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System Requirement Specification

Topic: Driverdroid - Driver Drowsiness Detection System

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Abstract

Accidents caused by the driver's drowsiness is one of the highest causes of vehicle accidents all around the world. These kinds of accidents not only can be deathly for the driver but also for others who are not even in the vehicle. According to worldwide reports, the rate of accidents caused by driver drowsiness is growing year by year. To reduce this rate worldwide governments are conducting many different efforts starting from conducting informative sessions to introducing new laws and regulations. However, these efforts have proven less effective.

Worldwide data surveys indicate that driver drowsiness mostly causes by drunkenness, lack of sleep, depression, tiredness, and loneliness. While many companies already producing many systems that can detect and warn the driver when they are drowsy, those products are either cost highly or have low accuracy. Almost most of these devices judge driver's drowsiness by just running simple face and eye recognition algorithms. HelaDevs Driver Drowsiness Detection System is a solution to tackle this same problem but with more efficiency and with more accuracy. HelaDevs Driver Drowsiness Detection System is power with not just high-end low-cost hardware but also with machine learning and artificial intelligence to detect, analyze, and warn the user with much more accuracy and efficiency.

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Abbreviations

3D	Three-dimensional
4G	4th Generation
AI	Artificial Intelligence
API	Application Programming Interface
ARM	Acorn RISC Machine
BLE	Bluetooth Low Energy
CLI	Command-line interface
DC	Direct current
ECG	Electrocardiogram
EEG	Electroencephalogram
eMTC	enhanced Machine Type Communication
FDD	Frequency Division Duplex
FTDI	Future Technology Devices International
GB	Gigabyte
GHz	Gigahertz
GNSS	Global Navigation Satellite System
GPIO	General-purpose input/output
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
GUI	Graphical user interface
HDMI	High-Definition Multimedia Interface
HSPA+	Evolved High Speed Packet Access
IDE	Integrated development environment
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IR	Infrared
LPDDR	Low-Power Double Data Rate
LTE	Long Term Evolution
Mbps	Megabits per second
MIPI CSI	Mobile Industry Processor Interface Camera Serial Interface
MIPI DSI	Mobile Industry Processor Interface Display Serial Interface
ML	Machine Learning
MP	Megapixel
MS Office	Microsoft Office
MVC	Model, View, and Controller
NB-IoT	Narrow Band-Internet of Things
OOD	Object Oriented Design
OOP	Object Oriented Programming
OpenCV	Open-Source Computer Vision Library
OpenGL ES	OpenGL for Embedded Systems
OS	Operating system
RAD	Rapid Application Development
RGB	Red, Green Blue
SD	Secure Digital
SDLC	Software Development Life Cycle

SDRAM	Synchronous dynamic random-access memory
SIM	Subscriber identity module
SoC	System on a Chip
TDD	Time Division Duplex
UART	Universal asynchronous receiver-transmitter
UI	User Interface
UML	Unified Modeling Language
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
UTA-RLDD	University of Texas at Arlington Real-Life Drowsiness Dataset
UX	User experience
V	Volt

Chapter 1 - Introduction

1.1 Chapter Overview

In this chapter, here will discuss the project background, the problem introduction, definition, research questions, aim and scope of the project, objectives, proposed solution, and resource requirements. The topic introduction to the problem extended into subtopics of the problem boundary, examples in the problem and attempted solutions of the competitors with a feature comparison chart. The topic scope is extended in the subtopics of in-scope and out of scope. The objective is divided into the subtopics of research objectives, academic objectives, and operational objectives. The proposed solution topic is divided into 2 subtopics of rich picture diagrams and features of the prototype. The resource requirements are divided into 3 subtopics explaining hardware requirements, software requirements and technology stack.

1.2 Project background

1.2.1 Introduction to problem

1.2.1.1 Problem boundary

Over the past few years, the frequency at which accidents occur has been increasing drastically. Road security has become a global concern and a challenging problem that needs to be solved with real advanced solutions. Particularly according to various suggestions Driver drowsiness is one of the main causes of accidents on the roads. The analysis of the driver’s behavior on the road has become one of the leading research areas in recent years, Driving is a task that needs the driver’s full observation. This Driver drowsiness is caused due to a lack of sufficient sleep, more work hours, arduous work, non-work activities, mental stress or maybe merging of other factors (drivers with sleep disorders).

As a result of fatigue resulting from mental or physical fatigue or illness, drivers will get slow performance and reaction times, in a fatigue situation and sit still for a long time and when engaging in the same tasks repetitively (such as driving long distances), people getting bored, or changing their posture slightly. It will cause to fall into a sleep quickly (Drowsy Driving, no date)

Apart from that reduced careful observation, impaired thinking, troubling of keeping head up, troubles with maintaining speed, forgetting the road signs and turns, In the worst case, the driver will fall asleep while driving and drift out of the lane and cause a crash, several of these cause fatal crashes.

Physiological activities such as blinking, and yawning are normal and important ways in which drivers' weariness can be measured. Furthermore, repeated monitoring of the eye states is a very efficient way of assessing driver exhaustion, such as the length variations between the eye open state and the near state.

❖ youngers (under 25)

❖ long hours (over 60 hours a week) working people and shift workers

❖ long-haul drivers and commercial drivers

❖ people with undiagnosed sleep problems such as sleep apnea and acute insomnia

mostly become victims of driver drowsiness accidents

1.2.1.2 Examples in the problem

According to an estimation of The National Highway Traffic Safety Administration, record that for each year reporting 100,000 crashes are the direct result of driver fatigue. (sleep foundation, 2020)

Around 20% of all road accidents are due to fatigue of the driver and 50% on certain roads (Driver drowsiness detection, 2020)

As Australia, England, Finland, and other European nations report that driver drowsiness causes 10 to 30 percent of all crashes. An estimated 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary damages are the result. 100,000 police-reported crashes are the direct result of driver fatigue each year. (sleep foundation,2020)

Behavior	Number	Percent
Driving too fast for conditions or in excess of posted limit or racing	8,596	16.7%
Under the influence of alcohol, drugs, or medication	5,175	10.1
Failure to keep in proper lane	3,706	7.2
Failure to yield right of way	3,579	7.0
Distracted (phone, talking, eating, object, etc.)	2,688	5.2
Operating vehicle in a careless manner	2,797	5.4
Failure to obey traffic signs, signals, or officer	1,990	3.9
Operating vehicle in erratic, reckless or negligent manner	1,955	3.8
Overcorrecting/oversteering	1,617	3.1
Vision obscured (rain, snow, glare, lights, building, trees, etc.)	1,540	3.0
Driving wrong way on one-way traffic or wrong side of road	1,243	2.4
Drowsy, asleep, fatigued, ill, or blacked out	1,221	2.4
Swerving or avoiding due to wind, slippery surface, etc.	1,176	2.3
Making improper turn	635	1.2
Other factors	5,203	10.1
None reported	9,167	17.8
Unknown	16,012	31.1
Total drivers (1)	**51,490**	**100.0%**

Figure 1: (Facts + Statistics: Drowsy driving | III,2020)

Fetal crashes dependent on driver's drowsiness and exhaustion have occurred at a substantial rate in a year, according to the above map.

Also discovered drivers with fatigue driving at least once a week., 27% falling asleep behind the wheel before and 7 percent of involved in a crash related to nodding off (Elbaz et al., 2020)

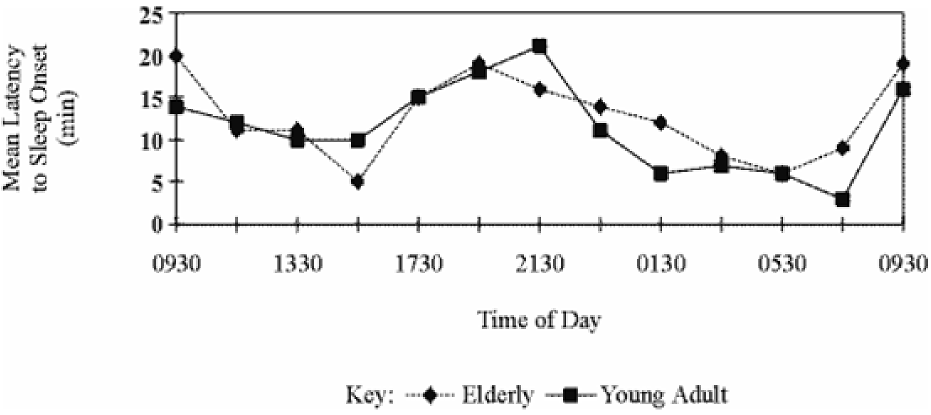

Figure 2: (Drowsy Driving,2020)

According to reports of National Transportation Safety Board above map indicates that drowsiness occurs both youngers and adults, and mostly youngers getting drowsy specially at nighttime and adults getting drowsy in early mornings.

Drowsiness accidents occur mostly between midnight and 6 a.m., and in the late afternoon, At both times of the day, Reports indicate that a single driver (and no passengers) mostly become victims of drowsiness accidents and frequently occur on rural roads and highways. (andrew.currin.ctr@dot.gov, 2016)

1.2.1.3 Attempted solutions of the Competitors

Attempted solutions of the Competitors chart have been moved to ***Appendix Section A.1*** for better clarity.

1.2.2 Problem definition

Driver drowsiness occurs in a fatigue situation. Due to lots of works, busy lifestyle, stress, disorders driver may feel tiredness when driving a vehicle. As a result of fatigue driver will have slow reaction time, lack of attention and in the worst driver fall into a sleep unknowingly. In drowsy crashes the driver does not make any effort to avoid crashes most of the time. At worst, these crashes lead to fatal accidents.

1.2.3 Research questions

Research Q1:
What algorithms can be used to detect driver drowsiness?
Research Q2:
What technologies to be used in IoT systems?
Research Q3:
What features can be extracted from drivers to detect drowsiness accurately?
Research Q4:
Will it be better to use AI to extract data from drivers?

1.3 Aim

The aim of this software development project is to design, develop, test, and evaluate a system to detect driver drowsiness by using an IoT device for the purpose of alerting the driver about his fatigue.

To elaborate further on this aim, this project will keep monitoring the driver's eyes and face and it will keep collecting data about the driver's heart rate. By comparing all those data, the system will predict whether the driver is feeling drowsy or not. If the system recognized the driver as a drowsy driver, then based on the driver's current location it will suggest some places where the driver can rest, and also it will suggest the driver the shortest way to his destination. By developing this system, we are also willing to contribute to decreasing the number of accidents which occur due to fatigue driving by keeping alerting the driver about his fatigue.

1.4 Scope

Based on the objectives of the project and analysis of the currently existing implementation, the scope is defined as follows.

1.4.1 In-Scope

● Image Processing will be conducted to detect the Fatigue and drowsiness of the driver by analyzing the facial features such as eyes, head, and face.
● Eye Localization, Thresholding (find the whites of the eyes) and calculating the eye aspect ratio will be done to determine whether the eyes of the driver has been closed for a long time or has been blinked.
● Recognizing and locating facial features and information will be done through various calculations and various self-developed image processing algorithms such as HAAR cascading method.
● Monitoring the heart rate will also be done to make sure that the heart rate does not exceed the threshold value that indicates the driver Is drowsy.
● Our IoT device will be trained to make sure that our model performs the designated functionalities.

1.4.2 Out of scope

● Vehicle collision avoidance, obstacle detection, and monitoring the Alcoholic level will not be implemented with our model.
● Automatic breaks, Autopilot driving, lane tracking and emergency calling will not be implemented in our system.

1.5 Objectives

1.5.1 Research Objectives

The research objectives for this project are as follows.

- To identify which hardware is more feasible for the project and how to use it more efficiently.
- To develop a ML and AI components for the system which runs on minimum requirements,
- To find a better and more efficient algorithm that can identify whether the user is asleep or not and if in sleep, which state the user is within minimum time using sensor data.
- To learn how to wake up the driver according to the state of his sleep and trying to keep him awake during the rest of the trip using the device.

1.5.2 Academic Objectives

The academic objectives for this project are as follows.

- Learning about IoT hardware components and how to assemble them.
- Identifying and gathering data from the sensors using GPIO inputs and Python.
- Gathering knowledge about better ways to use machine learning and artificial intelligence in the system.
- Gathering and improving skills such as problem solving, critical thinking, critical analysis, time management and project management.
- Using practical practice and theoretical knowledge.
- Producing and publishing project related research or concept papers.

1.5.3 Operational Objectives

Operational Objectives chart has been moved to ***Appendix Section A.2*** for better clarity.

1.6 Proposed Solution

1.6.1 Rich picture diagram

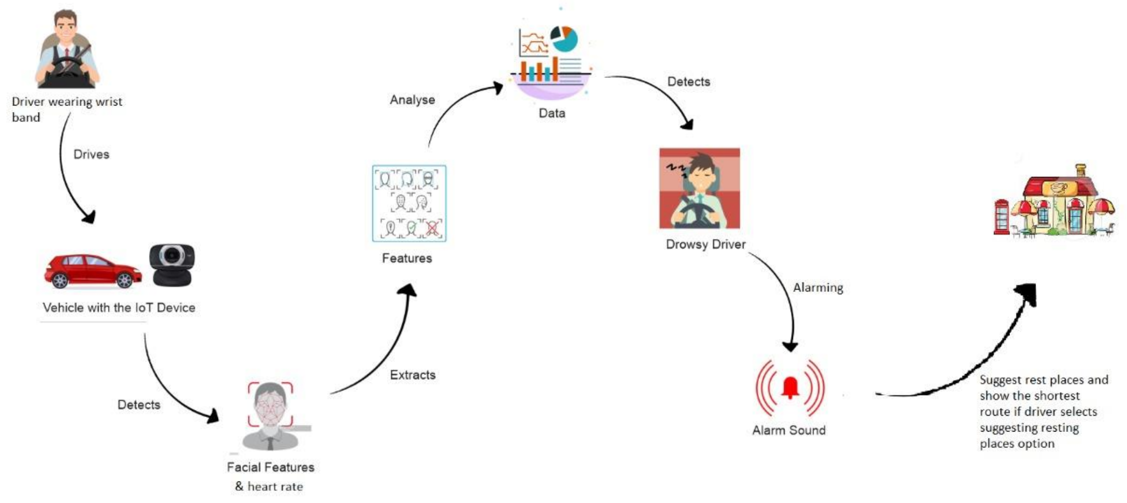

Figure 3: Rich picture diagram

Shown above is the rich picture diagram tailored to the proposed driver drowsiness detection system. As it states, as soon as the driver starts driving the vehicle with the IoT device, the active IoT device begins to recognize and observe the driver's facial features. Out of the observed facial features, the features to be used to identify driver drowsiness are then extracted, and then the collected data is analyzed. If the driver is found to be drowsy during the analysis of the relevant data, the driver will be notified accordingly.

1.6.2 Features of the prototype

The proposed driver drowsiness detection system will have the following features.

1. Capturing the real-time video and the heart rate of the driver

The IoT device will be capturing real-time video to detect the facial features of the driver. At the same time, the data related to the heart rate of the driver will be collected using a wrist band that has been placed on the driver's hand.

2. Extracting features and analyzing gathered data

The IoT system will extract the facial features that are going to be used in the course of detecting drowsiness (eye movements), from the real-time video. Then it will analyze the data gathered from the video as well as from the wrist band (heart rate data). After comparing the gathered data with the data in the data set, the device will predict the state of drowsiness of the driver.

3. Alerting the driver if he/she has been predicted as a drowsy driver.

After analyzing all the data, if the system has predicted that the driver is in a state of drowsiness, based on a given threshold value the system decides whether the driver is in an early stage of drowsiness or whether he/she has already passed the early stage of drowsiness. If the system detects that the driver has passed the early stage of drowsiness an alarm sound will be rung to alert the driver about his/her drowsiness state. Otherwise, if the driver is in the early stage of drowsiness a voice message will be passed to the driver to alert him/her, via the IoT device.

4. Suggesting suitable places to rest based on the current location of the driver.

If the system has recognized the driver as a drowsy driver, after alerting the driver, and right after the driver responded to the alarm sound, the driver will be given an option to get suggestions of some nearby resting places via the mobile application.

5. Suggesting the shortest route to a selected resting place

If the driver decided to take a rest and if he/she has chosen a resting place from the suggested nearby resting places, the driver will be given the necessary directions to reach the selected resting place through the shortest route identified, via the mobile application.

6. Providing a history related to the driving activity of the driver

The mobile application will provide the driver with an option to get a history of his/her driving activity. It will display the history on at which time and on which date the driver has become drowsy.

1.7 Resource requirements

1.7.1 Hardware Requirements

Hardware Requirements chart has been moved to ***Appendix Section A.3*** for better clarity.

1.7.2 Software requirements

From the research, it was identified that the following languages, IDEs, Other software, APIs, and libraries will be needed for the successful completion of the project.

Software requirements chart has been moved to ***Appendix Section A.4*** for better clarity.

1.7.3 Technology Stack

For the Front-End and Back-End of this Project, various kind of technologies are used. For the Front-End the software's which will be used for this project are Expo Go, Visual Studio code and Android Studio. For the Back-End and Machine learning part of the project the software's that are used are PyCharm, Visual Studio code and Anaconda. The API and frameworks that are used for this project are React Native and Django. OpenCV library is also used for our project for the Data science, AI, and Machine Learning Algorithms. The Bluetooth Technology will also be used to send the heart rate which is monitored from the Band and sent to the Raspberry pi for analyses. Database-SQL will be used to store the captured drowsiness data and log-in information.

1.8 Chapter Summary

This chapter provided a detailed summary of the IoT project by team HelaDevs. Detailed descriptions about the project domain and the background of the project are being discussed. The aim, objectives, scope, and the rich picture of the solution are clearly discussed in this chapter for the successful completion of the project. The next chapter outlines the Literature Review chapter where research related to the project is being discussed along with the previous research related to this project domain.

Chapter 2 - Literature Review

2.1 Chapter Overview

In This Chapter, here will drill deep into the problem domain on 'Driver Drowsiness'. Critically explore on existing applications, devices related to the project domain based on 'Internet of Things' (IoT), will navigate on the projects that used.

- Raspberry Pi
- Sensors
- Artificial Intelligence
- Open CV
- Algorithms (Image processing algorithm, Shape predictor algorithm, etc...)

Which will increase the accuracy of the invention. Provides an investigation on the project domain that comparing features of existing solutions,
Will further, sentiment analysis on used techniques, software, tools, and suggestions that can be used for a successful accomplishment on the project domain.

2.2 Project Domain

Under the project domain the problem and the study regarding the problem is being discussed. As we are proposing a project related to a system to prevent accidents caused by driver drowsiness, we would like to discuss the project domain driver drowsiness and the system our team came up with to prevent driver drowsiness and the accidents caused by it. Driver inattention is one of the major causes of highway car accidents. Generally, driver inattention is related to the degree of non-concentration when driving, which is usually a result of drowsiness and distraction. Drowsiness involves a driver closing his eyes because of fatigue and through the change in the driver facial expressions and posture.

Drowsiness is a main problem threatening driving wellbeing. It is a state between mindfulness and sleep in which the driver's capacity to control the vehicle diminishes and his reaction time increases. Drowsiness plays an important role in crashes (12%) and near-crashes (10%), and it increases the threat of crash/near-crash by a factor of four; additionally, it is associated with over 22% to 24% of accidents/close crashes. So intelligent monitoring of a driver's behavior is essential to give an effective warning message to the driver in the case a sign of drowsiness is being detected. (M. Omidyeganeh, 2011).

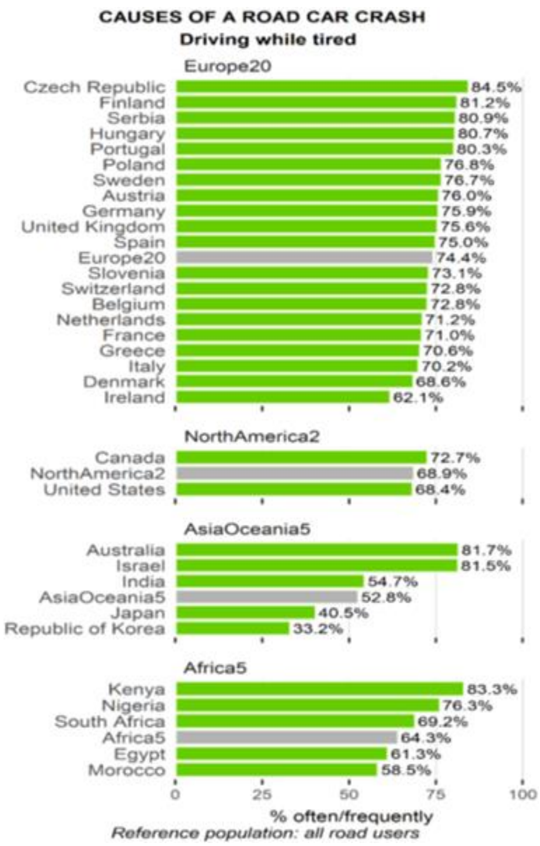

Figure 4: (Perception of fatigued driving as accident cause among all road users by region and country 2019)

As shown in the figure the highest rates of crashes have taken place in the European roads (74%), with lower rates being reported amongst road users in North America (69%), Africa (64%) and Asia-Oceania (53%). The results concerning the awareness of tired driving as a crash cause can be further split out for region and age group.

