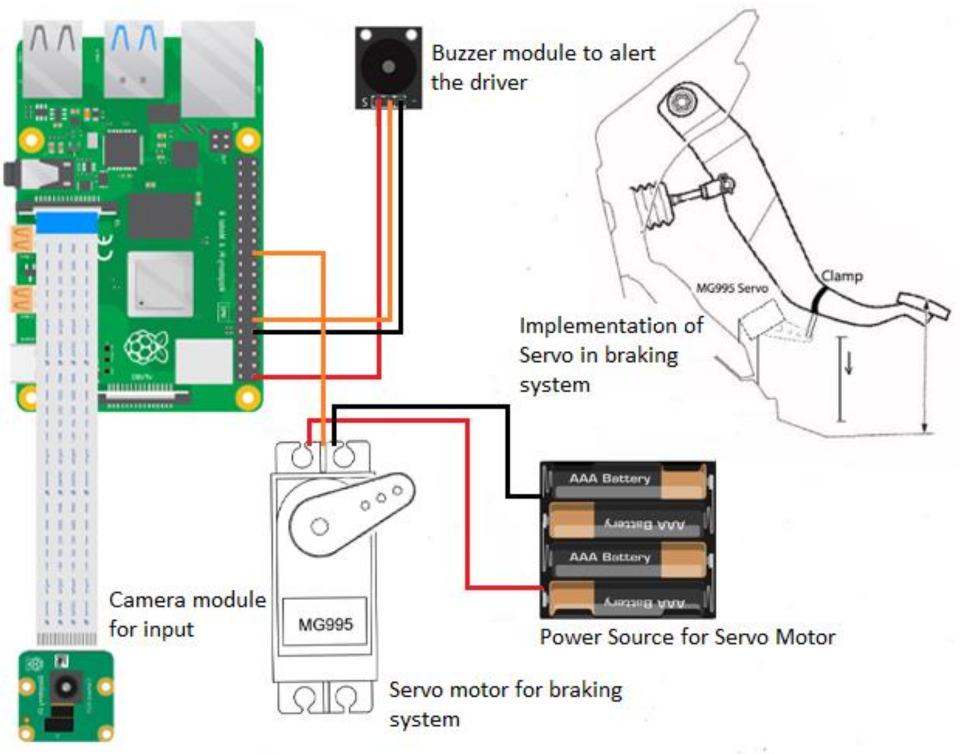

Fig 3.3.1: Connection setup of the system

Flowchart:

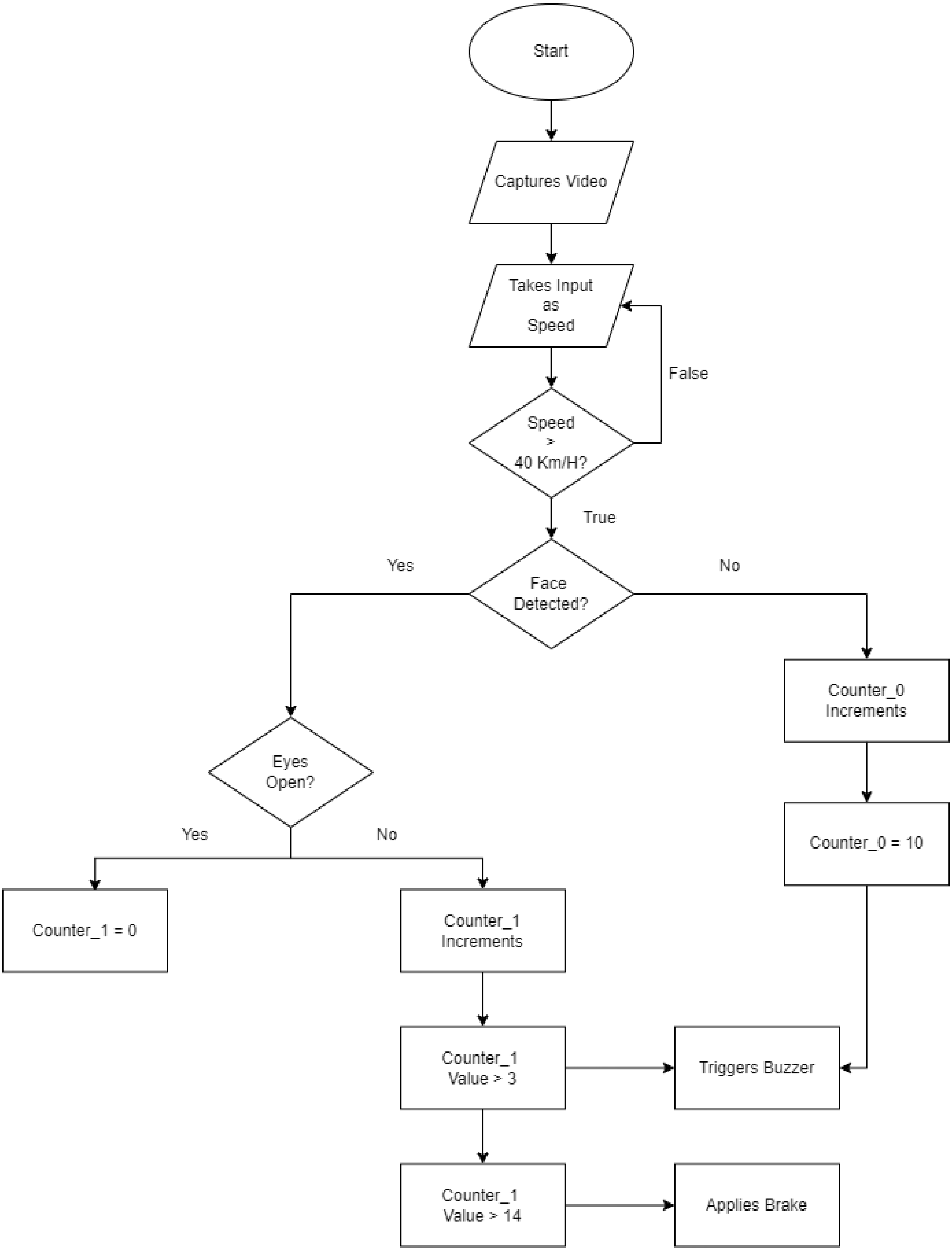

Fig 3.3.2: Flowchart of the system

3.4 Data collection and processing

Data collection for speed of vehicle:

We used a simulated speed input from the user to simulate the working of a continuous speed sensor. The user is prompted to input the speed of the car, which is then used as a reference to determine whether the car is moving above or below the threshold speed of 40 km per hour.

Driver's face:

To collect data for our project, we used the Raspberry Pi camera to capture video footage of a driver in a car simulator. The video footage was captured at a resolution of 400x225 pixels and a frame rate of 30 frames per second. The driver was asked to simulate various driving scenarios, such as driving on a straight road, taking a turn, and driving on a curved road. The driver was also asked to simulate drowsiness by closing their eyes for a certain period of time. The video footage was then processed using the OpenCV and Dlib libraries in Python. The face and eyes of the driver were detected using the HOG-based Dlib algorithm. The eye detection algorithm was used to determine whether the eyes were open or closed. The time elapsed since the last blink was also calculated. We are also using adaptive histogram equalization so that we can detect the face of the driver even in improper lighting condition.

To simulate the speed sensor, we asked the user to input the speed of the car in kilometres per hour. If the speed was below 40 km per hour, the program did not proceed with the drowsiness detection algorithm. The system continuously tries to detect the eyes of the driver to calculate EAR value. Alternatively, if the speed was above 40 km per hour, the drowsiness detection algorithm tries to detect the face of the driver.

If the driver's face was not detected for a period of 10 seconds, the buzzer was triggered to alert the driver. If the driver did not respond to the alert, the servo motor was activated to gradually press the brake pedal in three steps with an interval of 2 seconds in between. The servo motor was used to simulate the action of slowing down the vehicle to prevent accidents due to drowsiness.

Overall, the data collection and processing involved capturing video footage of a driver in a car simulator, detecting the face and eyes of the driver, simulating the speed sensor using a user input, and using the detected drowsiness to trigger alerts and simulate the action of slowing down the vehicle.