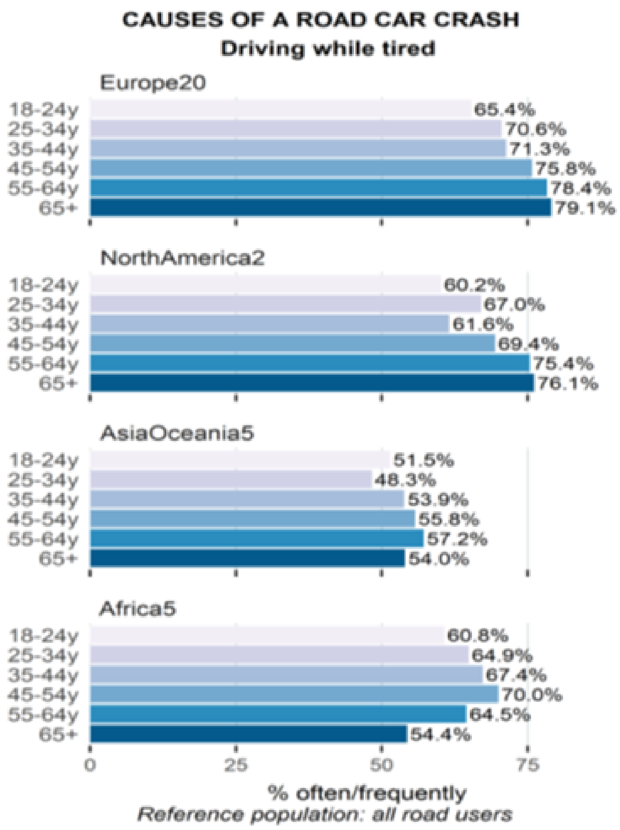

Figure 5: (The results of tired driving as a crash cause are further split out for region and age group in figure2)

As shown in Figure 2, In regions Europe and North America, the awareness of tired driving as a frequent crash cause is more prevalent among older age groups (55-64; 65+) than younger age groups. (Charles Goldened, 2019)

To prevent future accidents due to driver drowsiness our team came with a system to detect driver drowsiness by analyzing the facial features, heart rate and eye posture of the driver and give him a warning signal that he is not in a suitable condition to drive by sounding an alarm after analyzing the data. Our system will also suggest nearby suitable resting locations for the driver to have some rest before continuing the rest of the journey.

2.3 Technological Review

Driver drowsiness detection project is based on face recognition, image processing and deep learning which requires more processing power and memory to work on.

1. Raspberry Pi 4 Model B - 4GB variant
2. SIM700c 4GB NB-IoT 4G/eMTC/EDGE/GPRS/GNSS LTE Module
3. 5MP with IR Lights Camera Module for Raspberry Pi
4. Obstacle Avoidance Sensor IR Infrared Module
5. 5-inch Raspberry Pi Touch Screen Display

2.3.1 Raspberry Pi 4 Model B - 4GB variant

Specs of Raspberry Pi 4 Model B

- Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- 2GB, 4GB or 8GB LPDDR4-3200 SDRAM (depending on model)
- 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
- Gigabit Ethernet
- 2 USB 3.0 ports; 2 USB 2.0 ports.
- Raspberry Pi standard 40 pin GPIO header (fully backwards compatible with previous boards)
- 2 × micro-HDMI ports (up to 4kp60 supported)
- 2-lane MIPI DSI display port
- 2-lane MIPI CSI camera port
- 4-pole stereo audio and composite video port
- H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)
- OpenGL ES 3.0 graphics
- Micro-SD card slot for loading operating system and data storage
- 5V DC via USB-C connector (minimum 3A*)
- 5V DC via GPIO header (minimum 3A*)

Driver Drowsiness Systems are basically running on image processing. Raspberry Pi 4 Model B can provide required processing power and enough memory for those tasks while also providing enough GPIO headers for the sensors and other hardware's. Unlike previous Raspberry Pi models Raspberry Pi 4 comes with OpenGL ES 3.0 graphics which can provide more graphic functionality to the system. Finally, Raspberry Pi 4 model B consist built in bluetooth which needed to be used when connecting smartwatches and fitness bands to track heart rate.

2.3.2 SIM700c 4GB NB-IoT 4G/eMTC/EDGE/GPRS/GNSS LTE Module

When it comes to tracking GPS location and providing simultaneous network to the system the BK-SIM7600 can be a handful.

This module contains following features.

- SIM7600X-H is a complete multi-band LTE-FDD/ LTE-TDD/ HSPA+/ UMTS/ EDGE/ GPRS/ GSM module solution in LCC type which supports LTE CAT4 up to 150Mbps for downlink and 50Mbps for uplink data transfer.
- Stand-alone GPS
- Control Via AT Command, Rich interfaces including UART, USB2.0
- Supply voltage range:3.4v~4.2v, Typ:3.8V
- Dimension: 30x30x2.9mm

- Operation temperature: -40°C to +85 °C

This SIM7600 model contains many features that are required for the system to function properly and smoothly. This module provides connectivity up to 4GB LTE which can provide maximum download speed up to 150Mbps and upload speed up to 50Mbps which can be taken as an overkill specification for the Driver Drowsiness System when it comes to communicating with the AWS server. SIM7600 modules also can provide more accurate GPS location data which is needed when triangulating the user's location and use it to find cafes, restaurants, and hotels around the area.

2.3.3 5MP with IR Lights Camera Module for Raspberry Pi

The 5MP with IR Lights camera module can be directly connected via a camera header in the Raspberry Pi 4 model B board. This module consists of a Sony IMX219 camera sensor with built in IR sensor for dark environments which can be switched automatically.

2.3.4 Obstacle Avoidance Sensor IR Infrared Module

IR Infrared module is used to accurately position the driver with the camera inputs.

2.3.5 5-inch Raspberry Pi Touch Screen Display

5-inch Raspberry Pi touchscreen display module provides easy touch inputs and quality display in the same module which is used to display and get users inputs via a GUI interface.

2.4 Previous work related to the work domain

2.4.1 Similar products

There have been several approaches and methods that have been carried out in this domain and they all provide their benefits and drawbacks. Here we percent the previous work that has been done on this study.
Tests are carried out and several different sets of data are acquired using different methods, mainly in tree types.
1. Vehicle based measures
2. Behavioral measures
3. Physiological measures

During vehicle-based tests, the position on the road, the moment of the steering wheel, pressure on the accelerator and brake pedal is measured. During behavioral measures, closure of the eyes, yawning, head posture, blinking rate is monitored to gather data. During physiological measures, "electrocardiogram (ECG), electromyogram (EMG), electrooculogram (EOG) and electroencephalogram (EEG)" (Sahayadhas, Sundaraj and Murugappan, 2012) were studied to determine the drowsiness of the driver.

In order to eliminate the risk of accidents on the road, the tests are carried out in simulated environments with a model of the driver's cockpit that contain a steering wheel, a gear shifter, break and accelerator paddles. This has eliminated ethical issues but due to the awareness of the driver being in a simulation the accuracy of the data might have been low.

Figure 6: Simulated Driving Environment

Recently deep learning has come to play in drowsiness detection with greater accuracy. Convolutional neural networks show promising results at image classification, object detection, emotion recognition, scene segmentation etc.

At present time, the implementation of this system can be seen in luxurious cars. For example, major car companies like Tesla, Audi, BMW, Mercedes Benz, etc. But the main problem is that they are excluded only to higher end models. A portable standalone model is scarce. Even available devices do not provide some of the most important functionalities.

2.5 Research based on the project domain

Currently available statistical data on road traffic injuries, point out that the number of worldwide road traffic deaths has reached a high of 1.35 million per year. Furthermore, road traffic injuries have been recognized as the 8th leading cause of death for people of every age group, and the leading cause of death for children and young adults aged between 5 to 29 years (Global status report on road safety 2018, 2018).

Rank	Cause	% of total deaths
	All Causes	
1	Ischaemic heart disease	16.6
2	Stroke	10.2
3	Chronic obstructive pulmonary disease	5.4
4	Lower respiratory infections	5.2
5	Alzheimer's disease and other dementias	3.5
6	Trachea, bronchus, lung cancers	3.0
7	Diabetes mellitus	2.8
8	Road traffic injuries	2.5
9	Diarrhoeal diseases	2.4
10	Tuberculosis	2.3

Table 1: Leading causes of death, all ages (Global status report on road safety 2018, 2018)

US National Highway Traffic Safety Administration (NHTSA) has revealed that drowsy driving has reportedly been involved in 2.3 to 2.5 percent of fatal crashes in the United States from 2011 to 2015. Further, it points out that drowsy driving has been involved in 2.3 % of the fatalities which have occurred on U.S. roadways in 2015. Of all police–reported crashes that occurred in 2015 in the U.S., 90,000 out of 6.3 million crashes which means 1.4 % crashes involved reports of drowsy driving (Drowsy Driving 2015, 2017).

Crash Year by Crash Severity		Overall Crashes	Crashes Involving Drowsy Driving	
		Number	Number	Percent
2011	Fatal	29,867	721	2.4%
	Injury	1,530,000	29,000	1.9%
	PDO	3,778,000	36,000	1.0%
	Total	5,338,000	66,000	1.2%
2012	Fatal	31,006	744	2.4%
	Injury	1,634,000	34,000	2.1%
	PDO	3,950,000	47,000	1.2%
	Total	5,615,000	81,000	1.4%
2013	Fatal	30,202	714	2.4%
	Injury	1,591,000	32,000	2.0%
	PDO	4,066,000	39,000	1.0%
	Total	5,687,000	72,000	1.3%
2014	Fatal	30,056	747	2.5%
	Injury	1,648,000	33,000	2.0%
	PDO	4,387,000	53,000	1.2%
	Total	6,064,000	87,000	1.4%
2015	Fatal	32,166	736	2.3%
	Injury	1,715,000	33,000	1.9%
	PDO	4,548,000	56,000	1.2%
	Total	6,296,000	90,000	1.4%
2011-2015	Fatal	153,297	3,662	2.4%
	Injury	8,118,000	160,000	2.0%
	PDO	20,728,000	232,000	1.1%
	Total	29,000,000	396,000	1.4%

Table 2: Motor Vehicle traffic crashes and crashes involving drowsy driving, by year, 2011-2015 (Drowsy Driving 2015, 2017)

According to the Australian Transport Accident Commission (TAC), driver fatigue is a major cause of crashes in Victoria, Australia which results in approximately 50 deaths and 300 serious injuries each year. Further, it has mentioned if a driver who is travelling at a speed of 100 km/h, falls asleep just for 4 seconds, the vehicle will have gone 111 meters without a driver in control (Fatigue statistics - TAC - Transport Accident Commission, 2019).

All these statistics suggest that road traffic accidents cause the loss of numerous precious lives, while drowsy driving contributes much to it. Therefore, to prevent these devastating accidents, the behavior of the driver, while driving should be continuously monitored. As the proposed project`s domain is defined as driver drowsiness detection, the scope of this research will be confined to the approaches of detecting the state of drowsiness of the driver while driving.

The researchers have identified the importance of detecting the state of drowsiness of the driver, and therefore lots of research has been done related to the project`s domain, driver drowsiness detection. The term "drowsiness" depicts the feeling of being sleepy. The stages of sleep can be categorized into three main layers as awake, non-rapid eye movement sleep (NREM) and rapid eye movement sleep (REM). The non-rapid eye movement sleep (NREM) can be further subdivided into three stages as follows (Brodbeck et al., 2012).

- Stage 1: the transition from awake to asleep (drowsy)
- Stage 2: light sleep
- Stage 3: deep sleep

Stage 1, the transition from awake to asleep, which is the drowsiness phase, is the most studied stage by researchers to analyze the driver drowsiness (Sahayadhas, Sundaraj and Murugappan, 2012). In the previous research carried out by the researchers relevant to the project domain, several approaches can be recognized which have been used to measure driver drowsiness. All the recognized approaches have their own advantages and limitations. While some approaches are simple, it turned out that the accuracy of detecting the drowsiness state of those approaches are low, while some approaches with more complexity turned out to be more accurate. A critical analysis of selected widely used driver drowsiness measuring approaches, has been detailed below.

2.5.1 Subjective Measures based approach

Subjective measures that assess the state of drowsiness of the driver primarily involve some form of introspective assessment performed by the driver. Almost all studies based on subjective measures have used one of the two most common sleepiness scales which are Karolinska Sleepiness Scale (KSS) and Stanford Sleepiness Scale (SSS), which consists of numerical ratings that correspond to a unique verbal description for a particular state of sleepiness. Among these two mentioned sleepiness scales, the Karolinska Sleepiness Scale (KSS), which is a nine-point scale, can be recognized as the most commonly used sleeping scale in the related studies (Liu, Hosking and Lenné, 2009).

In a research conducted by Hu and Zheng, they have recorded the KSS rating of drivers every 5 minutes and have used it as a reference to the collected electrooculography (EOG) signals (Hu and Zheng, 2009). Several research projects have made use of the KSS ratings to quantitatively predict the probability of lane departures. Ingre et al. have measured the KSS ratings of drivers every 5 minutes during the driving task and compared the recorded data with the lane drifting, calculated as the standard deviation of the lateral position and with the blinking duration of the driver. During the study, they have recognized that there`s a relation between the KSS, ‘objective’ measures of driving performance (standard deviation of the lateral position) and sleepiness (blinking duration). Further, the researchers have identified that serious behavioral and physiological changes do not occur until a high level of KSS (KSS >= 7) are reached. However, as there were some considerable individual differences between subjective ratings and the risk of lane departure, the researchers have admitted that these estimates should be interpreted with caution (Ingre et al., 2006).

The subjective rating does not fully coincide with behavioral, physiological, and vehicle-based measures and can be pointed out as a drawback of subjective measures-based approach. Further, the process of self-introspection can stimulate the driver and therefore it may affect to reduce the level of drowsiness that has been measured. Another potential limitation of subjective measures is the difficulty to obtain the drowsiness feedback from a driver who is in a real driving situation. Therefore, while subjective measures can be useful in detecting drowsiness in a simulated environment, remaining measures may be better suited for determining the drowsiness state of the driver in a real driving situation (Sahayadhas, Sundaraj and Murugappan, 2012).

2.5.2 Vehicle-Based Measures based approach

Driver drowsiness detection using vehicle-based measurements, can be recognized as one of the prevalent methods currently in use. In this approach, most of the times, the measurements are gathered using number of sensors which have placed on various vehicle components such as the steering wheel and the acceleration pedal. The metrics like deviation from lane position, movement of the steering wheel, pressure on the acceleration pedal, etc., are monitoring constantly in this approach. If any change in these measures which crosses a specified threshold detected, then it indicates that there`s a high probability of the driver being drowsy (Sahayadhas, Sundaraj and Murugappan, 2012). The Steering Wheel Movement (SWM) and the Standard Deviation of Lane Position (SDLP) are the most consistently used vehicle-based measures during the research associates with drowsiness (Liu, Hosking and Lenné, 2009).

Steering Wheel Movement (SWM) is measured with the help of a steering angle sensor mounted on the steering column. Sleep deprived drivers made fewer steering wheel reversals when comparing to the normal drivers (Fairclough and Graham, 1999). When using SWM measures, some researchers have chosen to consider only small steering wheel movements which existing between 0.5 degrees to 5 degrees, which needed to adjust the lateral position within the lane. This decision was made in order to eliminate the effect that can occur due to the SWM measures related to lane changes (Otmani et al., 2005).

Standard Deviation of Lane Position is another measure which is mostly used to detect the state of drowsiness. While the software itself provides the SDLP, in a simulated environment based research, the position of the lane can be tracked using an external camera in a real driving situation (Sahayadhas, Sundaraj and Murugappan, 2012). A research conducted by Ingre et al. has found that there`s a relationship between the KSS ratings and the SDLP in meters, such as when KSS ratings increased, the SDLP also increased accordingly. From the KSS rating 1 where drivers have rated that they are “very alert”, to the KSS rating 7 where they have rated their drowsiness state as “sleepy but no effort to remain awake”, the SDLP has increased gradually (KSS = 1 and SDLP = 0.19, KSS = 7 and SDLP = 0.28). In the same research, the researchers have noted that at KSS rating 8 and 9, the SDLP has increased dramatically (KSS = 8 and SDLP = 0.36, KSS = 9 and SDLP = 0.47) (Ingre et al., 2006).

Though some drowsiness detection systems have adopted vehicle-based measures in detecting drowsiness, it can`t be determined as a much secure approach. Vehicle-based measures like SWM are highly dependent on the geometric characteristics of the road, and therefore, they work reliably only in very limited situations (Vural, 2009). Moreover, these metrics are not specific to drowsiness. As an example, the changes of SDLP can happen even by driving under the influence of alcohol or any other drug (Das, Zhou and Lee, 2012). Therefore, it will be more accurate if vehicle-based measures are used as an alternative source of information to further confirm the state of drowsiness which was detected using another form of drowsiness detection approach.

2.5.3 Behavioral Measures based approach

In behavioral measures-based approach, the behavior of the driver including the eye state, yawning, head movement, blinking rate etc. are consistently monitored through the mounted cameras in the vehicle. If the characteristics that a drowsy person tend to show, such as decreased eye blinking rate (normal eye blinking rate per minute is roughly 10), frequent yawning etc. detected, the system will alert the driver about his drowsiness (Ngxande, Tapamo and Burke, 2017).

In related studies, researchers have first extracted the facial features from the camera feed. Afterward, further processing has been applied by typically applying the selected techniques to determine the level of drowsiness. Support Vector Machines (SVM), Hidden Markov Models (HMM), Convolutional Neural Networks (CNN) can be pointed out as some of the machine learning techniques that can be used in determining drowsiness state using behavioral based measures (Ngxande, Tapamo and Burke, 2017).

Eye state can be recognized as the frequently used feature to determine the drowsiness using behavioral measures (Ngxande, Tapamo and Burke, 2017). Percentage of the eye closure (PERCLOS), which means the percentage of the eyelid closure over the pupil, over a period of time has been analyzed and used in many such studies. It has been found as a reliable measure when it comes to detecting drowsiness using behavioral measures (National Highway Traffic Safety Administration, 1998). Eye aspect ratio (EAR) is the ratio between the height and width of the eye. It has also been used along with PERCLOS in drowsiness detection methods which consider behavioral measures (Ngxande, Tapamo and Burke, 2017).

Behavioral measures-based approaches have some of its own limitations. The most crucial limitation of this approach is that the performance of this approach is being affected by lighting conditions (Sahayadhas, Sundaraj and Murugappan, 2012). Usually, normal cameras do not perform very well at night and at bad lighting conditions. As a solution for this limitation, several researchers suggest using infra-red (IR) cameras to monitor the driver behavior (Ngxande, Tapamo and Burke, 2017). Some researchers point out that the use of IR cameras for PERCLOS measures may work well at night, but not very well in daylight as ambient sunlight reflections make it impossible to obtain retinal reflections of infra-red (National Road Transport Commission - Australia, 2000). Some other limitations of this approach are the performance is being affected by the camera movements and the frame rate that used to capture the videos of the face of the driver (Ngxande, Tapamo and Burke, 2017).

2.5.4 Physiological Measures based approach

In this approach the physiological measures of the driver will be taken into consideration. Most of the approaches which are used to detect drowsiness state in the driver, have difficulties in detecting the drowsiness in its early stages. As an example, in vehicle-based and behavioral measures-based approaches the measures become apparent when the driver is really drowsy, which means that he is nearly asleep. Detecting drowsiness at that level, might not help to prevent the crashes or any effect that can happen due to drowsiness. The physiological measures-based approach can be introduced as a solution which will address this problem as the physiological measures begin to show changes in early stages of drowsiness. This will make it possible to alert the driver about his drowsiness somewhat earlier (Sahayadhas, Sundaraj and Murugappan, 2012).

Electroencephalogram (EEG), Electro-oculogram (EOG), Electromyogram (EMG), Electrocardiogram (ECG), Heart Rate Variability (HRV), pulse rate and brain activity are some of the physiological signals that researchers have used to determine the drowsiness. EEG and ECG can be recognized as two widely used physiological measures in research related to this approach (Saini and Saini, 2014).