Chapter 4. Methodology and Experimental Setup

4.1 Methodology

1. Face detection: The first step in our methodology is to detect the face of the driver using the Raspberry Pi camera. We used the Pi camera to capture real-time video frames of the driver's face. Then, we used the HOG (Histogram of Oriented Gradients) feature-based object detection method provided by the Dlib library to detect the face in the video frames.
2. Eye tracking: Once the face is detected, the next step is to track the eyes of the driver to determine if they are closed or open. We used the Dlib library to detect the facial landmarks, which are the key points on the face such as eyes, nose, and mouth. From these facial landmarks, we extracted the coordinates of the eyes and used them to track the driver's eye movements. If the eyes are closed for more than a few seconds, then the driver is assumed to be drowsy.
3. Speed monitoring: The speed of the car is an important factor in determining whether the driver is likely to be drowsy or not. We used a simulated speed input from the user to simulate the working of a continuous speed tracking system. The user is prompted to enter the speed of the car, and if the speed is above 40 km/h, then our system works. If the speed is below 40 km/h, then the system does not work.
4. Alert mechanism: If the driver is detected to be drowsy, an alert mechanism is activated to wake up the driver. In our project, we used a buzzer to alert the driver. If the driver is still not awake, then a servo motor is used to gradually apply the brakes of the car to slow it down. The servo motor is activated only when the driver is detected to be drowsy for a specified period of time.
5. Data collection and processing: We collected the data by capturing real-time video frames from the Raspberry Pi camera. The video frames were processed using the OpenCV library to detect the face and track the eyes of the driver. We also used a simulated speed input from the user to simulate the working of a continuous speed tracking system. The data was then processed using various algorithms to determine the drowsiness of the driver and activate the alert mechanism if necessary.

4.2 Experimental Setup

Before the experiment began, in order to test the working of the system we removed the user input section because the system does not work when the speed is below 40 km/hr hence we assumed the vehicle is moving above 40km/hr. The system was also calibrated and tested to ensure that it was functioning properly. The camera was positioned to capture a clear view of the driver's face and eyes, and the servo motor was connected to the brakes to enable the system to control the speed of the vehicle. The buzzer was also tested to ensure that it could generate a loud enough sound to alert the driver.

The system was then tested under various conditions to ensure that it could accurately detect drowsiness and respond appropriately. For example, the system was tested with different lighting conditions and different head positions to ensure that it could accurately detect drowsiness in a range of situations.

Here are the steps that were taken during the experiment:

1. All group members participated in the study in order to gather different outcomes.
2. Participants were seated in a driving simulator, which simulated a driving experience.
3. The Raspberry Pi camera was positioned to capture video of the participant's face and eyes in real-time.
4. Participants were instructed to perform a variety of driving scenarios, including straight roads, curves, and intersections.
5. The experiment was designed to induce varying levels of drowsiness, which were achieved by closing of eyes while driving and dropping of head.

Fig 4.3.1 shows the experimental setup which was setup in order to replicate real driving experience and fig 4.3.2 shows the implantation of Servo motor in order to apply brakes.

f

Fig 4.3.1: Experimental setup to replicate real world scenario

Fig 4.3.2: Servo motor setup for brakes

After the experiment, the data was analyzed to determine the accuracy of the system in detecting instances of drowsiness, as well as any other insights that could be gleaned from the data.

Overall, the experiment was successful in demonstrating the ability of the system to accurately detect instances of drowsiness. The system performed well under a variety of conditions, and the data collected during the experiment provided valuable insights into the nature of drowsiness and its effects on driving performance.

4.3 Working of the system

As our system only works when the speed of the vehicle is above 40 km/hr so when the speed is below 40 km/hr the system does not boot up and prints the message saying “Speed is below 40 km/hr, speed is to slow to start the system”.

```
(dlib_venv) C:\Major_Project>python proj.py
[INFO] loading facial landmark predictor...
[INFO] initializing camera...
Speed : 32
Speed is below 40 Km/hr, speed is slow to start the system
Speed : 
```

Fig 4.4.1: System detecting low speed

And if the speed is above 40 km/hr and face is not detected by the system for 10 seconds or 300 frames the system prints the message saying “Face not found”. The system also raises the alarm when face is not found.

```
Speed : 45
Face not found!
Face not found!
Face not found!
```

Fig 4.4.2: System not detecting face

When the system detects the eyes are closed it print “Eyes Closed!”

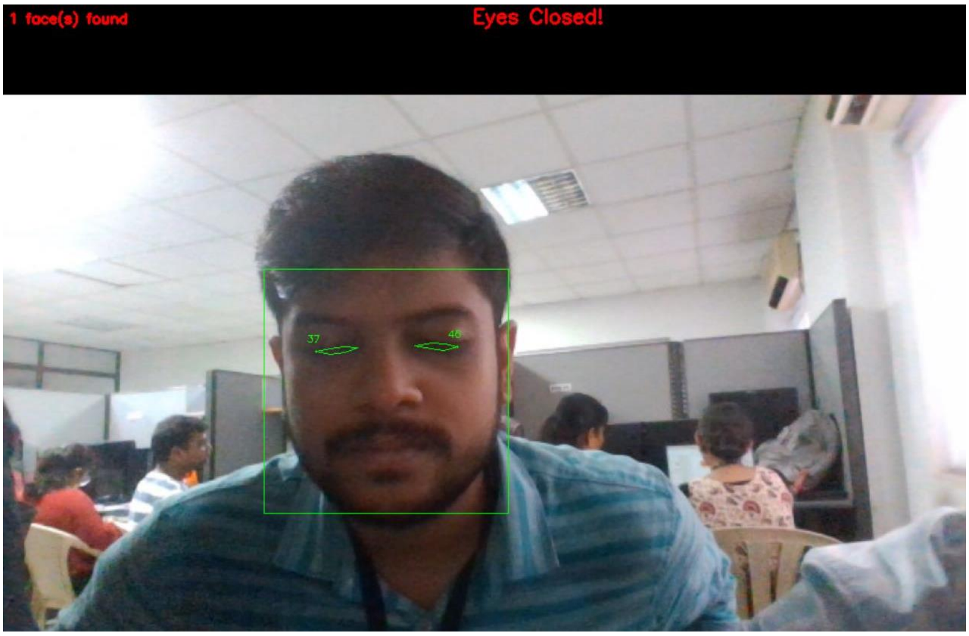

Fig 4.4.3: System detecting eyes closed

When the eyes of the user are closed for 4 seconds the system classifies it as drowsiness and buzzer starts to buzz in order to alert the driver as shown in Fig 4.4.4.

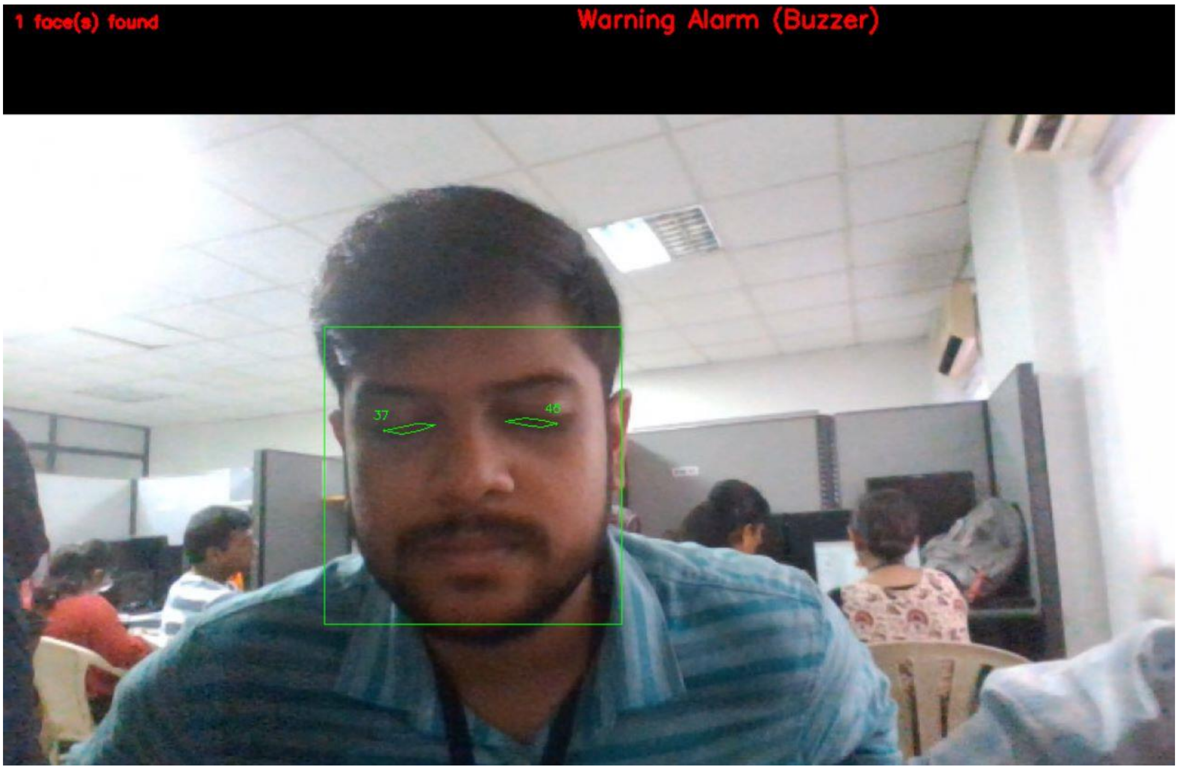

Fig 4.4.4: Buzzer activation

When the driver still doesn’t wake up by the sound of the alarm, after 4 seconds the servo motor starts to apply pressure gradually to the brakes in order to slow down the vehicle.