EEG is the recording of electrical activity in the brain. It has five various frequency bands which are alpha, beta, theta, delta and gamma. Alpha waves which range from 8 to 12 Hz tend to occur during relaxation or keeping the eyes closed. Beta waves (12 - 30 Hz) represent alertness, anxiety, or active concentration. Theta band (4 – 7.5 Hz) corresponds to drowsiness in adults (Vural, 2009). When the alertness level decreases EEG power of the alpha and the theta bands increases. Normally EEG recordings are extremely sensitive to motion artifacts.

Therefore, the EEG signals can be contaminated by the artifacts caused by body, head and eye movements. This can be pointed out as a drawback of using EEG signals to determine drowsiness (Liu, Hosking and Lenné, 2009).

Heart Rate Variability (HRV) which can be calculated using time series of heartbeat pulse signals determined by the ECG, is another physiological method that has been used in previous works (Vural, 2009). It has three main frequency bands which are high frequency band (HF) (0.15 – 0.4 Hz), low frequency band (LF) (0.04 – 0.15Hz) and very low frequency band (VLF) (0.0033 – 0.04Hz). Previous research has revealed that the LF to HF power spectral density ratio (LF/HF ratio) decreases progressively when a person progresses from an awake to a drowsy state. Accordingly, the HF power associated with that status increase (Yu, 2009).

The main limitation of this approach can be defined as the intrusive nature of measuring physiological signals. To overcome this problem, some researchers have used wireless devices to measure the physiological measures in a less intrusive manner. They have placed electrodes on the body and have used wireless technologies like Bluetooth to obtain the signals (Klingeberg and Schilling, 2012). Some researchers have gone further ahead by using non-intrusive methods to measure the physiological signals. Such researchers have placed electrodes on the driver's seat or on the steering wheel to obtain the signals (Yu, 2009). Anyhow, physiological measures-based approach can be considered as a more reliable and accurate approach when compared to other approaches (Sahayadhas, Sundaraj and Murugappan, 2012).

When comparing all the above-mentioned approaches which are used to determine the state of drowsiness of the driver, all those approaches have their own advantages and limitations. Subjective measures-based approach will not be possible to implement in real time situations. Vehicle-based measures-based approach may be unreliable, as the considering measures are not specific to drowsiness, but it will give the advantage of being a non-intrusive approach. Behavioral measures-based approach will have the limitations of being affected by lighting conditions and background and will provide the advantage of being easy to use and being a non-intrusive approach. Furthermore, physiological measures-based approach will be more reliable and accurate to use and it will have the limitation of being an intrusive method (Sahayadhas, Sundaraj and Murugappan, 2012).

It can be recognized that most of the research done so far to detect the drowsiness level of the driver, have made use of just one of the above approaches in their projects. Therefore, they might not be able to achieve the accuracy and reliability that they wanted in their projects. After considering all these facts, the proposed project was selected to be implemented using a hybrid measures-based approach. This project will combine the behavioral measures and the physiological measures which can be considered as the two most accurate approaches from the approaches listed above. The team members believe that it will give more accuracy and reliability to the proposed project.

2.6 Chapter Summary

This chapter, literature review has been focused on multiple aspects on driver drowsiness. Explore on previous research, referenced to the problem, and identify the factors and sectors that should be improved in the domain. The chapter analyzes the technological requirements, recommendations, and suggestions, which can be extracted to the project domain, a sentiment analysis on the used techniques, devices, and tools and how the existing limitations should be improved on the domain. Also, the chapter discussed the competitor analysis and how the work will be unique from existing solutions.

Chapter 3 – Project Management

3.1 Chapter Overview

In this chapter the most suitable project management methodologies for this project will be Focused and discussed. The possible risks involved with the project and the mitigation plan for the system are being identified and discussed. The most appropriate software development methodologies and project management methods are also discussed in detail. The activity schedule, work breakdown structure and Gantt chart diagram are also illustrated in this chapter.

3.2 Methodologies

3.2.1 Research Approach

There are two different types that the research approach can be broken down into. They are called inductive and deductive approaches. The deductive approach describes the use of an already existing theory and use of testing to prove the point. The inductive approach describes the generation of a new idea from the gathered data.
Here in this project, we will be using the deductive approach as the aim is to detect the drowsiness state of the user in order to alert them about their state of drowsiness.

3.2.2 Process model

Process model chart has been moved to ***Appendix Section B.1*** for better clarity.

From the available SDLC process models, Agile process model will be used for this project. Since the requirements of the system are clearly defined and each task is divided into time boxes to deliver specific features.

Using the Agile Process model iterative approach is taken, and the working software build is delivered after each iteration. With a small set of software requirements developed across all components it is easier to develop and test Our IoT device after each iteration.

Since the device is developed step by step, defects can be identified at an early stage. Table below shows the details why other popular methodologies were not chosen. The Figure shows the steps in the Agile model.

Model	**Reasons for not choosing the model**
Waterfall	Testing for each Iteration can be done and also changes can be done to adapt.

Spiral	More suitable for complex and long-term projects
V-model	Lacks adaptability
RAD	High technical knowledge is required
Prototyping	The effort invested in building prototypes may be too much if it is not monitored properly.

Table 3: Reasons for not choosing other models

3.2.3 Analysis and design approach

The Object-Oriented Design approach is selected for the analysis and design approach. The OOD approach decreases the complication of the system and increases the readability of the code. This approach adds flexibility of reusing components using the object-oriented techniques.

3.2.4 Programming methodology

Implementation of the IOT system and mobile application will be done using OOP programming methodology that supports the MVC design pattern and Container design pattern. Using OOP will help to increase the code Reusability and maintainability in the long term. OOP also improves the software development productivity and provides easy troubleshooting.

3.2.5 Testing methodologies

The IEEE 829 test plan will be used to test the product. Under the testing plan, one testing methodologies like usability testing, performance testing, compatibility testing, system testing will be used to improve the product.

3.2.6 Project management methodology

Waterfall methodology, Agile methodology, Hybrid and Scrum are some examples for project management methodologies. For this project Agile project management methodology was chosen from the many project management methodologies available.

Agile project management methodology came into being in 2001 as the waterfall model failed to manage complex projects. Unlike the waterfall model which focuses on completing the previous stage before moving to the next, the agile model is iterative. The model is flexible and responds to requirements with small incremental changes. Also, the model is low risk as continuous feedback can be gathered and changes can be made to improve the product.

Figure 7: Agile Methodology

3.2.7 Data gathering method

There are several data gathering methods that can be used in this project to gather data. Some of those methods are described below.

- Research papers and other documents on the internet. – Books, media files, research papers, and several other sources of data is available on the internet that will be used in the project
- Questionnaires – Questionnaires will be sent to the target audience in order to gather the thoughts and ideas of the relevant parties.
- Interviews – interviews will be held with the target audience and relevant parties in order to gather information on the requirements if the proposed product.
- Observations – The requirements of the target audience are observed by engaging with the drivers.
- Self-gathered data – The driving experience while drowsy will be experienced first-hand by the team.
- Prototypes – Data will be gathered from the user using wireframes and used to improve the product in the future.
- Brainstorming – Brainstorming sessions will be held with the domain experts and their ideas will be gathered to improve the product.
- Literature review – The previous work done will be analyzed to gather data and used to identify the new features that can be used to improve the project.

3.3 Risks and mitigations

Risk ID	Risk Category	Risk Description	Risk Mitigation
1	Requirements	required to make significant changes to the implementation	Have a well-planned configuration and a design before start implementation
2	Technical	Inability to update with the new technologies related to the field	Communicate with professionals in the field and get responses related to new technologies
3	Technical	Inability to achieve the functionalities to demonstrate the performance of the design	Do researches well to find out strategies to acquire challenging area of the project
4	Technical	Loss data due to unexpected hardware or software issues	Having constant backups and keep data safe
5	Planning	Inability to achieve required functions in the expected time period	Have a master plan of implementation of functions and features that would have the main focus on and complete them at the earliest level
6	Planning	Unable of group members to achieve their task at expected time duration	Having an idea of each member's capability on related fields and sharing the works, keep communicating of the group members constantly

Table 4: Risks and mitigations

3.4 Activity Schedule

Activity Schedule has been moved to ***Appendix Section B.2*** for better clarity.

3.5 Work breakdown structure

Work breakdown structure has been moved to ***Appendix Section B.3*** for better clarity.

3.6 Gantt Chart

Gantt Chart has been moved to ***Appendix Section B.4*** for better clarity.

3.7 Chapter Summary

This chapter, project management, has focused on the most crucial components which helps to proceed with the project, with a clear plan. Project management methodologies have been discussed in detail within the chapter. The chapter involved identifying the possible risks involved with the project as well as the mitigation plans for the identified risks. Project management chapter has further detailed the activity schedule, work breakdown structure and also it has illustrated the Gantt chart diagram.

The next chapter is System Requirements Specification, and it will focus on identifying stakeholders, gathering the requirements for the project, designing use case diagrams, domain model as well as identifying functional and non-functional requirements.

Chapter 4 - System Requirement Specification

4.1 Chapter Overview

This chapter mainly focuses on the Software Requirements Specification which goes through the appropriate Stakeholders analysis, Requirements gathering, Models, functional and non-functional requirements along with their priority levels, use case diagram, use case descriptions and domain model for our IoT system. Different requirement gathering techniques will be examined and suitable ones will be selected that would be ideal for the needs of this project. Finally Use-Cases will be developed for which Functional and Non-Functional Requirements can be defined.

4.2 Stakeholder analysis

4.2.1 Onion model

Onion model has been moved to ***Appendix Section C.1*** for better clarity.

4.2.2 Stakeholder descriptions

Stakeholder descriptions has been moved to ***Appendix Section C.2*** for better clarity.

4.3 Requirements gathering

4.3.1 Techniques for requirements gathering

The gathering of requirements is the process of investigating and identifying consumers, clients, and other stakeholders for the requirements of a system. There are several methods to gather requirements. Such as brainstorming, document analysis, interface analysis, interview, survey/questionnaire etc. Following requirements gathering techniques have been used throughout this project.

1. Survey/Questionnaire

Creating a survey/questionnaire is a free and easy method of communication with the audience and also to gather data. Surveys or questionnaires are inexpensive and easy for analyzing and visualizing. Survey or questionnaire has a high level of comparability and scalability which is easy for gathering data.

2. Document Analysis

Document analysis is a popular way to gather data for projects. Reviewing and evaluating documentations on existing projects and articles/blogs can be very helpful to gather requirements for a project. Existing documentation provides the titles of stakeholders who are part of the system. This technique was used to identify questions for surveys or questionnaires to be sent out to stakeholders and target audience.

4.3.2 Questionnaire design

One survey/questionnaire was sent to drivers to gather data and identify some requirements for the project. Explained below the description of each question.
Questionnaire design has been moved to ***Appendix Section C.3*** for better clarity.

4.4 Analysis of gathered data

The questionnaire had 8 questions to gather data on the requirements that has been identified. This was distributed on 30th November 2020 and gathered responses for 2 weeks. Following details are the analyzing of gathered data.
Analysis of gathered data has been moved to ***Appendix Section C.4*** for better clarity.

4.5 Models

4.5.1 Use Case Diagram

Use Case Diagram has been moved to ***Appendix Section C.5*** for better clarity.

4.5.2 Use Case Description

Use Case Description has been moved to ***Appendix Section C.6*** for better clarity.

4.5.3 Domain Model

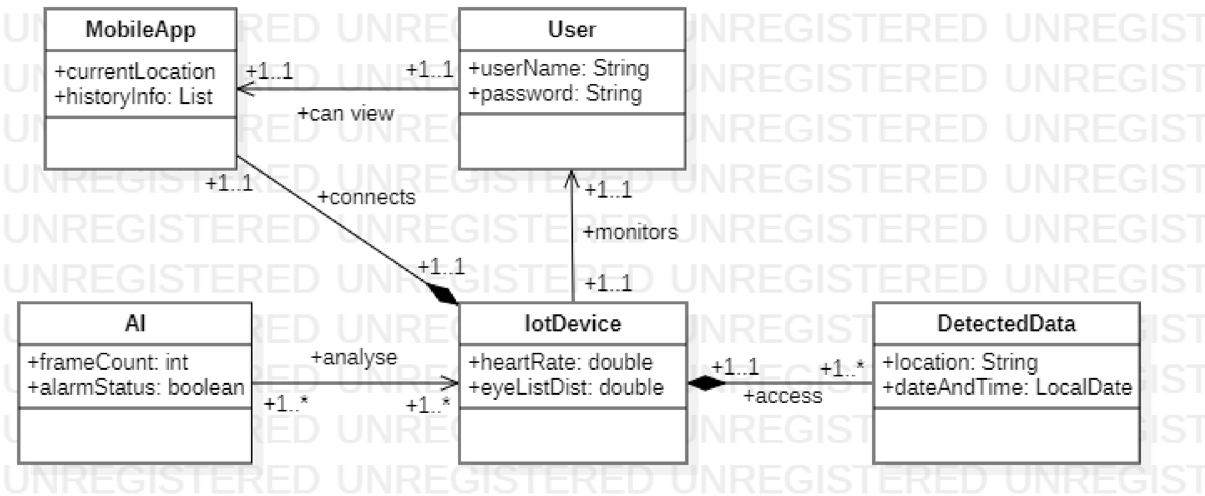

Figure 8: Domain model

4.6 Functional requirements

Given below are the functional and non-functional requirements of the IoT system along with their priority levels.

- Required – The requirements that are needed for successful completion
- Desirable – The requirements that add value, but are not required right away

Functional requirements chart has been moved to ***Appendix Section C.7*** for better clarity.

4.7 Non-Functional requirements

Non-Functional requirements chart has been moved to ***Appendix Section C.8*** for better clarity.

4.8 Chapter Summary

Within this chapter, discussed about the analysis of the appropriate stakeholders, details about gathering of requirements such as techniques, used questionnaires and formal interviews with domain experts, Analysis of gathered data, a description of used models, description about functional and non-functional requirements. Next chapter will be focused on the design diagrams of the Driver Drowsiness Detection System.

Chapter 5 – Design

5.1 Chapter Overview

The previous chapter was focused on System Requirements Specification. This chapter is about the Design chapter which mainly focusses on the design of the Driverdroid System. The High-level architecture diagram, class diagram, sequence diagrams, activity diagram and the wireframes for Driverdroid will be discussed and presented.

5.2 High-Level Architecture Diagram

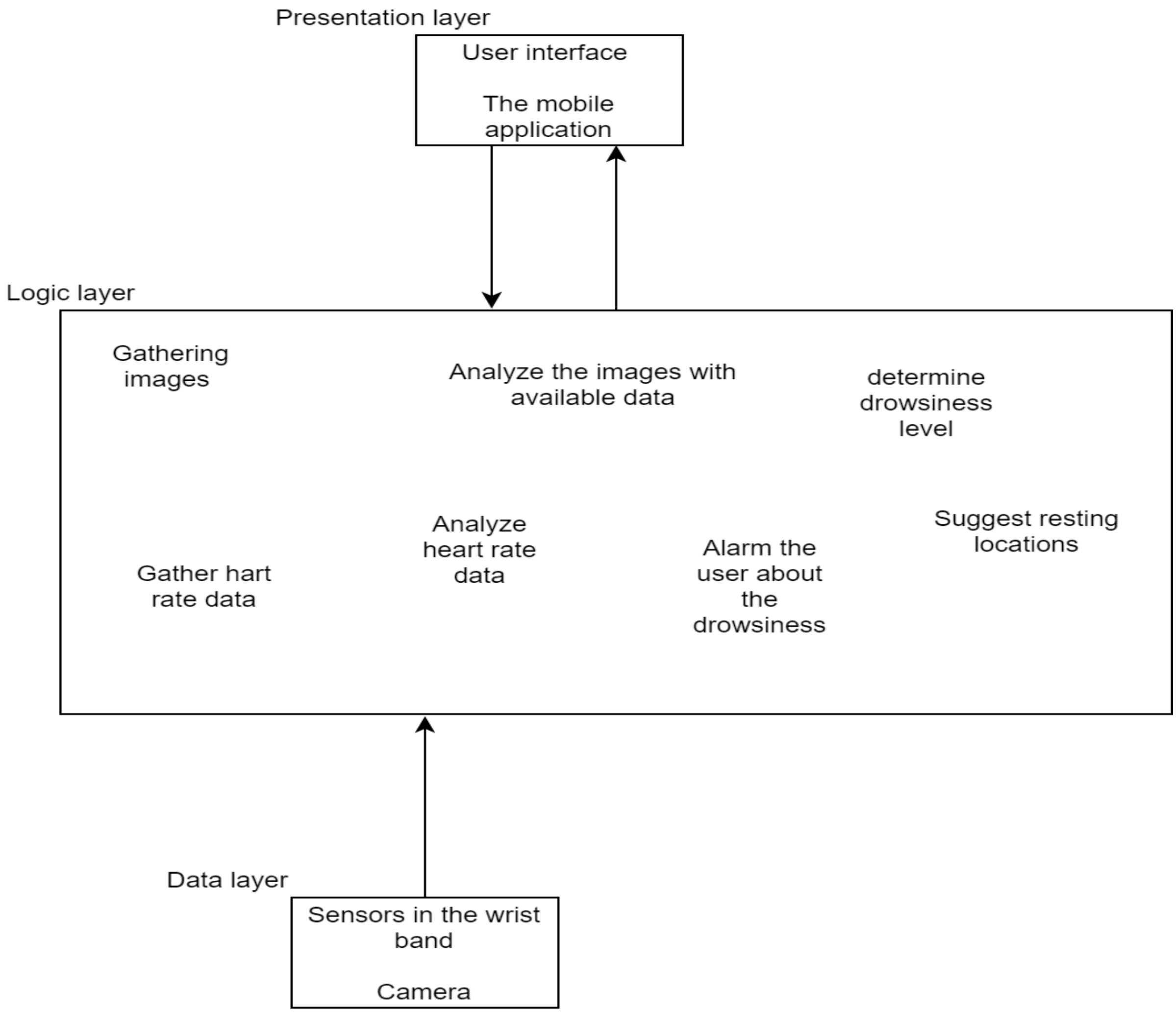

Figure 9: High-Level Architecture Diagram

The high-level architecture diagram is designed in mid to allow the general public to easily understand the structure of the project. The diagram also allows others to review the project. The above diagram has three layers, the presentation layer, logic layer and data layer. The data layer represents the source of the data involved in the program. The logic layer shows all the logical processes like machine learning data processing that allow the device to distinguish the drowsiness of the driver and send appropriate alerts to keep the driver informed. The presentation layer is the place where the user interacts with the device to operate it.

5.3 Class Diagram

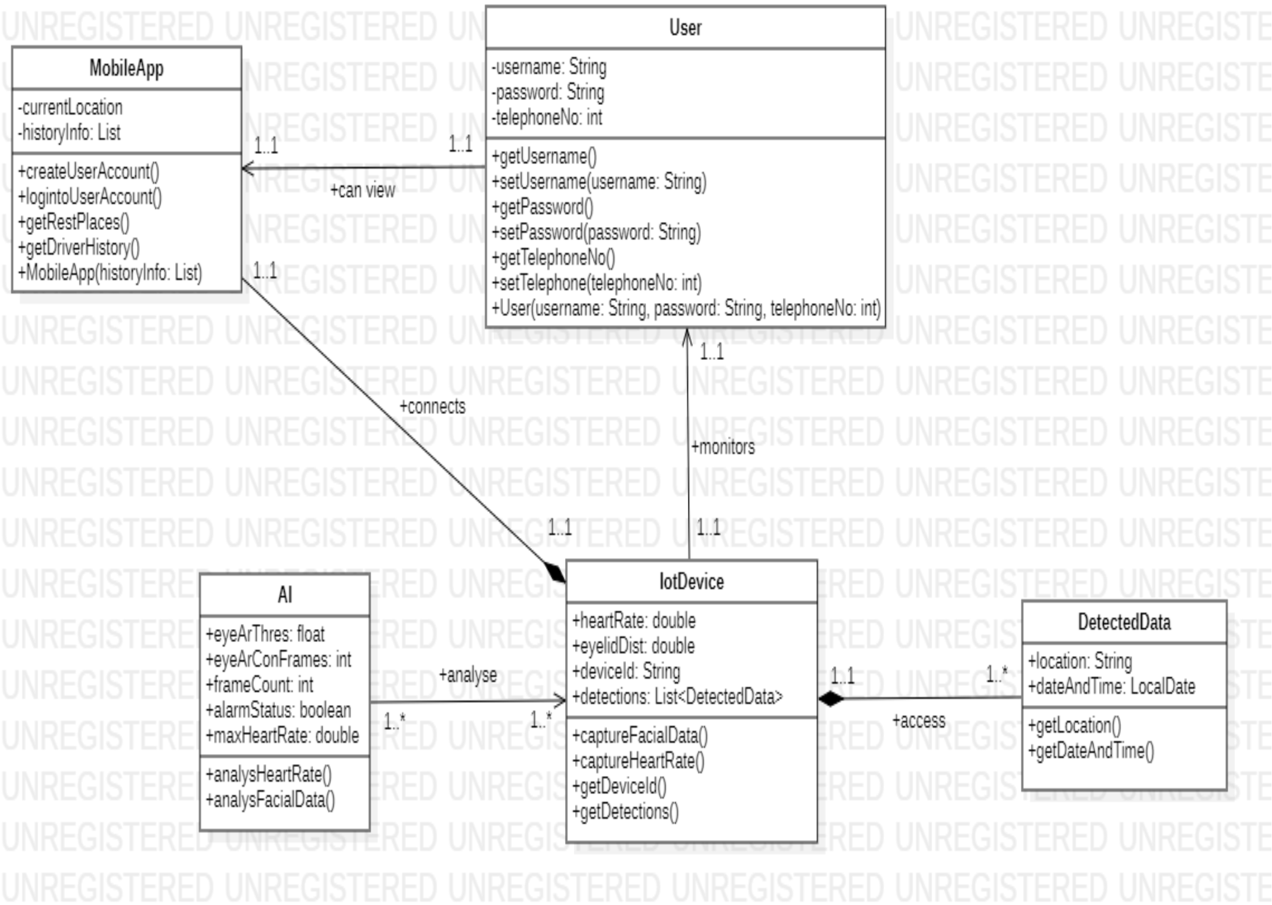

Figure 10: Class Diagram

5.4 Sequence Diagram

There are two sequence diagrams that describe the flow of the system.
1) Device enrollment-describe the flow driver interacts with device
2) Mobile app- describe the flow of driver interaction with mobile app

1) Device enrollment-describe the flow driver interacts with device
Drivers start the device by operating device, device start extract features of the driver and send data to backend, machine learning model and analyze driver features and check weather driver is drowsy, if detected drowsy return a voice message or alarm depend on the drowsiness level to the driver through the device while the database saves detect data of the driver.