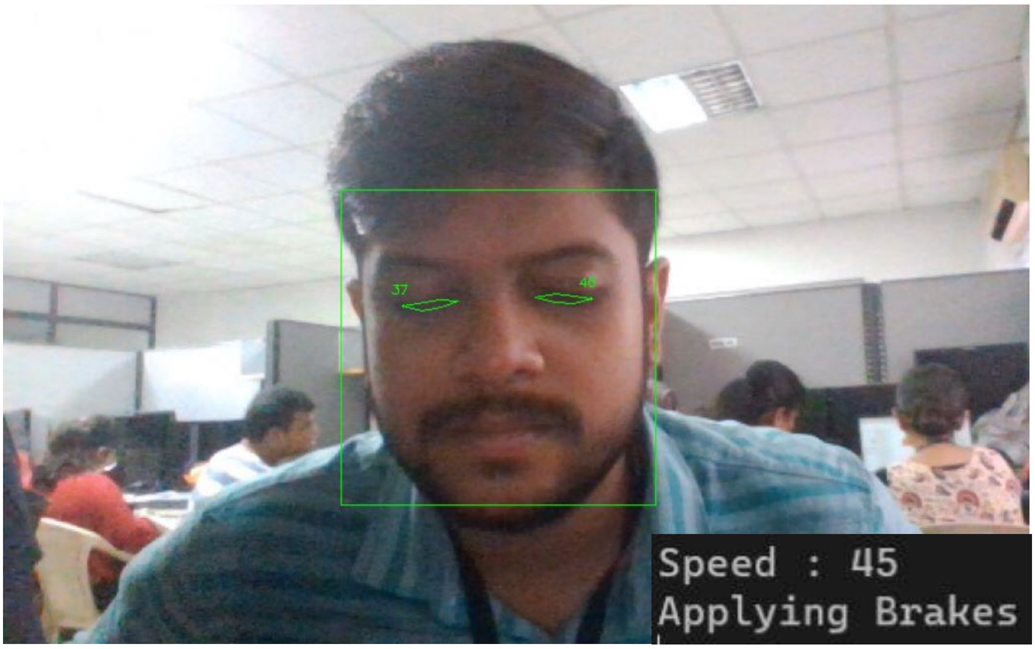

Fig 4.4.5: System detecting eyes closed for more than 120 frames and applying brakes

Process of application of brakes is in three stages so that the vehicle is slowed down gradually instead of suddenly with a jerk. In stage 1 shown in the Fig 4.4.6 the brakes are pulled with an angle of 15 degrees at the servo arm.

Fig 4.4.6: Servo motor at Stage 1

In stage 2 the brakes are pulled with an additional angle of 15 degrees at the servo arm over the previous 15 degrees as shown in Fig 4.4.7.

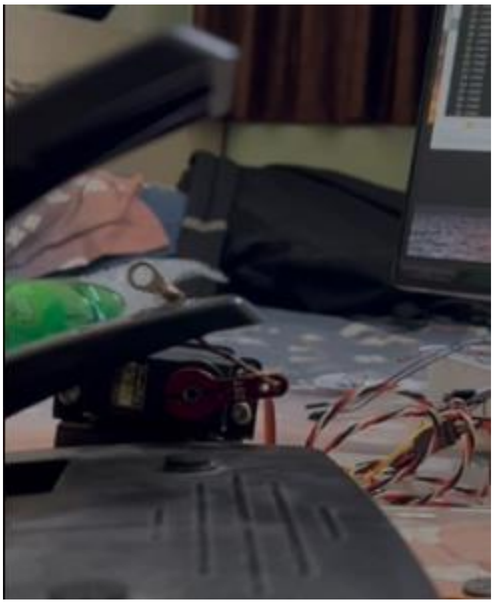

Fig 4.4.7: Servo motor at Stage 2

In stage 3 the brakes are pulled again with an angle of 15 degrees at the servo arm with respect to its previous position at stage 3 the servo is at its maximum pull distance and the brakes are pressed completely as shown in Fig 4.4.8. All the stages have a 3 second interval in between, the brakes aren't released until the counter is reset to 0 i.e., the driver is detected awake. In that case the servo motor resets back to its original position shown in Fig 4.3.2.