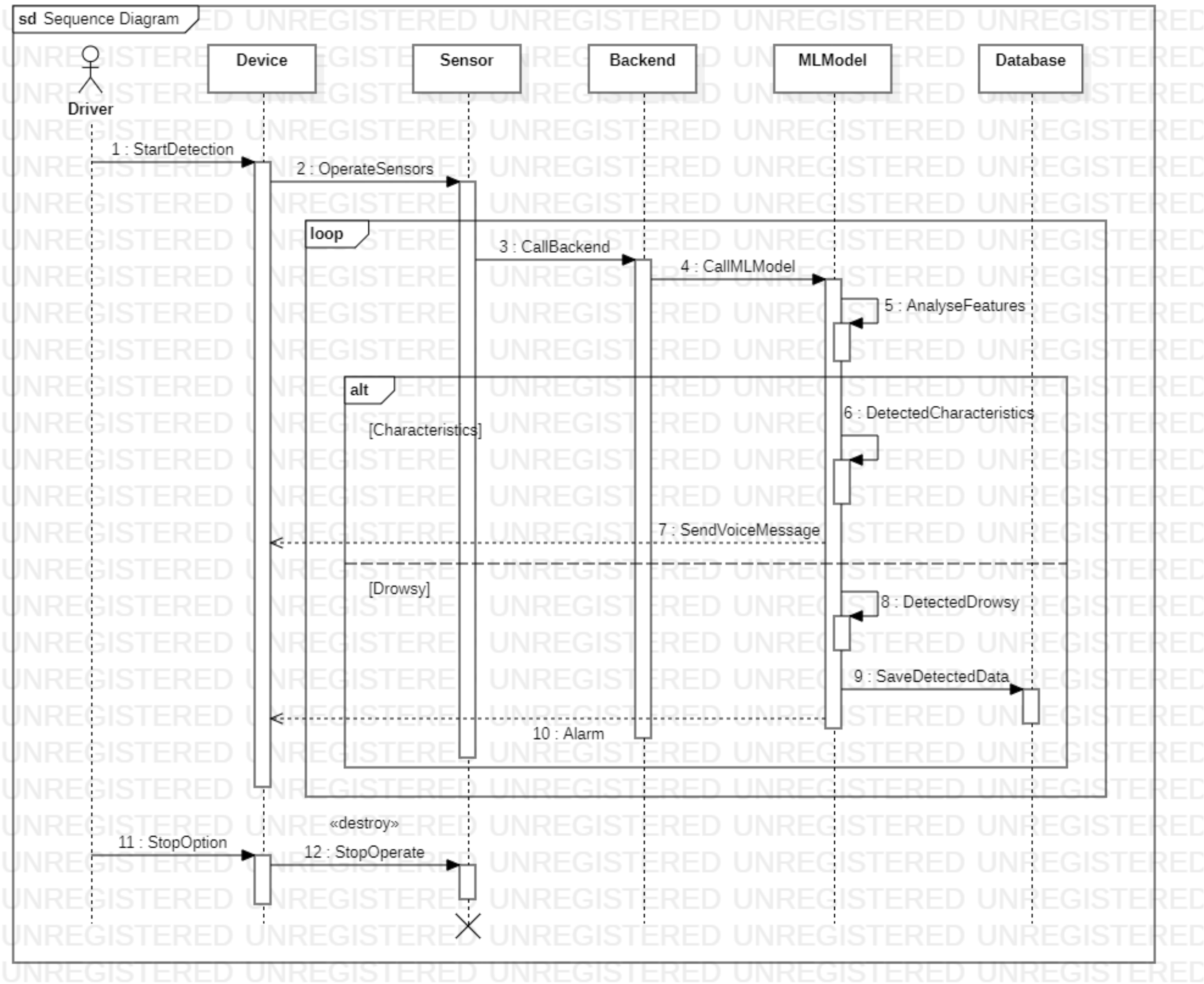

Figure 11: Sequence Diagram 01

2) Mobile app- describe the flow of driver interaction with mobile app
Driver who registered in the mobile app and logged into the application would be able to check driver history of detect drowsy and check nearby resting places and show the shortest route to the selected place.

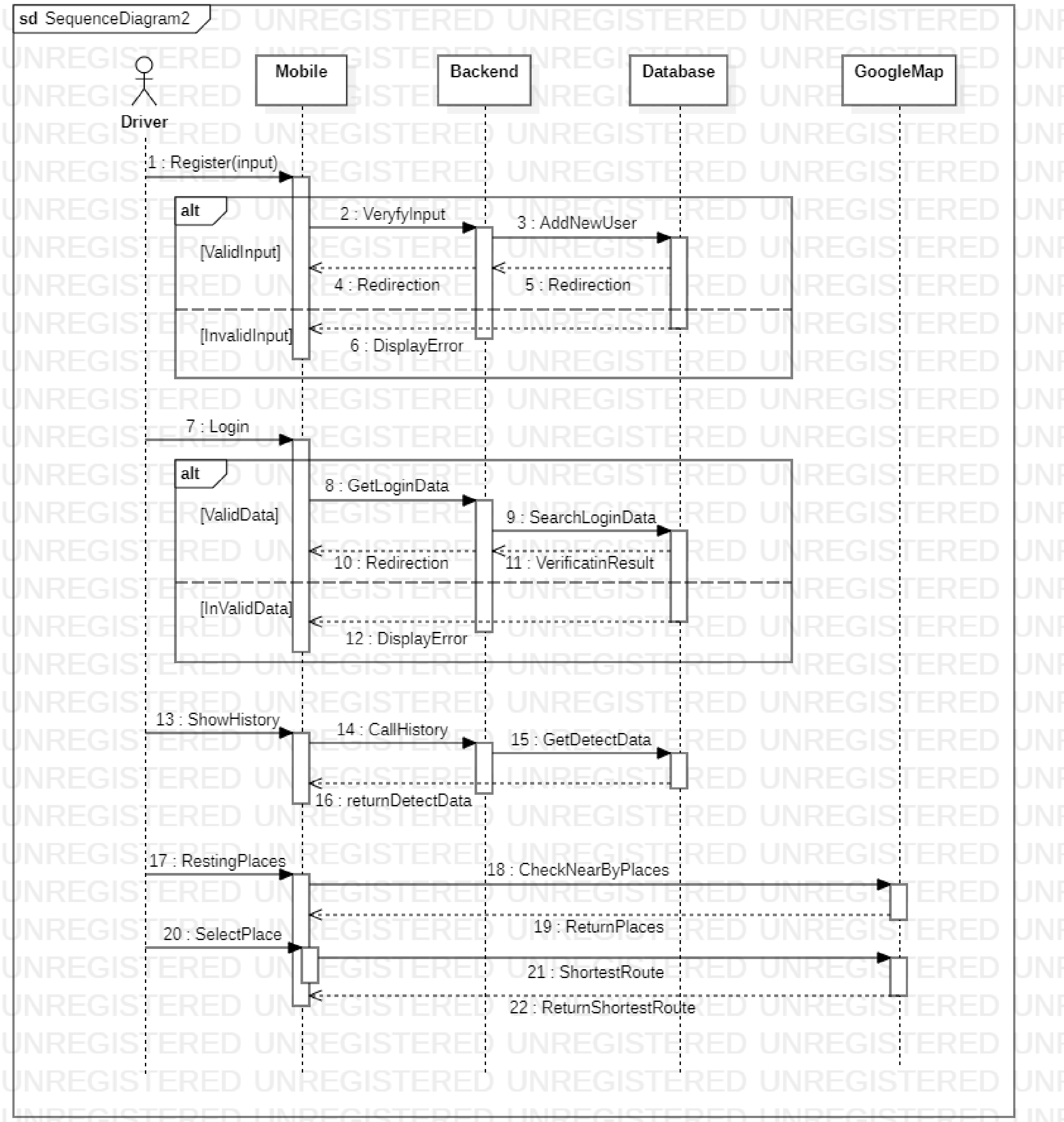

Figure 12: Sequence Diagram 02

5.5 Activity Diagram

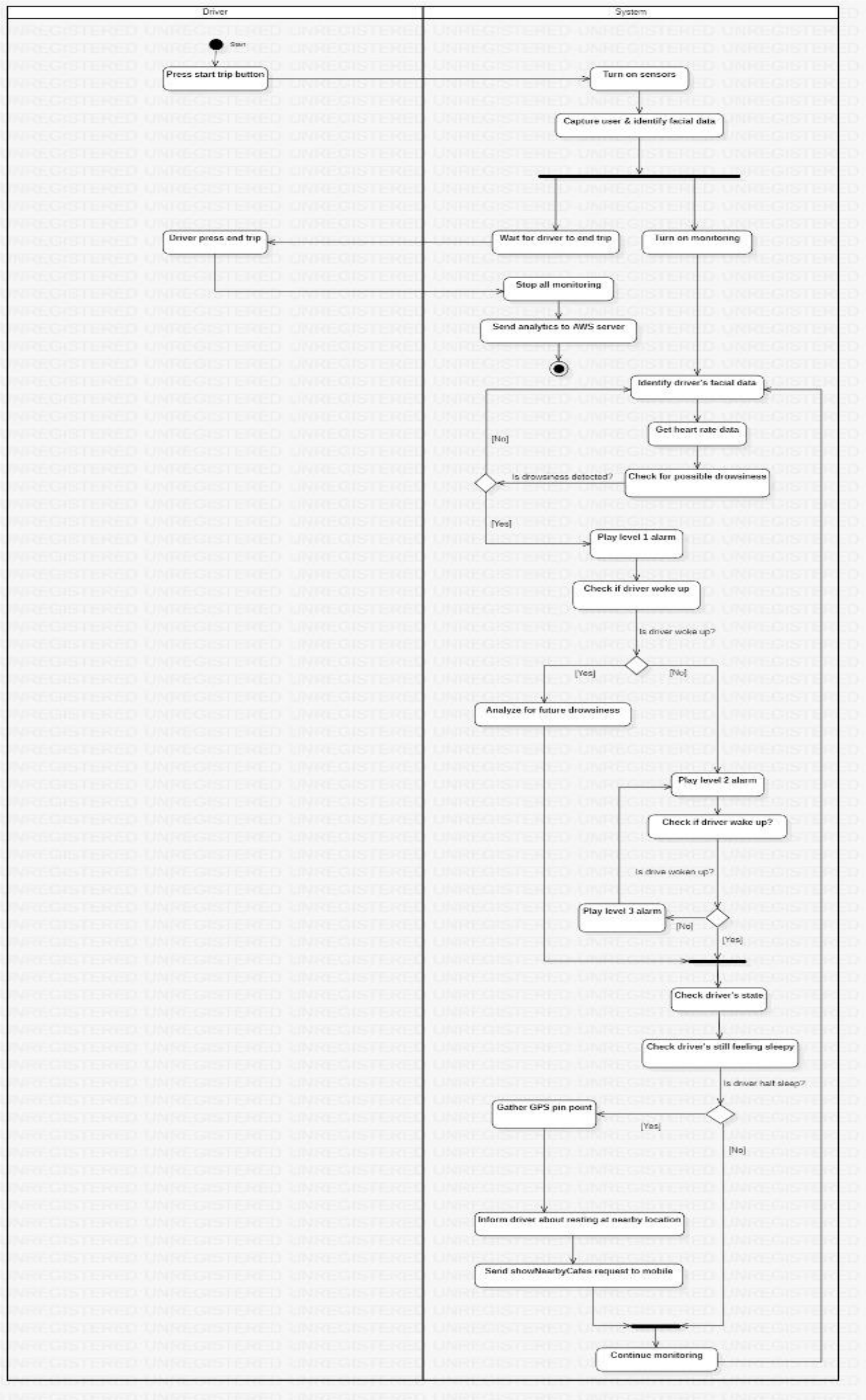

Figure 13: Activity Diagram

Activity Diagram: https://drive.google.com/file/d/133LQz0mBQNaRHxs517q4Lpl1y2oa1-Mv/view?usp=sharing

5.6 Wireframes

Wireframes has been moved to ***Appendix Section D.1*** for better clarity.

5.7 Chapter Summary

This chapter mainly summarized the high level and low-level Design of Driverdroid. The High-level architecture diagram, class diagram, sequence diagrams, activity diagrams and the wireframes for Driverdroid were brought forward and discussed in detail.

Chapter 6 - Conclusion

6.1 Chapter Overview

In the previous chapter analysis of data, functional and nonfunctional requirements of the project and other system required specifications was discussed and studied. This chapter will be the conclusion of the project. Conclusion would be summarized the plans on implementation, data set that used in this project and references, this chapter will also discuss the legal, social, ethical impact and circumstances on driver drowsiness software development project. Also discuss the professional issues came across on implementation.

6.2 Dataset

The University of Texas at Arlington Real-Life Drowsiness Dataset (UTA-RLDD) that was created for the task of multi-stage drowsiness detection was used for this Project. It is an informative dataset with 30 hours of RGB videos of 60 healthy participants. For each participant that took part, a video for each of the three different classes, alertness, low vigilance, and drowsiness, was taken for a total of 180 videos. This was the only main dataset that was used for this project to accomplish the research objectives.

6.3 Legal, social, ethical, and professional issues

Handling legal, social, ethical, and professional issues during the course of the software development group project is very important. Legal, social, ethical, and professional issues that are related to the proposed driver drowsiness detection system has been detailed below.

6.3.1 Legal

All the project details such as information, data set, requirements, materials, and code that has been used have been correctly credited and proper acknowledgment has been given. Software licensing had also been prioritized. Throughout the project, the MS Office package, StarUML, CorelDraw software's and Canva online tools have been used for the documentation, Justin mind wireframing tool has been used for designing wireframes and PyCharm, IntelliJ, Anaconda (V4.8.3), Android Studio, Visual Studio Code software's and Google Collab, Expo CLI online tools have been used for the implementation.

The data set that we used is publicly available for everyone and reference to the data set has been added to the reference section. It was ensured that to fulfill this project, none of the copyright law or intellectual property was violated. During the requirement gathering stage, the questionnaire had not collected any personal information from the users. The information collected was handled confidentially and users' identity was covered.

6.3.2 Social

The proposed IoT device is not designed to target any particular race, religion, or culture, and the creators have made sure that the device does not interfere with the values of any particular race, religion, or culture.
Also, no concept or strategy has been used in the design of this device, which could lead to a socially problematic situation. At present, the device uses the English language as its medium of communication, making it difficult or impossible for people with little or no knowledge of the English language, to use the device.
Thus, as a possible future development of the IoT device, multi-language support can be proposed, which will allow the user to communicate with the device without interruption, using his / her native or preferred language.

6.3.3 Ethical

The project team ensured that this project was always carried out subject to ethical acceptance. Accordingly, the researchers sought to provide the community with an overview of the project and the purpose of collecting relevant data, before collecting relevant information through the questionnaire.
The project team made sure not to store any data that could reveal individuals' identities during data collection. Furthermore, the researchers always worked to protect the confidentiality of the data collected, leaving no room for use of relevant data outside of the project.
According to the instructions on the 'UTA Real-Life Drowsiness Dataset' web page, regarding the dataset that has been used in the project, only 36 out of the 60 people who participated in the data collection in this dataset have given permission to publish their photos in public. Revealing the identity of any person among those 60 people has completely forbidden.
Thus, the research team fully complied with the terms and conditions when using the dataset for the project. The researchers also made sure that the data contained in this dataset was not used for any other purpose outside of project use and not misused.

6.3.4 Professional

Professionalism was there in every stage of the project. All the tasks to complete the project were handled professionally among team members. The questionnaire was sent out to the target audience professionally. Professional project management technologies have been used such as Trello.

6.4 Plans for implementation

The implementation plan for the project is divided into 3 sectors.

1. Hardware Configuration and Implementation.
2. Hardware Core Program
3. Mobile Application

The implementation plan for the project is divided into 3 sectors.

1. Hardware Configuration and Implementation

Hardware configuration is the first step of the project. After gathering the required hardware, they should be tested. A USB to Serial converter such as Deek-Robot DK FTDI ISP breakout board can be used to verify the sensor modules with a computer. Raspberry Pi can be tested by booting it up with a Raspberry Pi OS. Raspberry Pi OS only comes with limited libraries, so the required libraries for the project hardware should be installed manually if needed. After this raspberry pi and sensor modules should be connected, configured and tested with the system console. The hardware components should be working properly with the raspberry pi. After configuring the hardware, the hardware core programming and mobile application can be started.

The hardware system should be configured again and again to provide better accuracy with the core program and mobile application while those under development.

After the hardware core program and mobile application sectors are done the hardware should be configured properly. The hardware should be soldered into a PBC and placed into a proper casing. This casing will be 3D printed to fit into the expectation of the final device.

2. Hardware Core Program

Hardware core programs should be started after all the hardware components are configured. The program should use the sensor raw data and use machine learning and AI to identify and provide appropriate responses to the user. In this process raw camera data should be used with the OpenCV library to recognize face, eyes and read data from the Fitness Tracker or Smartwatch to get the heartbeat. These data should be filtered, analyzed, and processed to identify users' status and if the user is in a sleeping state the proper actions should be taken. Meanwhile the analyzed data should be submitted to the cloud server too. The accuracy of the data cannot be 100% accurate by this time, so the hardware components and core program should be improved to at least provide much better accuracy.

After the basic data reading, analysis and responding procedures are implemented, the GUI for the project should be implemented. This GUI should consist of a basic status monitor, device configurations, and a map view. The GUI should be improved to fit with UI/UX principles and to provide easy access to the user.

The hardware core program should optimize into fit within the raspberry pi and provide optimal performances and fast response according to the data. The final product should consist of a program that fits with the expectation of the device.

3. Mobile Application

The mobile application should be fit to communicate with the hardware system over the internet and should be able to provide advanced statistics, predictions, suggestions, and some settings. The mobile application should consist of an easy to use and appropriate graphical user interface which follows the standards of the UI/UX principles. The mobile application should implement the following functionalities.

- Register a new user
- Register a device
- Basic Statistics
- Advance Statistics
- Predictions and Suggestions
- Map View
- Notifications
- User Settings and Device Settings

The final mobile application should be able to fit with the project expectations. Also, the application should be available for both Android and IOS devices and should be responsive to fit within any resolution.