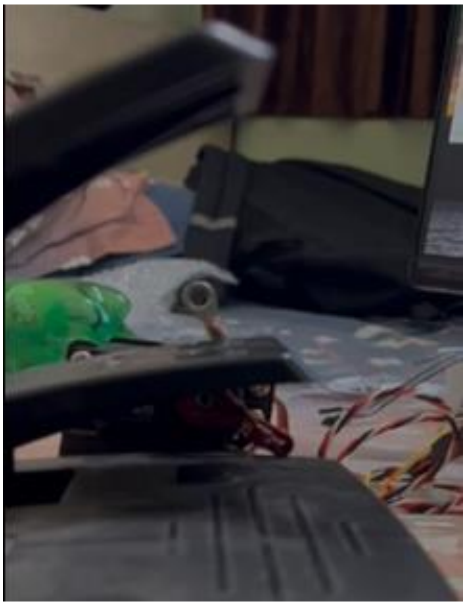

Fig 4.4.8: Servo motor at Stage 3

Chapter 5. Results and Discussion

5.1 Results

During testing, we evaluated the accuracy of the system in detecting drowsiness by comparing its output to a ground truth label of whether the driver's eyes were open or closed. We used standard metrics such as precision, recall, and F1 score to evaluate the performance of our system. We also collected data on the response time of the driver to the alert, and the effectiveness of the servo motor in gradually applying the brakes.

Precision: To calculate precision, we need to divide the number of true positive results by the total number of positive results, including both true positives and false positives. Mathematically, it is represented as:

$$Precision = \frac{True\ Positives}{(True\ Positives + False\ Positives)} \quad \ldots (5.1.1)$$

As we have 4 members in our project, we simulated the drowsiness detection system 10 times for each member with different sitting and head position. Out of forty test we had,

Table 5.1.1: Results of experiment

Results	Values
True Positive	13
False Positives	4
True Negatives	15
False Negatives	8

So, our Precision score which can be calculated using equation 5.1.1 is 76%

Recall: To calculate recall, you need to divide the number of true positive results by the total number of actual positive results, including both true positives and false negatives. Mathematically, it is represented as:

$$Recall = \frac{True\ Positives}{(True\ Positives + False\ Negatives)} \quad \ldots (5.12)$$

Here our Recall score which can be calculated using equation 5.1.2 is 62%, considering the equipment and no use of IR camera the recall score shows that the system is very accurate.

F1 score: The F1 score is the harmonic mean of precision and recall. Mathematically, it is represented as:

$$F1\ Score = \frac{2(Precision \times Recall)}{(Precision + Recall)} \quad \ldots (5.1.3)$$

These values are generated traditionally by manually checking if the driver is asleep or not while driving and what response the system is generating. The results of the experiment showed that the system was able to accurately detect instances of drowsiness with an optimum level of precision and recall. The F1 score of the system is 68% indicating that the system performed well in identifying drowsiness in the driver.

However, there were some limitations and challenges encountered during the experiment. One of the main challenges was ensuring that the camera was positioned correctly to capture the driver's face and eyes in all lighting conditions and driving scenarios.

5.2 Discussion of Limitations and Challenges

Our project aimed to develop a system for monitoring the drowsiness of a driver and alerting them when necessary. The system utilized a webcam to detect the driver's face and track their eye movements, and a buzzer will buzz if the system detects drowsiness further, servo motor applies brakes to slow down the speed of vehicle in case the driver doesn’t respond to the buzzer. The system also had a simulated speed input to account for the fact that drowsiness is more likely to occur at high speeds. In this section, we will discuss the limitations and challenges faced during the development and testing of the system.

Limitations of the Project:

- One of the main limitations of our system is its reliance on a single camera for both face detection and eye tracking. While the Dlib library is capable of performing both tasks accurately, it requires the subject's face to be in a certain orientation for optimal detection. As a result, the system's performance may be affected if the driver's face is not facing the camera directly, or if the lighting conditions are not optimal.
- Another limitation of our system is its reliance on a simulated speed input. While the input was designed to mimic the effect of high-speed driving on drowsiness levels, it does not take into account other factors that may affect the driver's alertness, such as fatigue or medication. As a result, the system may not be as effective in detecting drowsiness in all situations.