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Appendix Section A - Introduction

Appendix Section A.1 - Attempted solutions of the Competitors

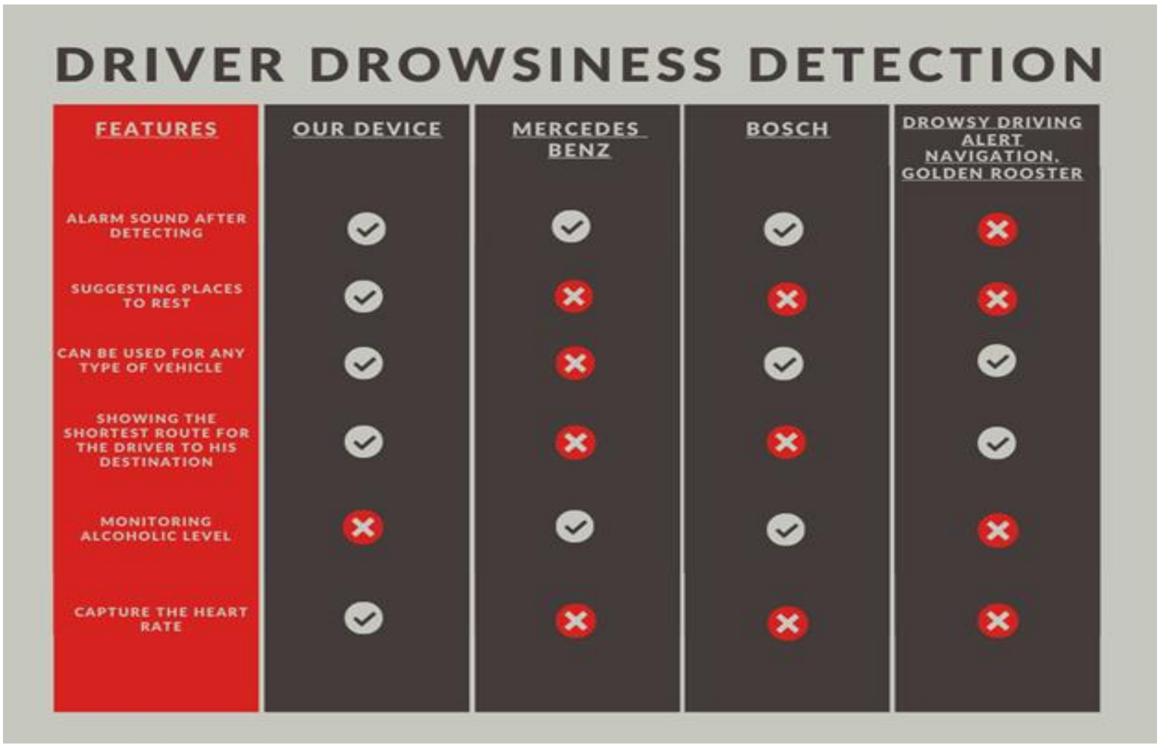


Figure 14: Attempted solutions of the Competitors

Appendix Section A.2 - Operational Objectives

#	Objective Description
Objective 1 - Purpose	• A deep study on the problem identified and the existing solutions. • Discuss with frequent drivers about their experience on feeling drowsy when driving. • Conduct a survey with people who frequently drive from all ages. • Study about ML and AI approaches for this domain. • Define the problem domain. • Identify and analyze about competitors and their solutions. • Submit the Project Initiation document.
Objective 2 - Gather Data	• Research about crashes happened because of driver's drowsiness and research about causes of driver drowsiness. • Gather data from news sites

Objective 3 - Study and Review Existing Work	● Create a well analyzed literature survey on driver drowsiness detection systems for drivers with evaluating previous research done by competitors. ● Do a critical analysis on existing systems for detecting driver drowsiness and identify the flows and missed features in the systems. ● Do a deep research about techniques and methods used in competitors' systems and open-source projects available in the internet that can be incorporated. ● Analyzing gathered techniques and methods and selecting appropriate and efficient ones. ● Research about the hardware components used in competitor's and publicly available projects. ● Submit the Literature Review document.
Object 4 - Design	● Recognize the appropriate techniques that will be used in the system. ● Identify, analyze, and arrange functional and non-functional requirements and plan the system. ● Analyzing the current data to design an appropriate hardware system. ● Select suitable development tools and technologies for the project. ● Create a final design document of the system and submit the Design document.
Objective 5 - Implement	● Gathering required hardware components according to the analyzed data about research done in literature review and design document. ● Assembling the hardware components. ● Checking hardware components and analyzing sensor inputs. ● Develop appropriate ML components/ ● Developing the program to run on the hardware system. ● Developing the mobile user access platform ● Create a prototype device and a prototype mobile application. ● Enhance the hardware and mobile platform systems.
Objective 6 - Test	● Create and execute appropriate test cases using the prototype system. ● Fix bugs if presented. ● Improve and collaborate hardware components if needed. ● Report on the test results.
Objective 7 - Evaluate	● Evaluate and verify the prototype and check whether it fit with the requirements. ● Create an Evaluation document.

Table 5: Operational Objectives

Appendix Section A.3 - Hardware Requirements

Device	Specification
Raspberry Pi camera to capture video input of the user	Raspberry Pi 4 Model B - 4GB variant
Bk-7000v2 Act as a modem	SIM700c 4GB NB-IoT 4G/eMTC/EDGE/GPRS/GNSS LTE Module
5MP with IR Lights Camera Module to capture footage at dim or no light.	5MP with IR Lights Camera Module for Raspberry Pi
Obstacle avoidance sensor to collaborate with camera data input.	Obstacle Avoidance Sensor IR Infrared Module
Touch Screen Display to act as a video output and user interface display for the user	5-inch Raspberry Pi Touch Screen Display

Table 6: Hardware Requirements

Appendix Section A.4 - Software Requirements

Languages	
Python (V3.7)	For the Development of the IoT System
IDEs and other software	
Anaconda (V4.8.3)	Used for the Machine Learning Component
Google Collab	Used for the Machine Learning Component
PyCharm (V2020.3)	For programming with Python with OOP
Star UML	For designing Use Case diagrams
Microsoft Office Word (V16)	For making the reports and other documentation
Microsoft Office Excel (V16)	For making the Gantt Chart diagram & Work Breakdown Structure

Corel Draw	For making the Rich Picture Diagram
Google Drive	For managing the documents and data in the cloud
Trello	For managing the documents and research data
Justinmind	For designing wireframes for the mobile application
Android Studio	To run and test the mobile application virtually using AVD
Visual Studio Code	To code React Native
Expo Go	To run and test the mobile application
APIs, Libraries, and frameworks	
OpenCV (V3.4. 9)	Machine Learning library with pre-built algorithms
React Native	Used for the mobile application development
Django	To connect the mobile app with the backend

Table 7: Software requirements

Appendix Section B - Project Management

Appendix Section B.1 - Process Model

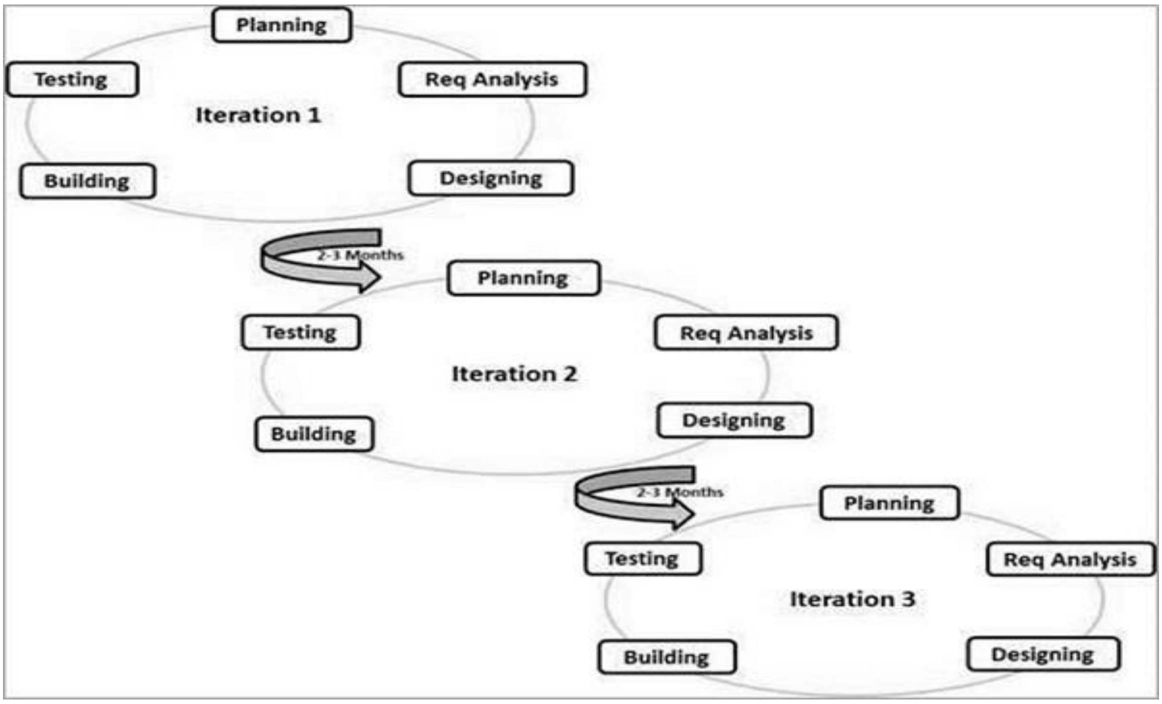


Figure 15: Process Model

Appendix Section B.2 - Activity Schedule

Date	Activity	Time frame
06/10/2020	Finalizing on project idea	2 Weeks
24/10/2020	Submission of the Project proposal	2 Weeks
22/11/2020	Submission of the literature review	1 months
04/01/2020	Submission of the SRS	1 month

Table 8: Activity Schedule

Appendix Section B.3 - Work Breakdown Structure

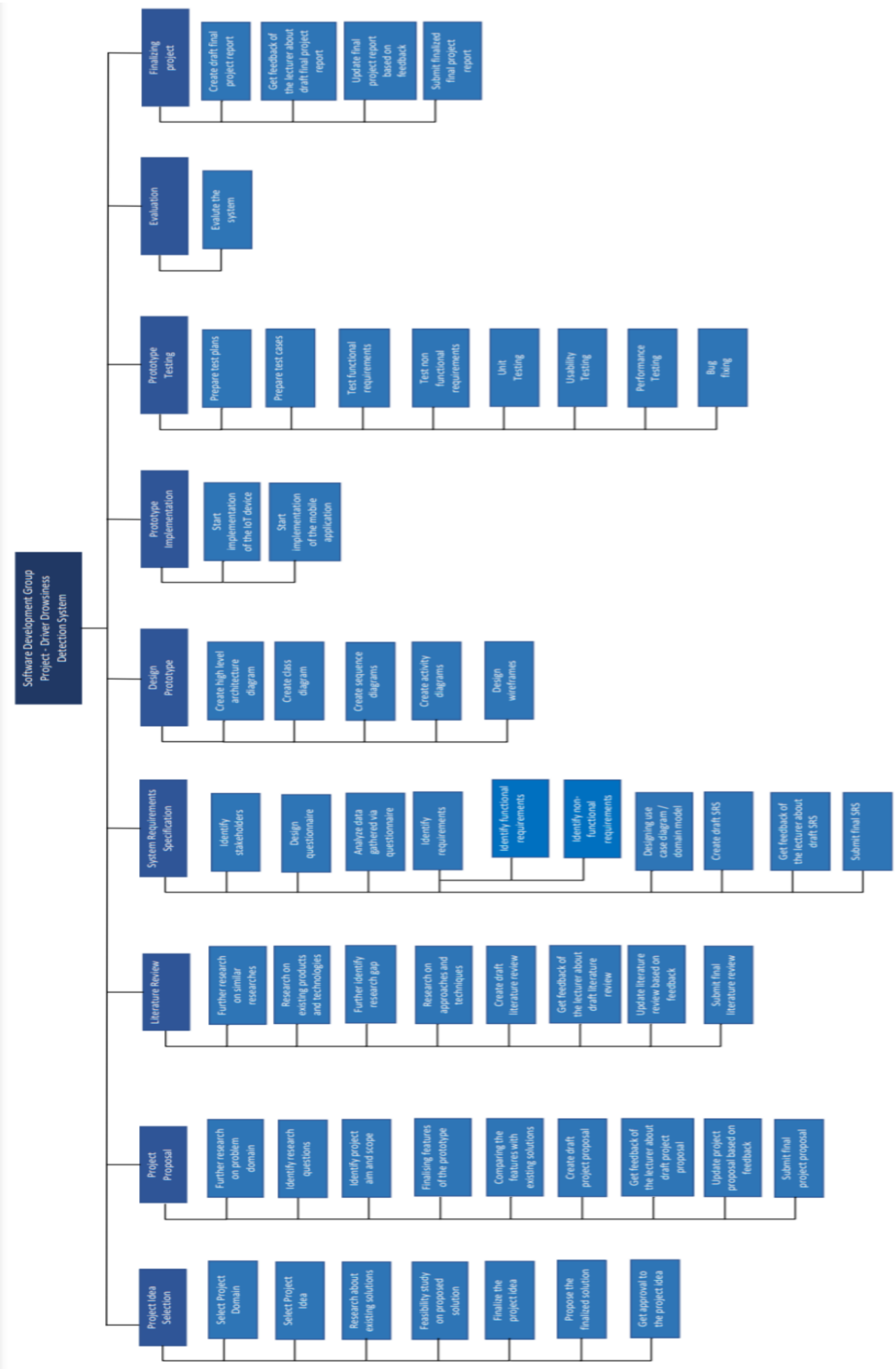


Figure 16: Work Breakdown Structure

Work Breakdown Structure:
https://drive.google.com/file/d/1cPnWovIeq1FDUZt_5gzcEvmWITD8cOn0/view?usp=sharing

Appendix Section B.4 - Gantt Chart

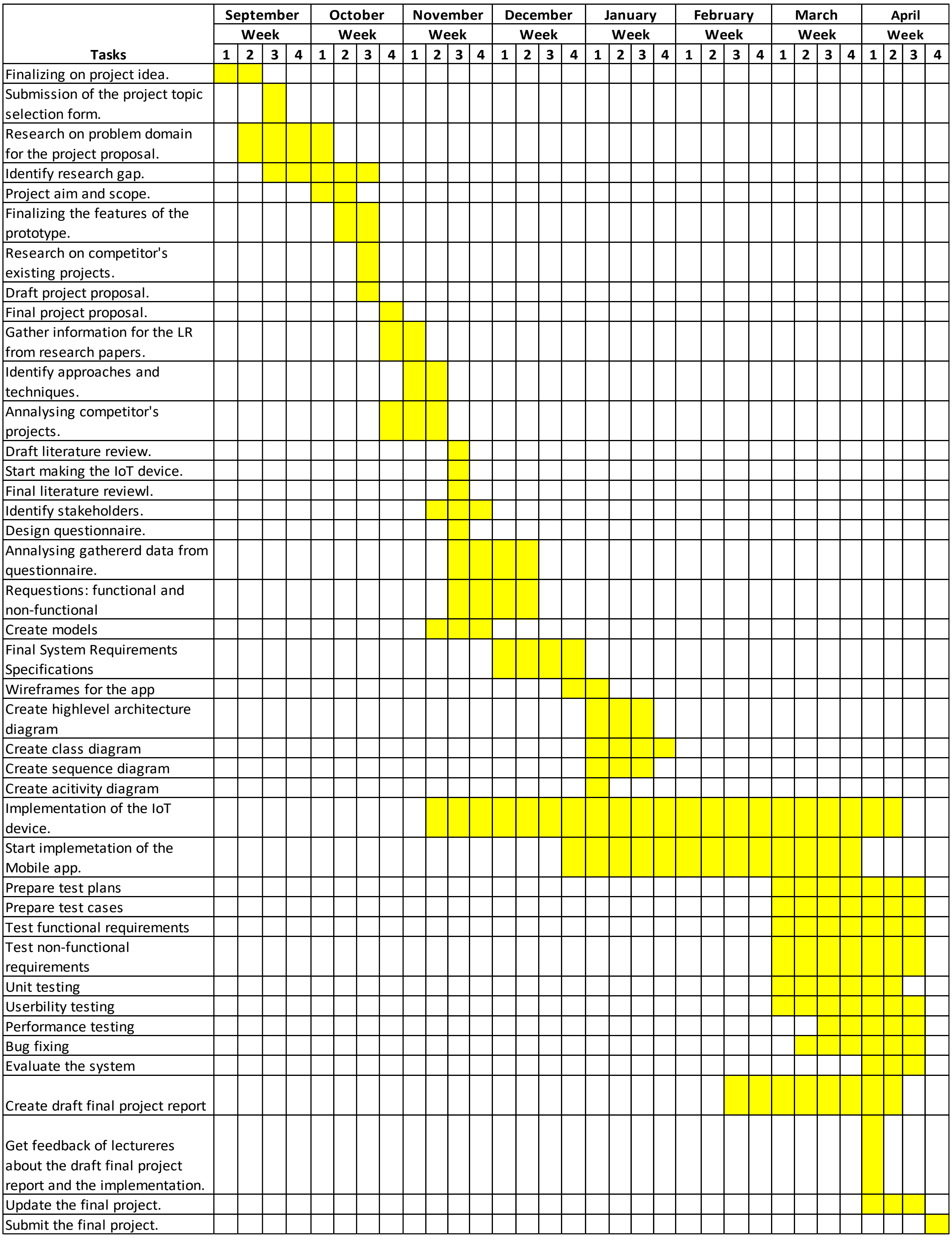


Figure 17: Gantt Chart

Gantt Chart: https://drive.google.com/file/d/1rjBMRF1LCguYg-n3PoIuP53lM6J2_V-J/view?usp=sharing

Appendix Section C - System Requirement Specification

Appendix Section C.1 - Onion Model

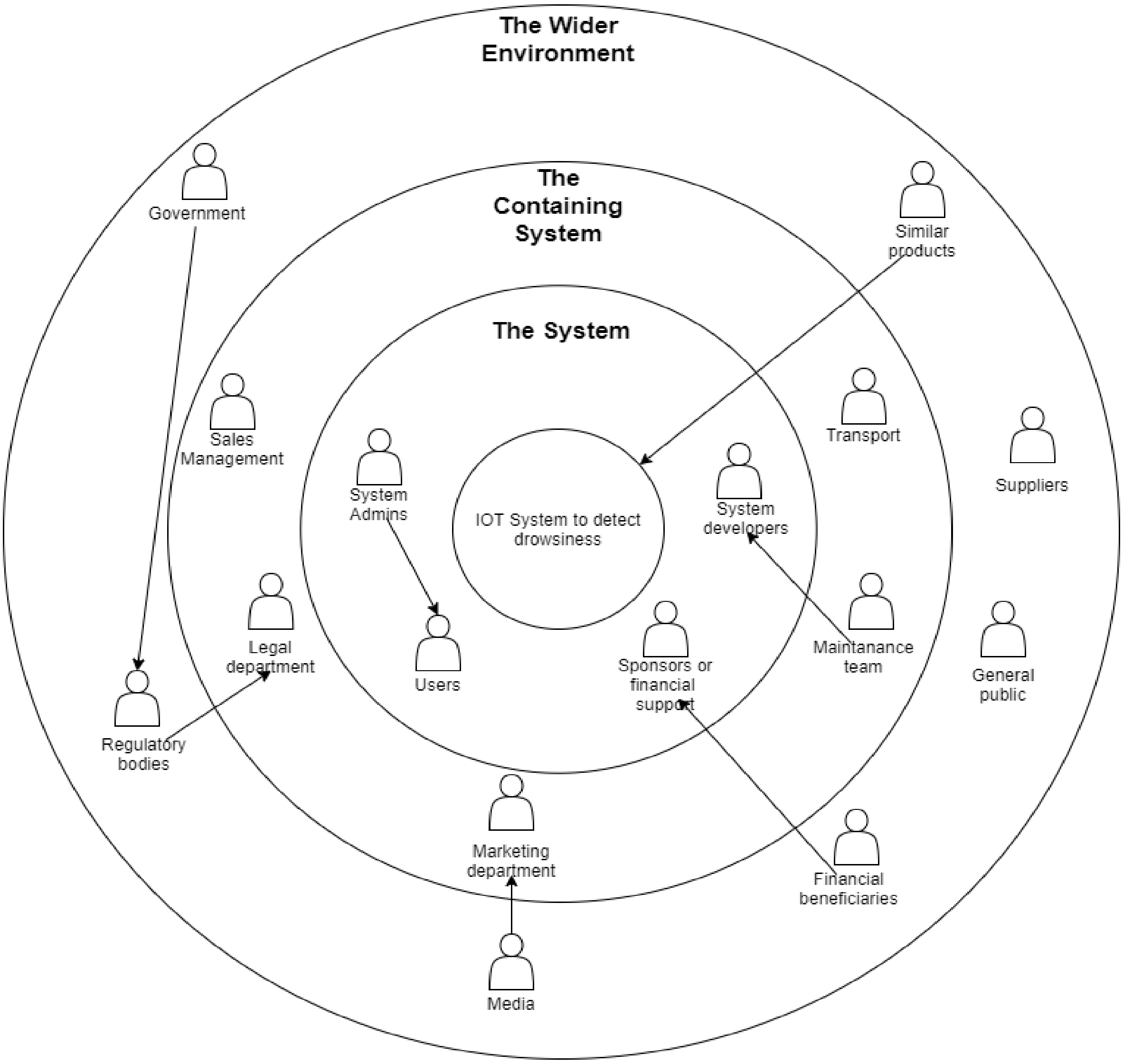


Figure 18: Onion model

Appendix Section C.2 - Stakeholder Descriptions

Stakeholder	Viewpoint
Functional beneficiaries	
Users	Users use the drowsiness detection system and they are benefited by the productivity and efficiency of the system.
System admins	Wants to run the system as successfully as they can, for it to be most productive.
Financial beneficiaries	
Sponsors	Sponsors will be interested in the financial success of the product as it means that their investment has returned the results.
Suppliers	Increased sales of the product mean the suppliers will be making more sales.
Sales management	Hope to improve the position in the company from the success of the product.
Marketing department	Hope to improve the position in the company from the success of the product.
Social beneficiaries	
General public	Hope to reduce the traffic accidents.
Users	Hope to avoid accidents due to drowsiness.
Government	Wants to reduce the damage to public properties by roadside accidents.
Operational beneficiaries	

Users	Want to reduce the risk of meeting with an accident. Being able to drive late at night without risk of falling into sleep.
Negative stakeholders	
Rival products	Want to reduce the competition by eliminating their rivals and coming on top.
Regulatory bodies	
Government	Wants to reduce the rate of accidents and regulate the market by imposing taxes.
Experts	
System developers	Wants to improve the system, both hardware and software, in order to compete with the rivals
Maintenance team	Want to keep the systems running at its peak efficiency.