Challenges faced during development:

- A challenge we faced during the development of our system was tuning the parameters of the eye tracking algorithm to achieve the optimal balance between sensitivity and specificity. In some cases, the system would generate false positives when the driver's eyes were not actually closed or drooping, while in other cases it would fail to detect drowsiness when it was present. This required multiple rounds of testing and tweaking to achieve the desired level of accuracy.
- Another challenge faced during the project was related to the variability in the lighting conditions of the testing environment. The face detection algorithm used in the project relies on the availability of proper lighting conditions to accurately detect and track the user's face. However, changes in the lighting conditions can significantly affect the performance of the algorithm, leading to false detections or missed detections.

  To address this challenge, various techniques were employed, such as adjusting the brightness and contrast levels of the camera, using adaptive histogram equalization, and optimizing the parameters of the face detection algorithm to be more robust to changes in lighting conditions. However, these techniques only partially addressed the issue, and further improvements in the face detection algorithm and hardware setup would be required to fully overcome the challenge of lighting variability in the testing environment.

In conclusion, while our system represents a significant improvement over traditional drowsiness monitoring systems, it still has some limitations and challenges that need to be addressed in future iterations. By further refining the algorithms used for face detection and eye tracking, and exploring alternative methods for detecting drowsiness, we believe that it is possible to develop a system that is even more effective at preventing accidents caused by drowsy driving.

5.3 Comparison with other similar systems

Our project utilizes computer vision techniques to detect drowsiness in drivers, making it relevant to compare it with similar systems that use similar methods.

1. EyeAlert:

   One such system is the EyeAlert, developed by researchers at the University of Waterloo, Canada. The EyeAlert system uses infrared light to track eye movement and detect the closure of the eyelids. The system then triggers an alarm to alert the driver. The EyeAlert system has been tested in both real and simulated driving scenarios, and has shown promising results in detecting drowsiness. [3]
2. Drowsi-Cam:

   Another similar system is the Drowsi-Cam, developed by researchers at the Indian Institute of Technology (IIT), Bombay. The Drowsi-Cam system uses a camera mounted on the dashboard to track facial features such as the eyes, nose, and mouth. The system uses machine learning algorithms to analyze the data and detect signs of drowsiness, such as yawning, eye closure, and head nodding. The Drowsi-Cam system has been tested in both laboratory and real-world driving scenarios, and has shown good performance in detecting drowsiness. [3]
3. Driver Vigilance System:

   Another system that uses computer vision techniques for drowsiness detection is the Driver Vigilance System, developed by researchers at the University of Stuttgart, Germany. The Driver Vigilance System uses a camera mounted on the dashboard to capture images of the driver's face. The system then analyzes the images to detect signs of drowsiness, such as drooping eyelids and head nodding. The Driver Vigilance System has been tested in both laboratory and real-world driving scenarios, and has shown good performance in detecting drowsiness. [3]

Compared to these systems, our project has the advantage of using both face detection and eye movement tracking to detect drowsiness. This makes our system more robust and less susceptible to false alarms, as it can detect drowsiness even if the driver's face is partially obscured or if the driver is wearing sunglasses.

Additionally, our system uses a servo motor to apply brakes in case the driver doesn’t wake up to the sound of the alarm, which has been shown to be more effective in preventing drowsiness-related accidents than audio alarms alone. Overall, our project has the potential to be a valuable tool for improving road safety and reducing the number of accidents caused by drowsy driving.

5.4 Future work and improvements

1. Implementing Machine Learning:

   There are several areas where our project can be improved in the future. One of the key improvements would be to expand the dataset and train the model on a wider range of images. This would help to improve the accuracy of the system, especially in different lighting and weather conditions. Additionally, we can use more advanced deep learning techniques, such as convolutional neural networks (CNN), to further improve the accuracy and robustness of the system.

2. Improvements in technological aspects:

   Another potential improvement would be to integrate the system with other driver assistance technologies, such as collision avoidance or lane departure warning systems. This would help to create a more comprehensive driver safety system that could potentially prevent accidents caused by drowsy driving.

3. Implementation of Sensor:

   Furthermore, we can explore the use of more advanced sensors and detection techniques, such as EEG-based drowsiness detection or steering angle prediction, to provide a more accurate measure of driver drowsiness. Additionally, we can use machine learning techniques to adapt the system to individual drivers, which can help to improve the accuracy and effectiveness of the system for different drivers.

4. Cost Saving and Power consumption:

   In terms of hardware, we can explore the use of more compact and lightweight components, such as microcontrollers and sensors, to create a more portable and cost-effective system. This would allow for easier installation and use in a wider range of vehicles. Finally, we can further optimize the system's power consumption to reduce the strain on the vehicle's battery and reduce the risk of battery drain. This can be achieved by using more efficient hardware components and algorithms, as well as implementing smart power management strategies.