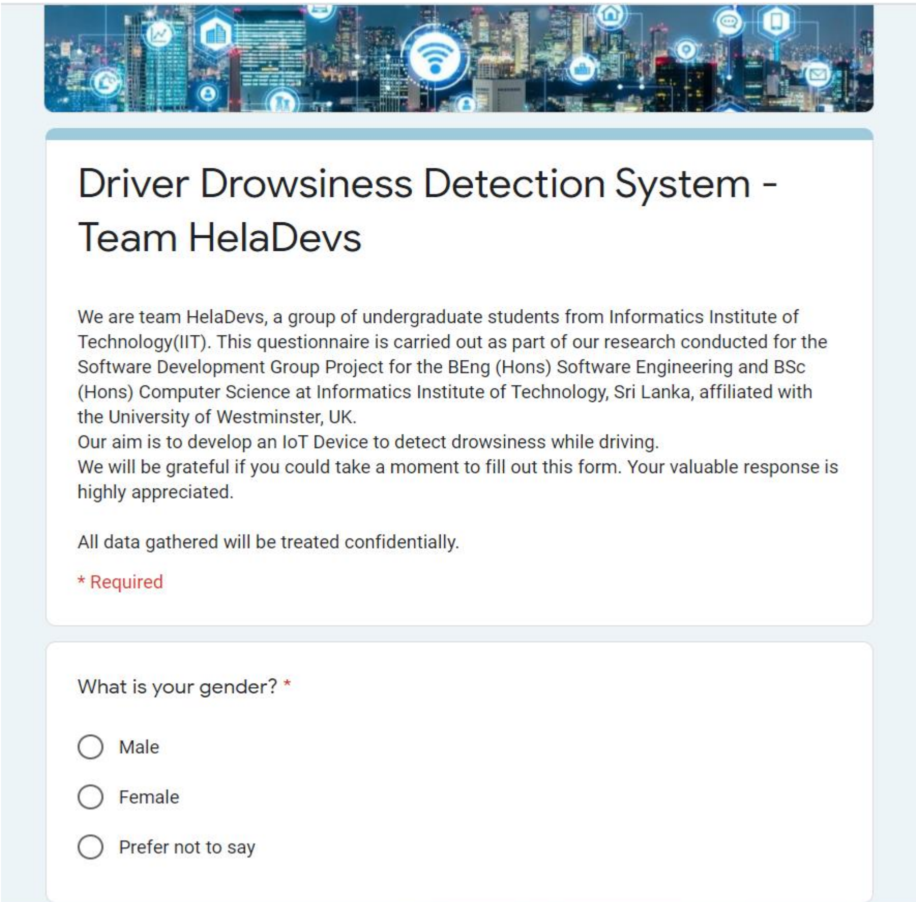
Table 9: Stakeholder descriptions

Appendix Section C.3 - Questionnaire Design

Question	**Goal**
What is your gender?	To get the gender of the driver to analyse the collected data based on gender
Choose your age group?	To get the age category of the driver
At what time do you mostly drive?	To get an idea about at what time usually the respondents drive most
How long does it take for you to reach your destination as an average?	To get an idea about the time duration which usually takes for a driver to reach his/her destination as an average

How often do you feel drowsy while driving?	To get to know how often drivers get drowsy as an average
Do you usually take a rest if you feel drowsy or tired?	To get the idea how often drivers tend to take a rest if they feel drowsy
Do you think it's better to have a high accuracy IOT device to detect driver drowsiness rather than a mobile application?	To get the opinion of the driver about the idea of implementing an IoT system to detect driver drowsiness
If you agree, what kind of features would you like to have in that IOT device?	To get the feedback of the driver about the currently finalized features of the IoT system and to let user to suggest further features they expect from the system

Table 10: Questionnaire design


Driver Drowsiness Detection System - Team HelaDevs

We are team HelaDevs, a group of undergraduate students from Informatics Institute of Technology(IIT). This questionnaire is carried out as part of our research conducted for the Software Development Group Project for the BEng (Hons) Software Engineering and BSc (Hons) Computer Science at Informatics Institute of Technology, Sri Lanka, affiliated with the University of Westminster, UK.
Our aim is to develop an IoT Device to detect drowsiness while driving.
We will be grateful if you could take a moment to fill out this form. Your valuable response is highly appreciated.

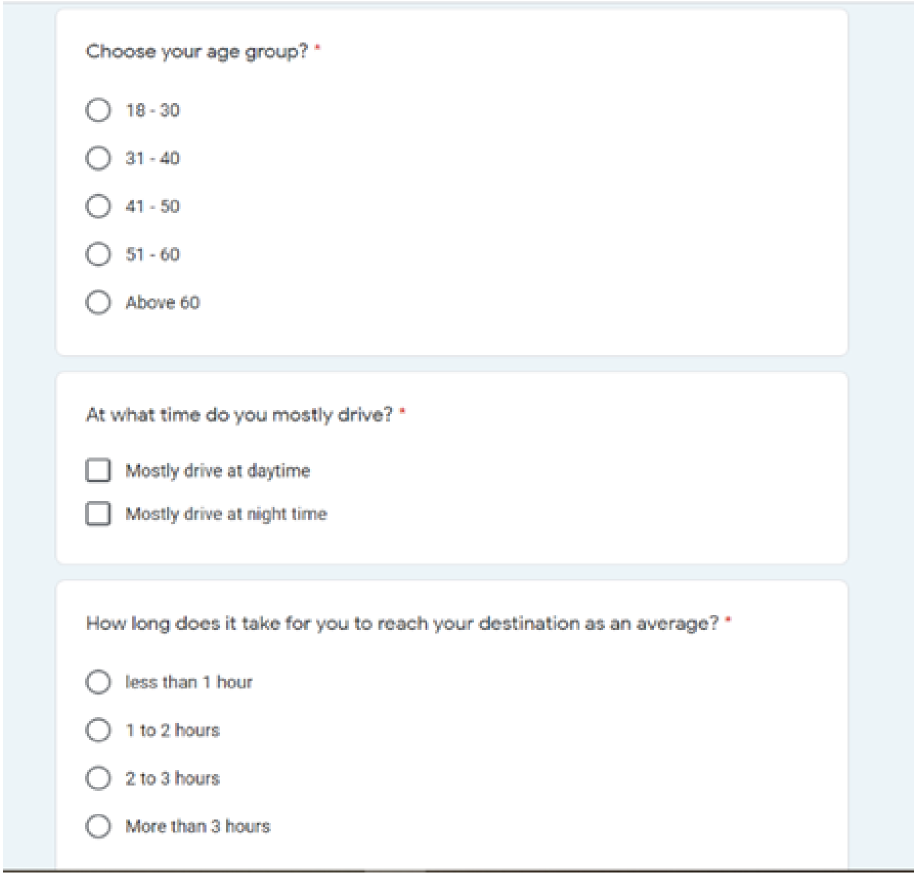
All data gathered will be treated confidentially.

* Required

What is your gender? *

- Male
- Female
- Prefer not to say

Figure 19: Form Image 01



Choose your age group? *

- 18 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- Above 60

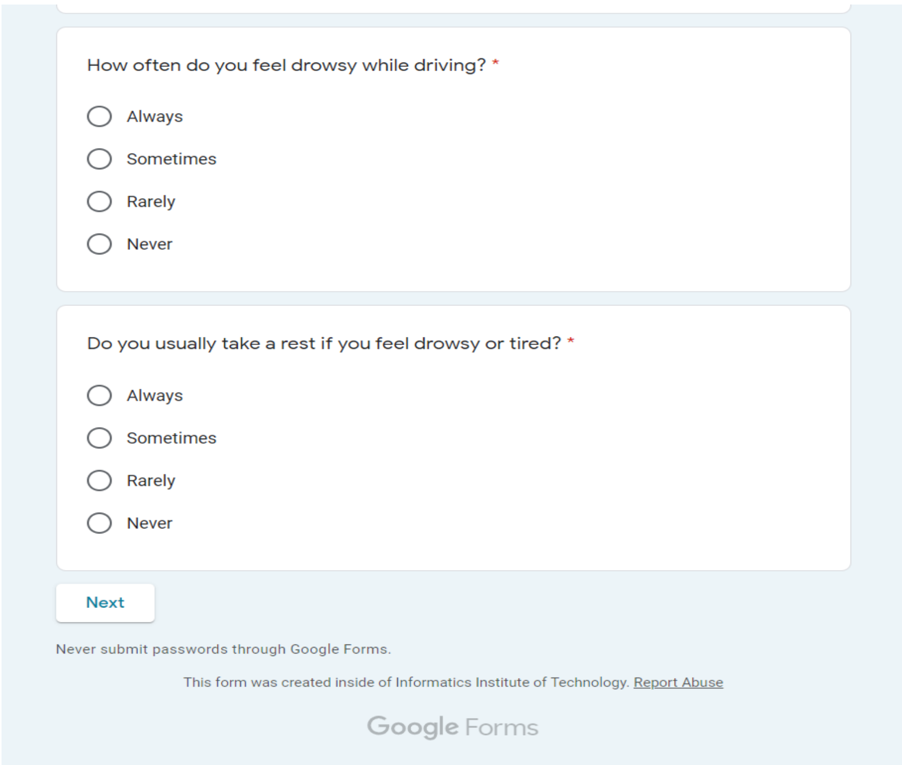
At what time do you mostly drive? *

- Mostly drive at daytime
- Mostly drive at night time

How long does it take for you to reach your destination as an average? *

- less than 1 hour
- 1 to 2 hours
- 2 to 3 hours
- More than 3 hours

Figure 20: Form Image 02



How often do you feel drowsy while driving? *

- Always
- Sometimes
- Rarely
- Never

Do you usually take a rest if you feel drowsy or tired? *

- Always
- Sometimes
- Rarely
- Never

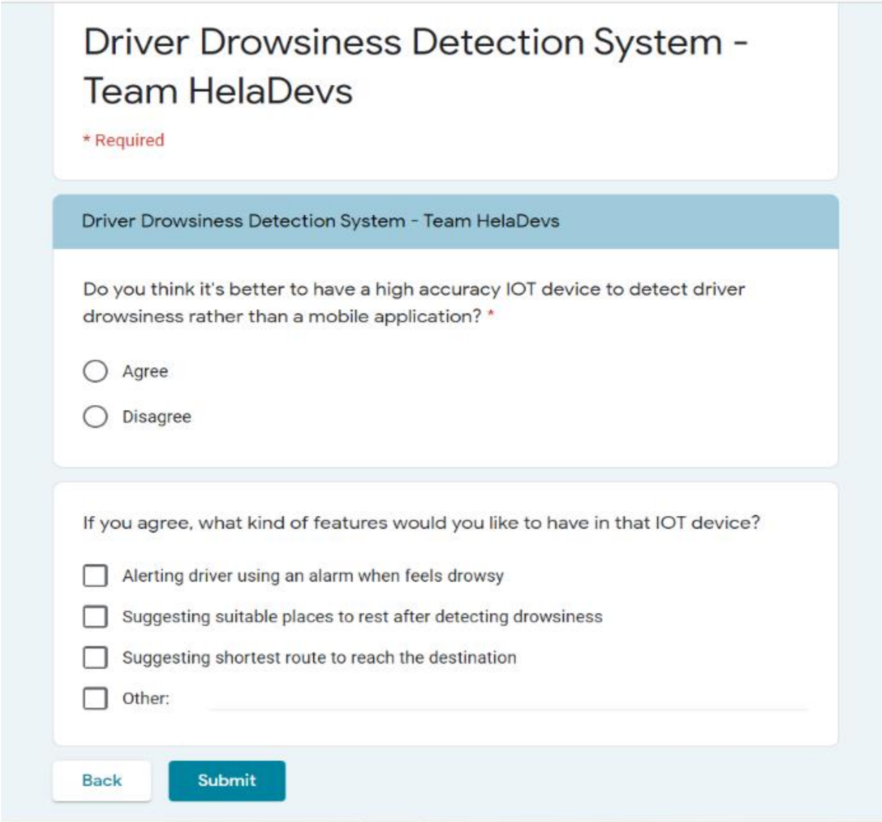
Next

Never submit passwords through Google Forms.

This form was created inside of Informatics Institute of Technology. Report Abuse

Google Forms

Figure 21: Form Image 03


Driver Drowsiness Detection System - Team HelaDevs

* Required

Driver Drowsiness Detection System - Team HelaDevs

Do you think it's better to have a high accuracy IOT device to detect driver drowsiness rather than a mobile application? *

- Agree
- Disagree

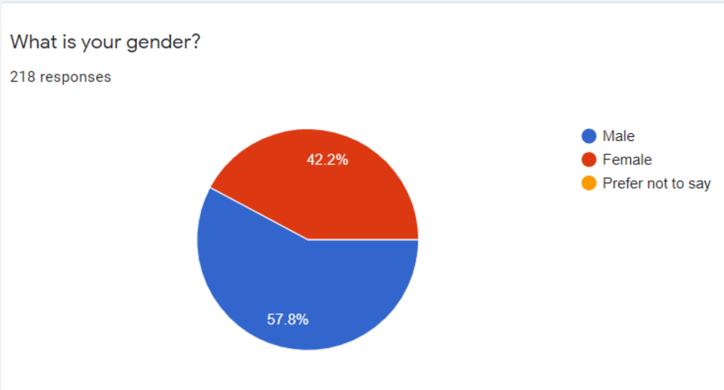
If you agree, what kind of features would you like to have in that IOT device?

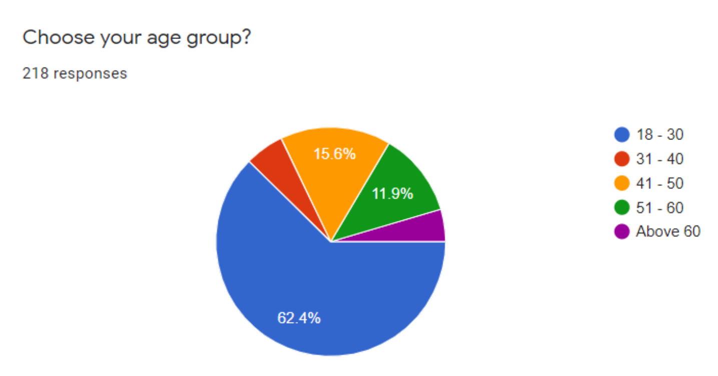
- Alerting driver using an alarm when feels drowsy
- Suggesting suitable places to rest after detecting drowsiness
- Suggesting shortest route to reach the destination
- Other:

Back Submit

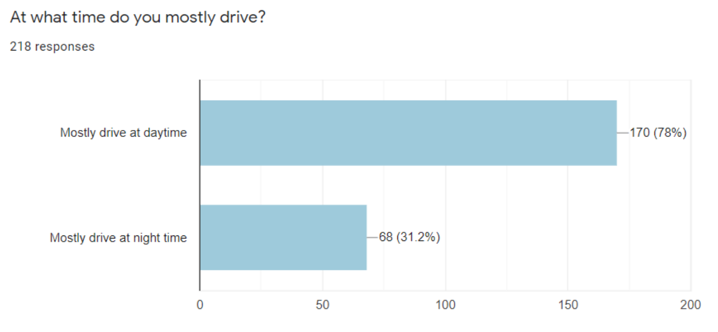
Figure 22: Form Image 04

Appendix Section C.4 - Analysis of gathered data

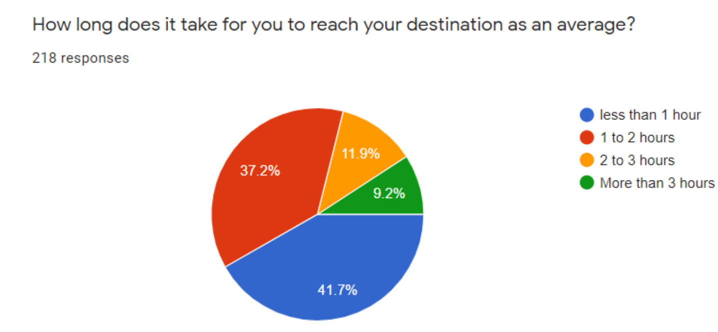
Analysis of gathered data	
	57.8% drivers have voted for Male, which means majority of drivers are male. Because of that, the end product of this project will be used by male.



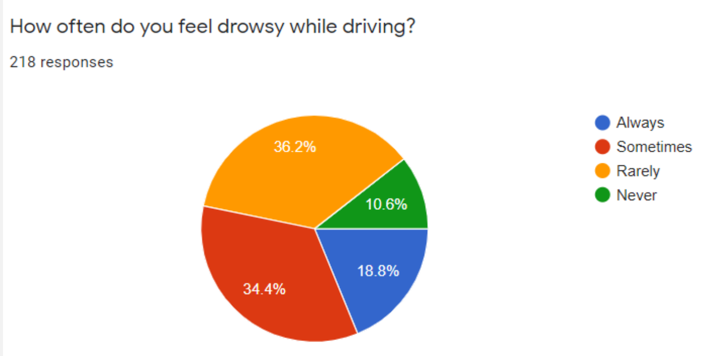
62.4% drivers have voted for 18-30 age group, which means majority of drivers are from 18-30 age group. There is 15.6% of drivers.



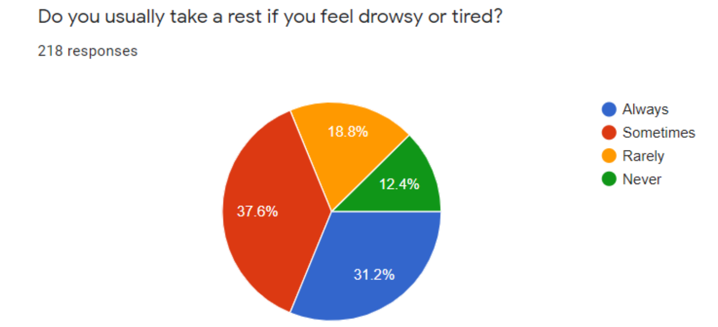
170(78%) drivers have voted for Mostly drive at daytime, which means there is a high chance to use this product at daytime.



41.7% drivers have voted for less than 1 hour option, which means majority of drivers take less than 1 hour to his/her destination as an average.



36.2% drivers have voted for Rarely option. But 34.4% drivers have voted for sometimes and 18.8% users have voted for always option. Which means there is good possibility to use this product to detect their drowsiness while drivng and for a safe journey.



#7.6% drivers have voted for sometimes option, which means majority of drivers usually take rest when they drowsy or tired. Therefour, there is a high probability to use “show shoertest parth to the nearest resting places” feature more.

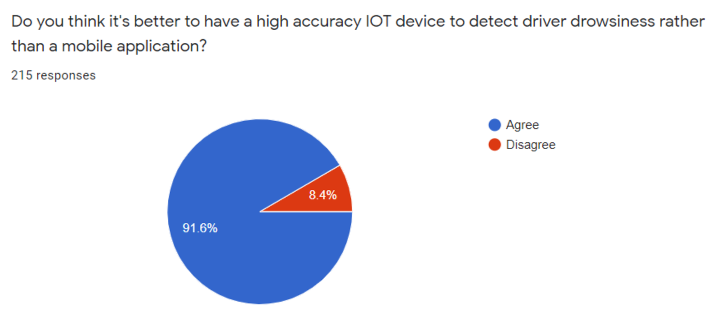
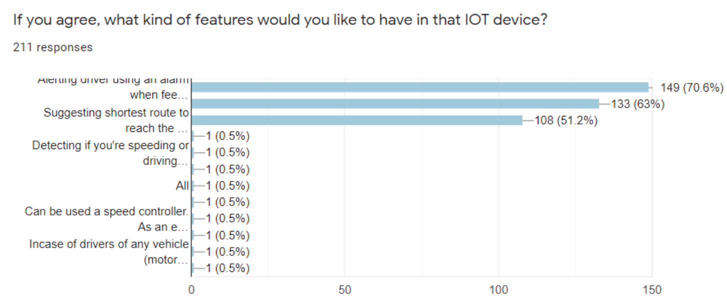
	91.6% drivers have voted for yes, which means majority of drivers think it is better to have a high accuracy IoT device to detect rather than a mobile application. Therefore, there is a high chance of drivers tend to buy the end product of this project.
	3 main features of this project has been put to this questionnaire to vote for any number of features drivers would like. According to the annalysis there are more than 50% of votes has been recorded for each feature. Some users have suggest some suggestions also. Suggestions have been considered.

Table 11: Analysis of gathered data

Appendix Section C.5 - Use Case Diagram

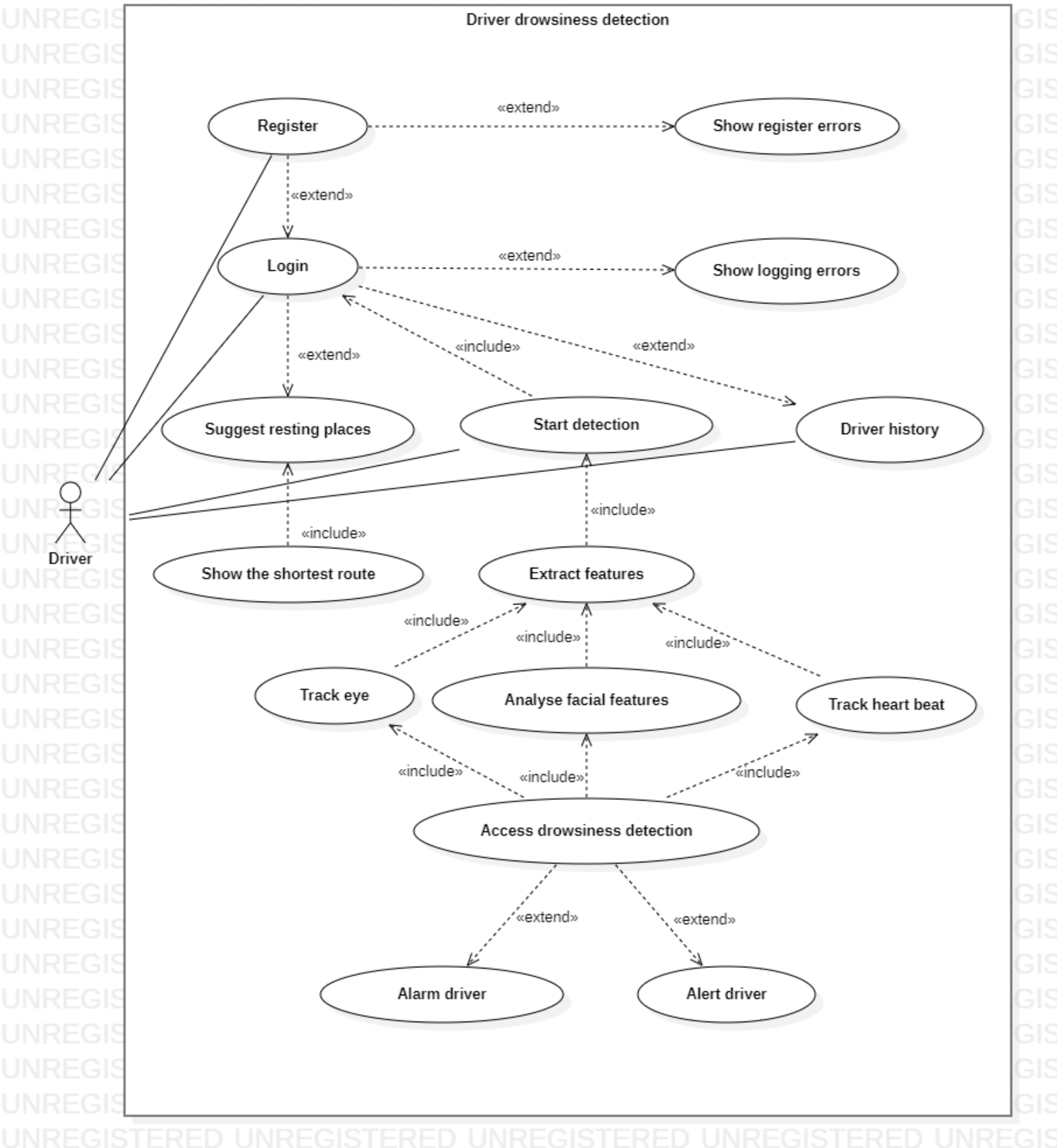


Figure 23: Use Case Diagram

Appendix Section C.6 - Use Case Description

Use Case No:	01	
Use Case Name	Register	
Description	Driver will register himself on the system mobile app.	
Primary Actor	Driver	
Priority	High	
Trigger Event	Driver will use the Sign-up option on the app to register	
Pre-Condition	User should not be already existing in the system	
Main Sets of Actions	Actor • Enter valid driver details to register • Click “Register” button	System • Loads the registration menu • Prompt for the driver registration form • Validate driver inputs • Prompt “Registered successfully”, after the driver successfully registered on the system and will be directed to the home page
Post Condition	Redirect to the home page	

Table 12: Use Case Description 01

Use Case No:	02
Use Case Name	Login
Description	Driver will log in to the system.
Primary Actor	Driver
Priority	High
Trigger Event	Driver will use the Sign-in option in the app to access the home page

Pre-Condition	Driver must be registered successfully	
Main Sets of Actions	Actor • Enter the user name and password • Click "Log-in" button	System • Prompts the login form • System will query for the username and fetch the password of given username. Compare username with the registered username. Authenticate the user. Redirect to user menu.
Post Condition	Redirect to the home page	

Table 13: Use Case Description 02

Use Case No:	03	
Use Case Name	Start detection	
Description	Driver will operate the system	
Primary Actor	Driver	
Priority	High	
Trigger Event	Driver will use the Start option on the device to start detecting drowsiness	
Pre-Condition	Place the device in the vehicle in front of the driver	
Main Sets of Actions	Actor • Set up the device in the vehicle, in front of the driver as face clearly appearing to the device • Wear the band on hand • Operate device	Device • Start capturing real time video of the driver • Band Keep track of heart beat
Post Condition	System extract features from driver	

Table 14: Use Case Description 03

Use Case No:	04
Use Case Name	Extract features
Description	System will start extract the features(data) of the driver

Primary Actor	driver	
Priority	High	
Trigger Event	Driver operate the device	
Pre-Condition	Driver should set up the device in the vehicle in front of the driver and wearing the band	
Main Sets of Actions	Actor • Operate Device • Wear hand band	System • Start capturing real time video of eye and face features by operating device camera • Start tracking heartbeat of the driver by operating sensor on the band
Post Condition	System starts analyzing features	

Table 15: Use Case Description 04

Use Case No:	05	
Use Case Name	Track eye	
Description	System will track the eye status of the driver	
Primary Actor	driver	
Priority	High	
Trigger Event	Operate device	
Pre-Condition	Place the device in front of driver	
Main Sets of Actions	Actor • Operate device	System • Track frequency of eye blink • Track eye closed time (duration of time for the eye closed state)
Post Condition	System checks whether eye status show drowsiness warning signs	

Table 16: Use Case Description 05

Use Case No:	06
Use Case Name	Analyze facial features
Description	System will analyze the facial features and movement of the driver
Primary Actor	driver

Priority	High	
Trigger Event	System camera will detect the facial features	
Pre-Condition	Driver should operate device	
Main Sets of Actions	Actor • Operate device	System • Analyse facial movements • Track assent of the head to the right • Track assent of the head to the left
Post Condition	System checks whether facial features show drowsy warning signs	

Table 17: Use Case Description 06

Use Case No:	07	
Use Case Name	Track heart beat	
Description	System will track the heart beat rate of the driver while driving	
Primary Actor	driver	
Priority	High	
Trigger Event	Wear Hand band	
Pre-Condition	Operate Device	
Main Sets of Actions	Actor • Wear the hand band	System • Track heartbeat of the driver by the hand band that driver wears while driving • Band containing the sensor track the heartbeat of the driver
Post Condition	Band keeps tracking on heartbeat whether shows drowsy signs	

Table 18: Use Case Description 07

Use Case No:	08
Use Case Name	Access driver drowsiness
Description	System will monitor all the real time data of eye, face and heart of the driver and checking whether the driver is drowsy
Primary Actor	Driver

Priority	High	
Trigger Event	System camera will detect the facial features Hand band track the heart rate	
Pre-Condition	Operate system and extract features of the driver	
Main Sets of Actions	Actor -	System • monitor the driver by analyzing captured data of eye, face and heart and check the overall percentage of fatigue and drowsiness
Post Condition	System keeps tracking all features together and check whether driver drowsy	

Table 19: Use Case Description 08

Use Case No:	09	
Use Case Name	Alert driver	
Description	System device will alert driver by voice messages if detected some drowsiness characteristics	
Primary Actor	Driver	
Priority	High	
Trigger Event	Detects drowsy characteristics	
Pre-Condition	Driver should operate the system.	
Main Sets of Actions	Actor -	System • System device will analyse data and identify drowsy characteristics
Post Condition	Alert driver about his drowsy characteristics by a voice message	

Table 20: Use Case Description 09

Use Case No:	10
Use Case Name	Alarm driver
Description	System will alarm driver if detected drowsiness
Primary Actor	Driver
Priority	High
Trigger Event	Detect drowsiness at high percentage

Pre-Condition	-	
Main Sets of Actions	Actor -	System • System detects drowsy of the driver
Post Condition	Alarm driver	

Table 21: Use Case Description 10

Use Case No:	11	
Use Case Name	Suggest resting places	
Description	System mobile app will give the option of suitable places for rest nearby if feels fatigue or drowsy	
Primary Actor	Driver	
Priority	low	
Trigger Event	Choose the option “Resting places”	
Pre-Condition	Driver should login	
Main Sets of Actions	Actor • Click the button on “Resting places nearby”	System • Prompt the driver the options of “Resting places” • Will be Directed to the “resting places nearby” in system mobile app
Post Condition	Show the nearby resting places	

Table 22: Use Case Description 11

Use Case No:	12
Use Case Name	Show the shortest route
Description	System will give the shortest route for the selected resting place
Primary Actor	Driver
Priority	High
Trigger Event	Choose the resting place

Pre-Condition	Driver selects the option of ‘Resting places nearby’ in the mobile app	
Main Sets of Actions	Actor • Driver clicks on button “Resting places nearby	System • Prompt for the shortest route for the selected resting place
Post Condition	Show the shortest route for the resting place	

Table 23: Use Case Description 12

Use Case No:	13	
Use Case Name	Driver history	
Description	System will give the option of checking driver drowsiness history	
Primary Actor	driver	
Priority	low	
Trigger Event	Choose the option “Driver history”	
Pre-Condition	Driver should be logged into the system	
Main Sets of Actions	Actor • Click the button ’Driver history’	System • Prompt for the past records of detected drowsy with the time and dates
Post Condition	Show the history of drowsy levels of the driver with date and time	

Table 24: Use Case Description 13

Use Case No:	14
Use Case Name	Show register errors
Description	System will show register errors
Primary Actor	Driver
Priority	high
Trigger Event	Drivers enter invalid register details
Pre-Condition	-

Main Sets of Actions	Actor • Click the button ’Sign-up’	System • Prompt error message “Please enter the phone number”. • Prompt error message “Please enter a strong password”. • Disable the sign-up button.
Post Condition	-	

Table 25: Use Case Description 14

Use Case No:	15	
Use Case Name	Show logging errors	
Description	System will show logging errors	
Primary Actor	Driver	
Priority	high	
Trigger Event	Drivers enter invalid login details	
Pre-Condition	Choose the option sign-in	
Main Sets of Actions	Actor • Click the button ‘Sign in’ • Input log in details	System. • Prompt error message “Entered Username or password is incorrect”. • Disable the sign in button.
Post Condition	-	

Table 26: Use Case Description 15

Appendix Section C.7 - Functional Requirements

Requirements list		Priority Level	Description
FR1	Monitor any Facial Drowsiness State	Required	The IoT system should be able to monitor any drowsy state detected from the driver.
FR2	Monitor the Eye Posture of the Driver	Required	The IoT system should be able to monitor the posture of the eye,

			whether the eyes of the driver are half or full closed.
FR3	Monitor the Heart Rate of the Driver	Required	The IoT System should monitor the Heart rate of the driver every moment.
FR4	Sound an alarm whenever a drowsiness state is detected.	Required	The IoT system should sound an alarm whenever a drowsiness state is being detected.
FR5	Suggest Nearby resting places to rest	Desirable	The IoT system should show nearby Resting places for the driver to rest after alerting the driver's drowsiness state.
FR6	Show the Shortest Route for the driver to his Final destination	Desirable	The IoT system should show the shortest route for the driver to reach his destination safely and in short, a time.

Table 27: Functional requirements

Appendix Section C.8 - Non-functional Requirements

Requirements List		Priority Level	Description
NFR1	Performance	Required	The IoT system should run at a reasonable speed without slowing down in a way that could harm the user experience
NFR2	Security	Required	The IoT system must always maintain the confidentiality of data obtained from the user
NFR3	Reliability	Required	The IoT system should perform reliably without crashing and should be reliable to the drivers to use
NFR4	Accuracy	Required	The IoT system should alert the driver if and only if the driver is drowsy. It should not alarm the driver if he is not showing any symptoms of drowsiness
NFR5	Extensibility	Required	The IoT system should maintain the scalability and it should be easy to maintain in future

NFR6	Usability	Desirable	The system should provide user friendly and easy to understand interfaces when interacting with the user