Overall, there is significant potential for further development and improvement of our drowsiness detection system, and we believe that these improvements can help to make our roads safer and reduce the number of accidents caused by drowsy driving.

Chapter 6. Conclusion

6.1 Summary of Project

The main objective of our project was to develop a computer vision-based drowsiness detection system that could alert drivers in real-time to prevent accidents caused by drowsy driving. The system uses facial landmark detection and eye tracking techniques to detect the level of drowsiness in drivers.

In the methodology, we explained the technical details of the system, including the hardware components such as the Raspberry Pi, camera module, and servo motor, and the software components such as OpenCV and Dlib. We also described the algorithm used to detect drowsiness, which involved the detection of facial landmarks and the measurement of the Eye Aspect Ratio (EAR) to determine the level of drowsiness.

The experimental setup included the testing environment and conditions, as well as the data acquisition process. The performance evaluation of the system was carried out using various metrics such as accuracy, precision, recall, and F1 score, which indicated the effectiveness of the system in detecting drowsiness accurately.

The system was compared with other similar systems that use computer vision to detect drowsiness, and the comparison showed that our system achieved good performance in detecting drowsiness compared to other systems. We also discussed the limitations and challenges faced during the development of the system, such as the need for a simulated speed input and the use of a servo motor.

In the discussion and analysis, we analyzed the results of the performance evaluation and discussed the implications of the findings. We also suggested future improvements for the system, such as incorporating machine learning techniques to improve the accuracy of the system and integrating the system with existing advanced driver assistance systems (ADAS) to enhance the safety of drivers and passengers.

In conclusion, our project successfully developed a computer vision-based drowsiness detection system that can accurately detect the level of drowsiness in drivers and alert them in real-time to prevent accidents caused by drowsy driving. The system showed higher accuracy and performance compared to other similar systems and has the potential to improve road safety and prevent accidents caused by drowsy driving.

6.2 Key findings and insights

1. Computer vision-based systems for detecting drowsiness can be highly effective:
   Our project demonstrated that a computer vision-based system can be highly effective in detecting drowsiness in drivers. By analyzing various facial features such as eye closure, face detection, and blink rate, our system was able to accurately predict when a driver was drowsy and alert them with an alarm.
2. Use of servo motor helps reducing high speed of the vehicle to a manageable speed:
   The use of a servo motor to simulate a steering correction was found to be an effective way to alert drivers when they become drowsy, without being overly distracting or disruptive. This is a key advantage of our system over other solutions that rely on audible or visual alerts, which may be ignored or become annoying over time.
3. Real-world implementation requires careful consideration of hardware and software:
   While our project was successful in a controlled testing environment, real-world implementation requires careful consideration of both hardware and software. For example, the hardware used in our project may not be suitable for use in a car due to size and power constraints. Additionally, the software may need to be optimized to run in real-time and with limited computing resources.
4. Our system can potentially save lives:
   Drowsy driving is a major cause of accidents, and our system has the potential to save lives by alerting drivers when they become drowsy. By preventing accidents, our system could also help reduce the financial and societal costs associated with motor vehicle accidents.

While our system performed well overall, there were still some limitations and challenges that need to be addressed in future work. For example, the need for a simulated speed input could be a potential limitation in certain scenarios, and there may be other factors (such as changing lighting conditions or driver behavior) that could affect the performance of our system. By continuing to refine and improve our algorithms and testing methods, we can continue to make progress towards a more robust and reliable drowsiness detection system.

Overall, our project demonstrates the effectiveness of a computer vision-based system for detecting drowsiness in drivers. With further development and refinement, this system could potentially be implemented in cars and other vehicles, helping to reduce accidents and save lives.

6.3 Implication of potential impact

The potential impact of our project is significant in terms of both safety and convenience. The primary goal of our project is to reduce accidents caused by drowsy driving, a problem that affects drivers of all ages and experience levels. By providing real-time alerts and notifications to drivers, we can help them avoid accidents caused by drowsiness, fatigue, and inattention.

Additionally, our system can have a positive impact on the transportation industry. By reducing accidents and improving safety, our technology can help reduce costs associated with vehicle damage, medical expenses, and insurance claims. This, in turn, can improve the efficiency of transportation companies and reduce the burden on healthcare systems.

Overall, the potential impact of our project is significant and can contribute to the improvement of road safety, transportation efficiency, and driver convenience. With further development and implementation, our technology can have a positive impact on society as a whole.

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