Table 28: Non-Functional requirements

Appendix Section D - Design

Appendix Section D.1 – Wireframes

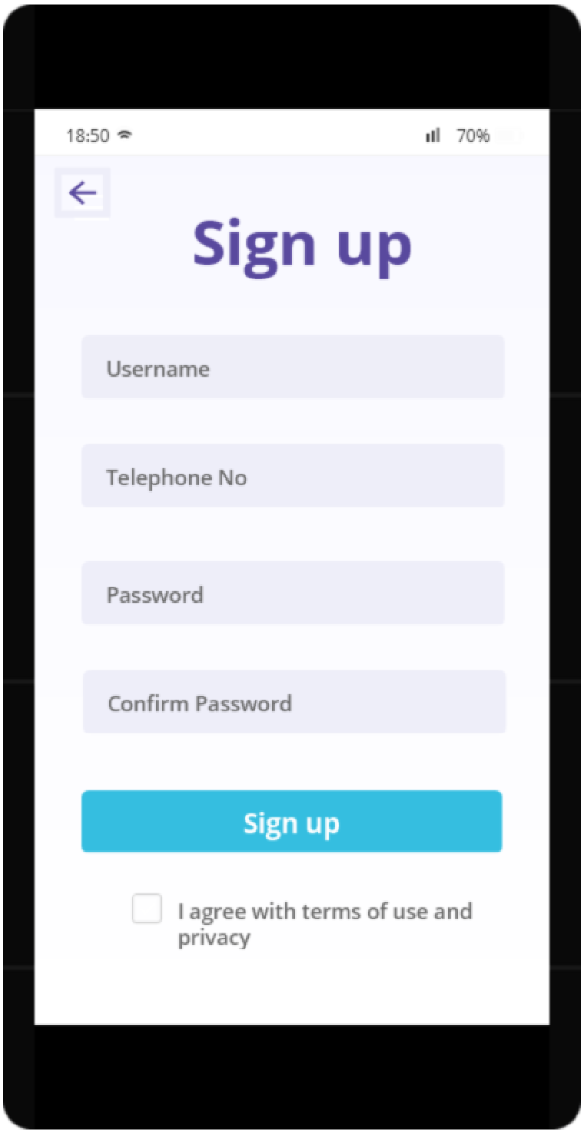


Figure 24: Sign up Page

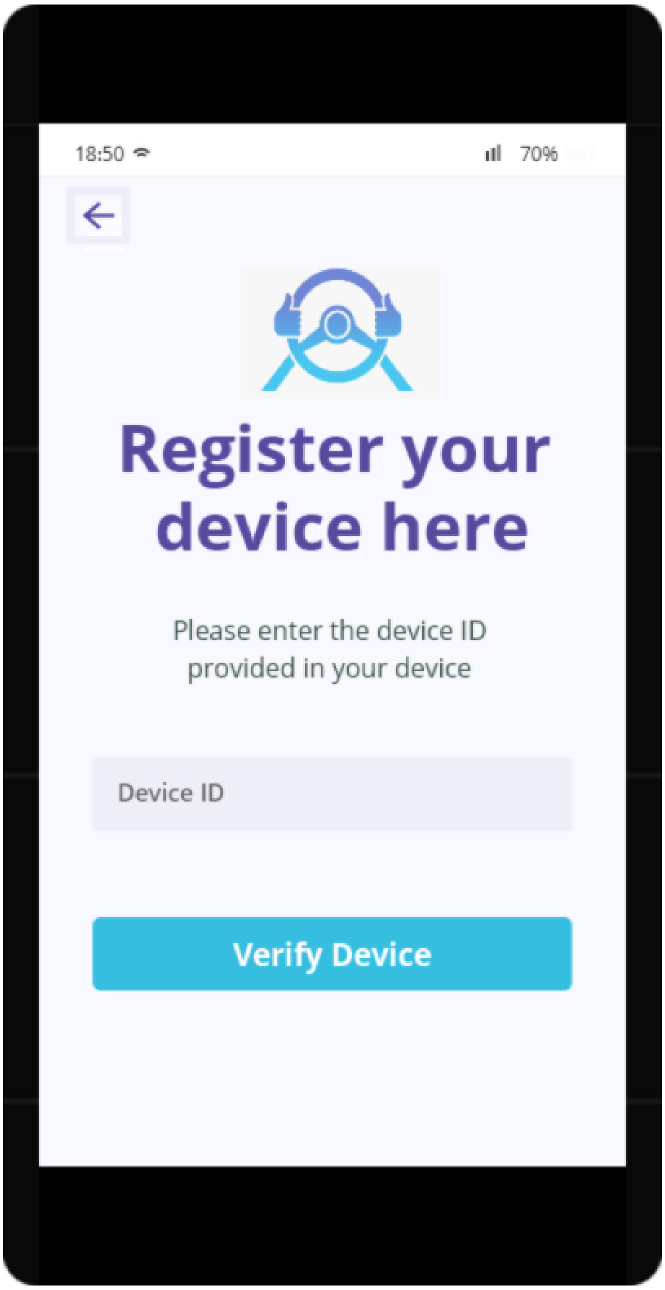


Figure 25: Device Verification Page

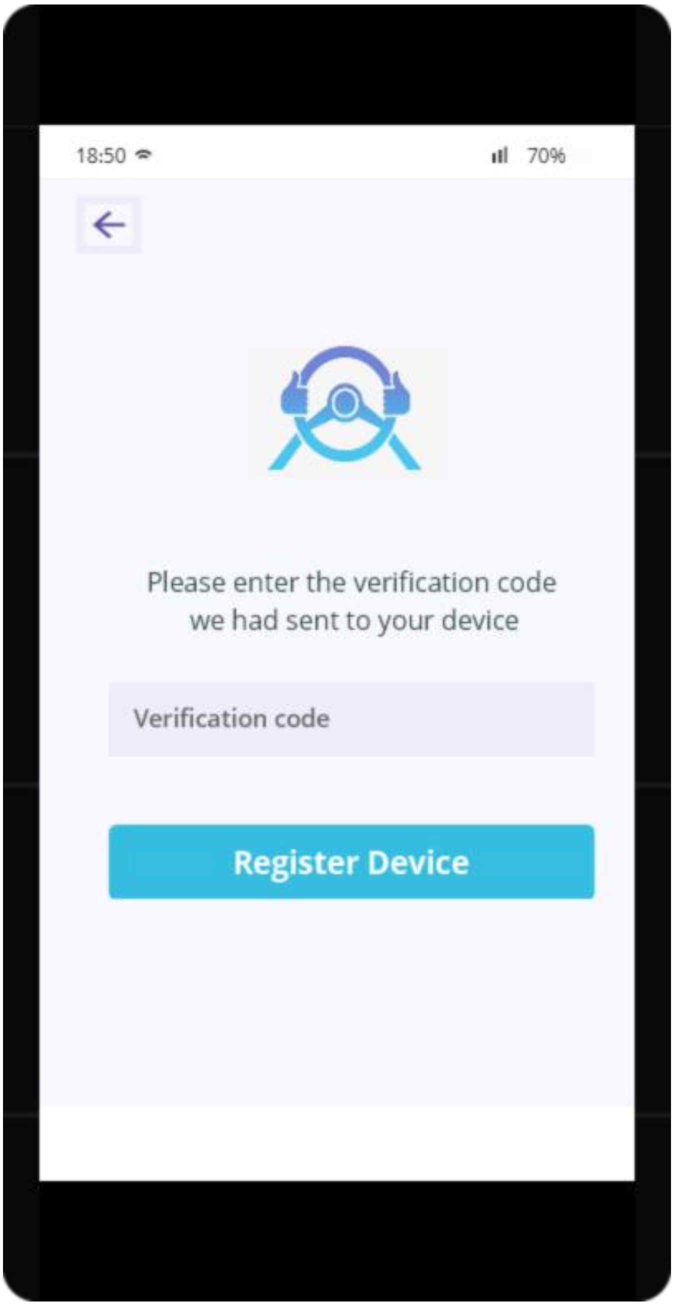


Figure 26: Device Registration Page

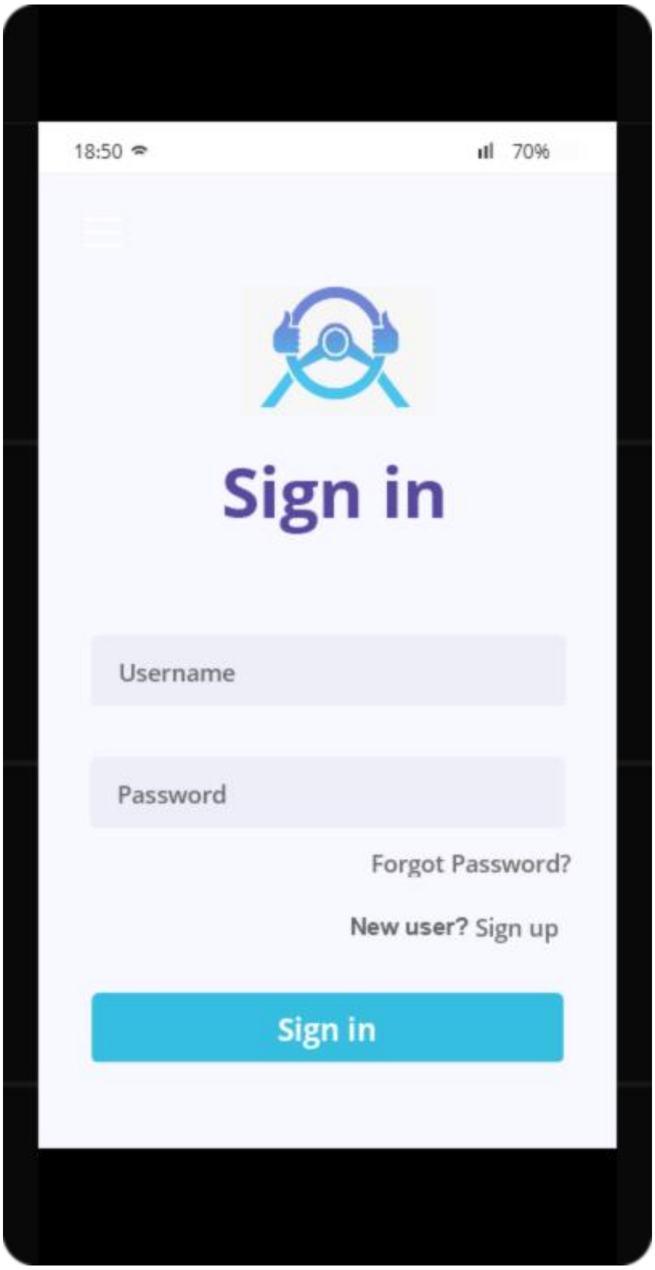


Figure 27: Sign in Page

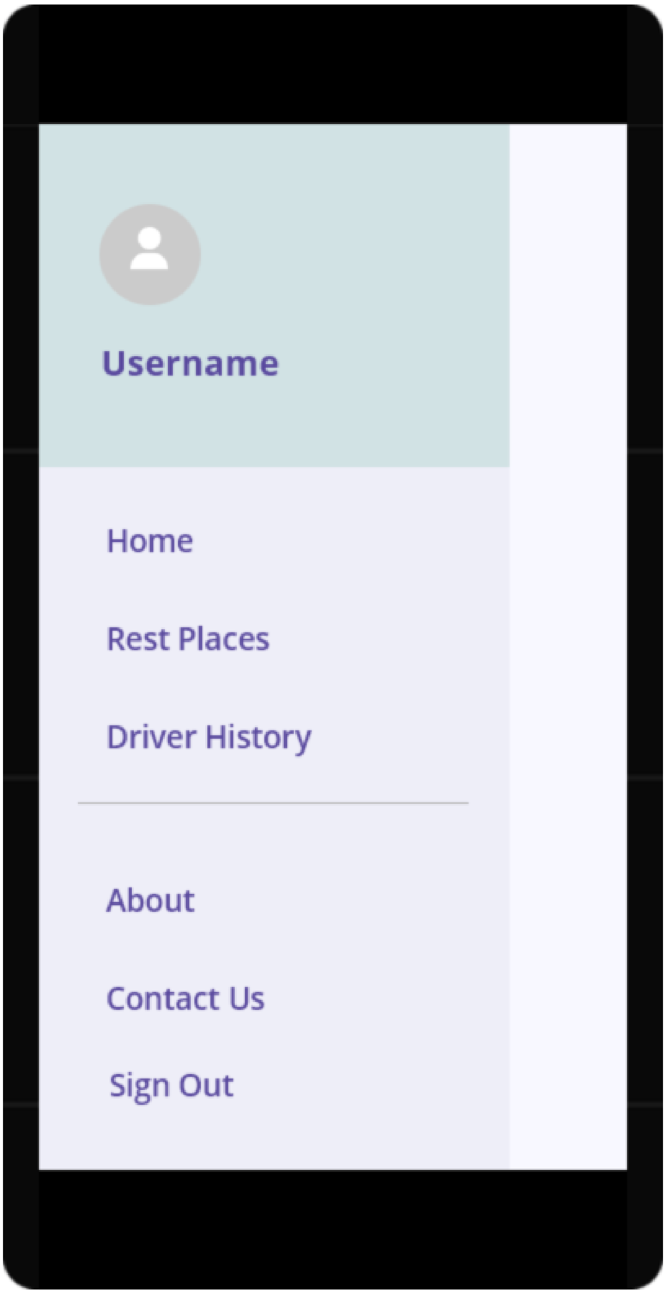


Figure 28: Menu

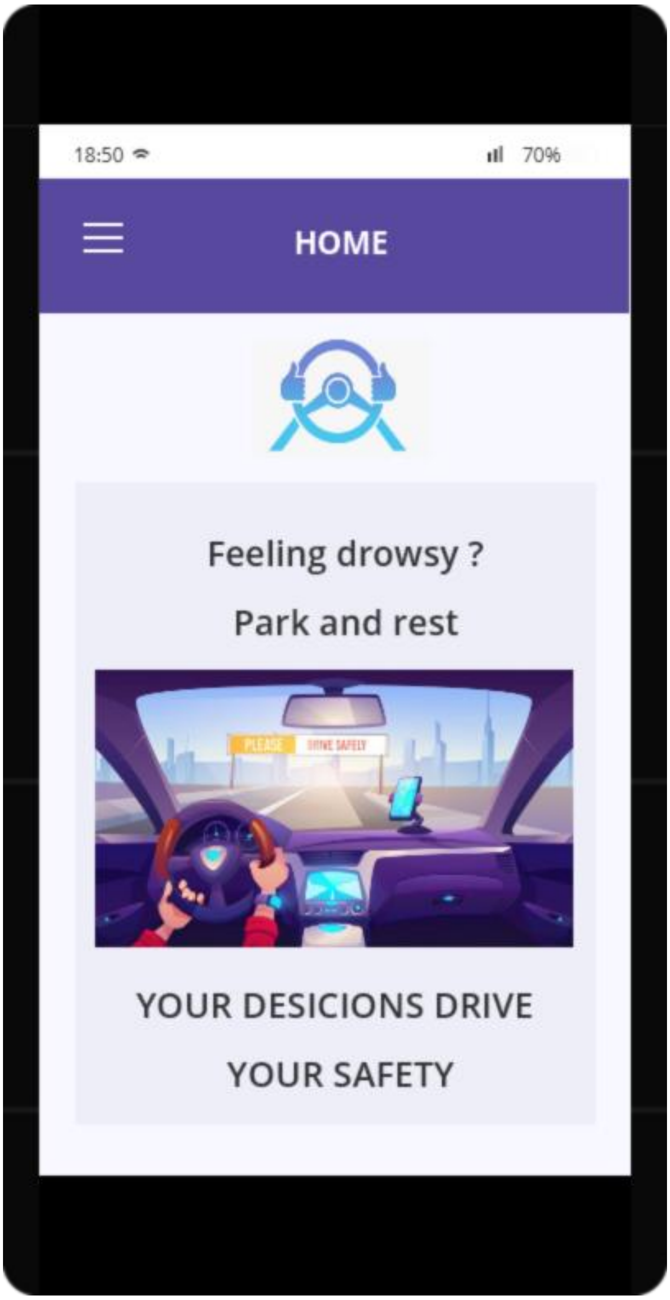


Figure 29: Home Page

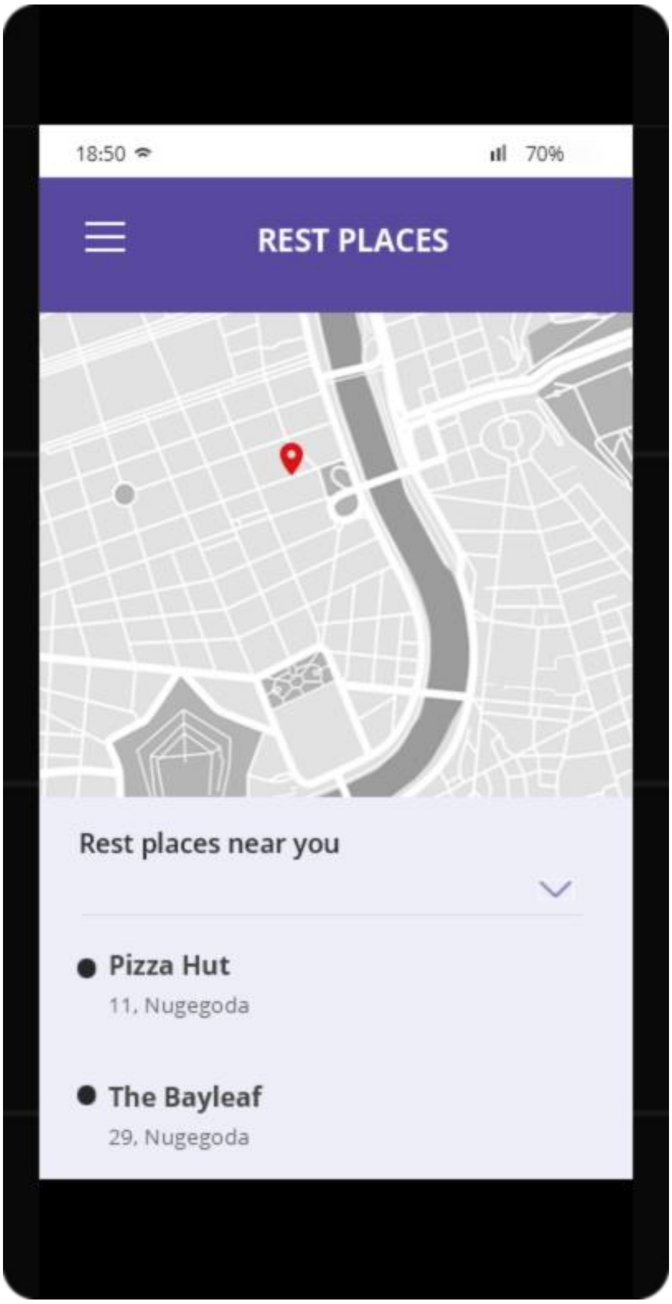


Figure 30: Rest Places Page

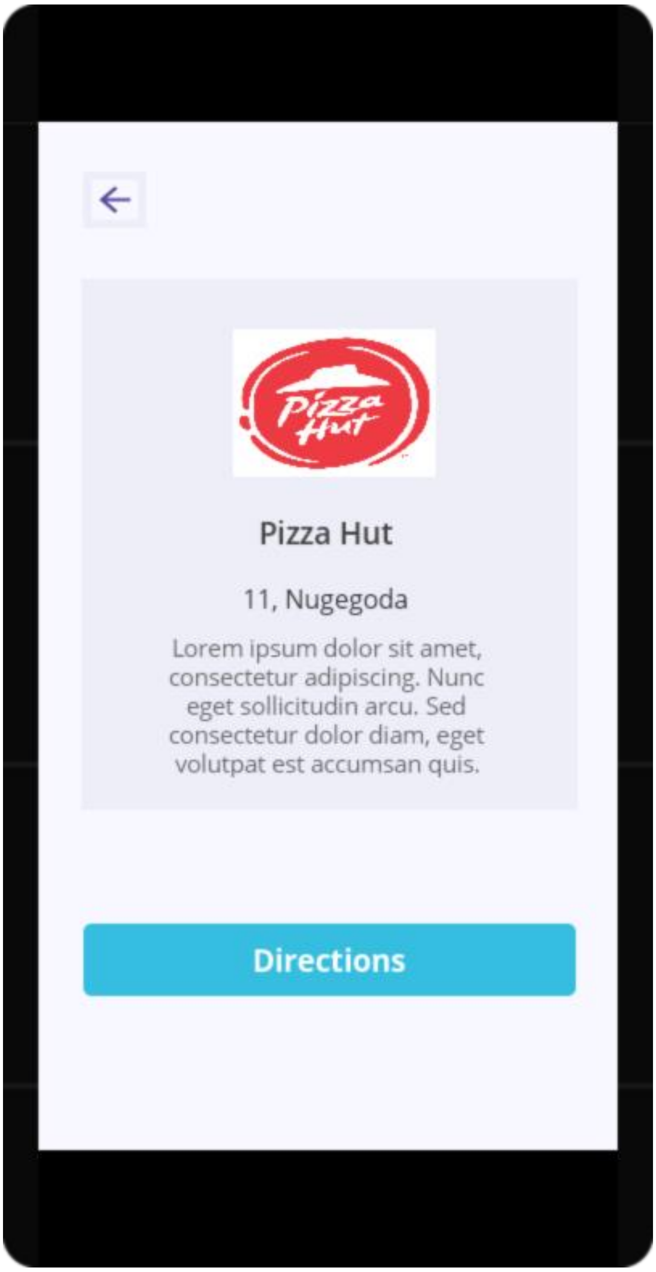


Figure 31: Rest Place Description Page

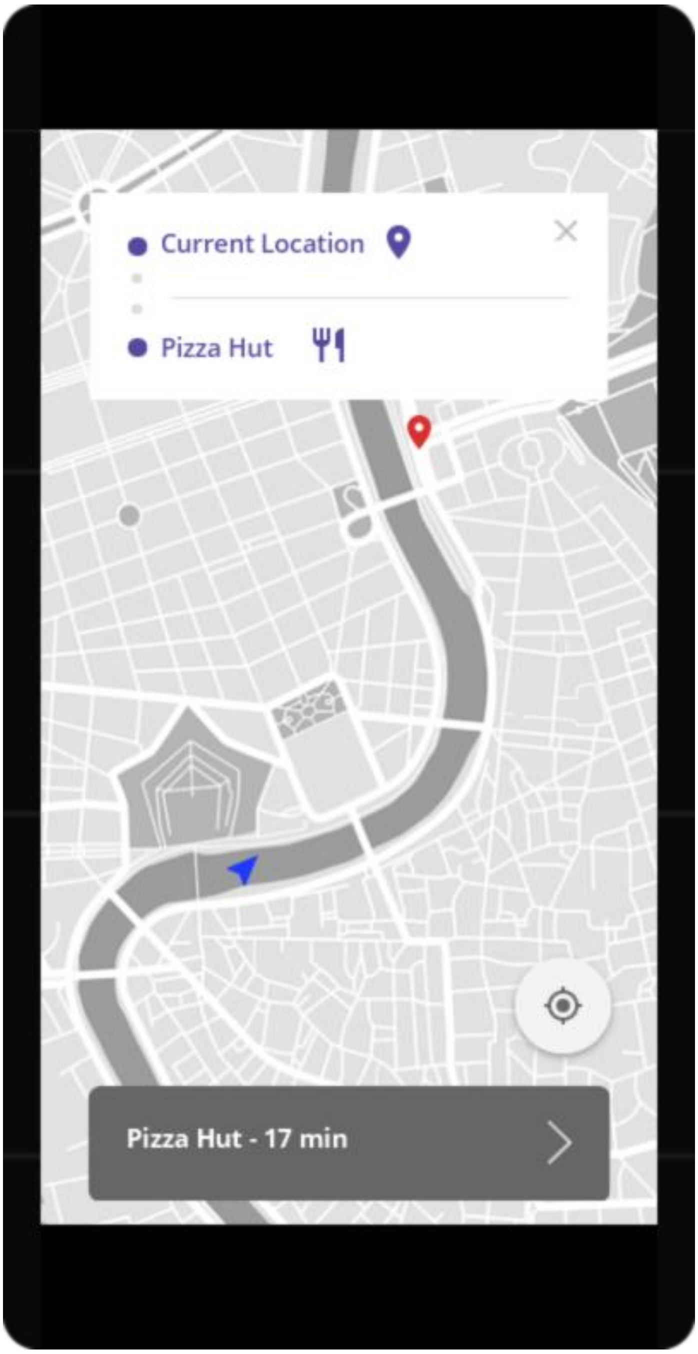


Figure 32: Rest Place Directions Page

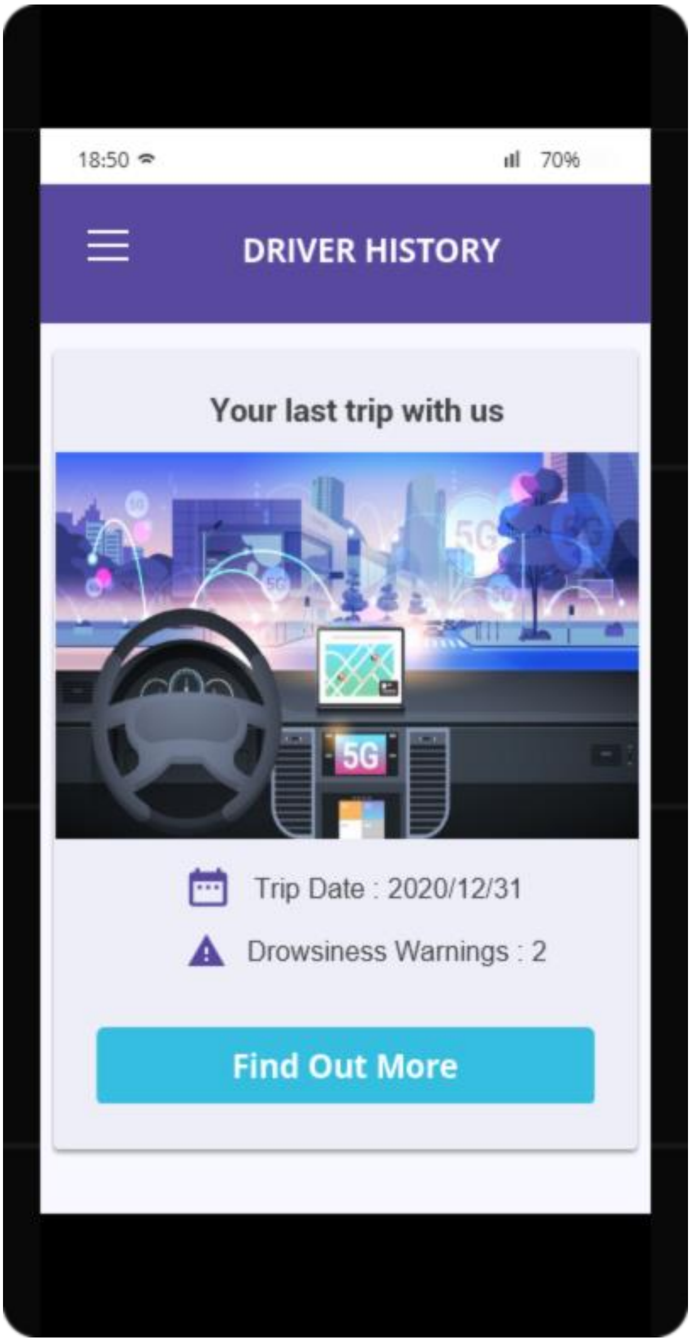


Figure 33: Driver History Page

Figure 34: Driver History Statistics Page

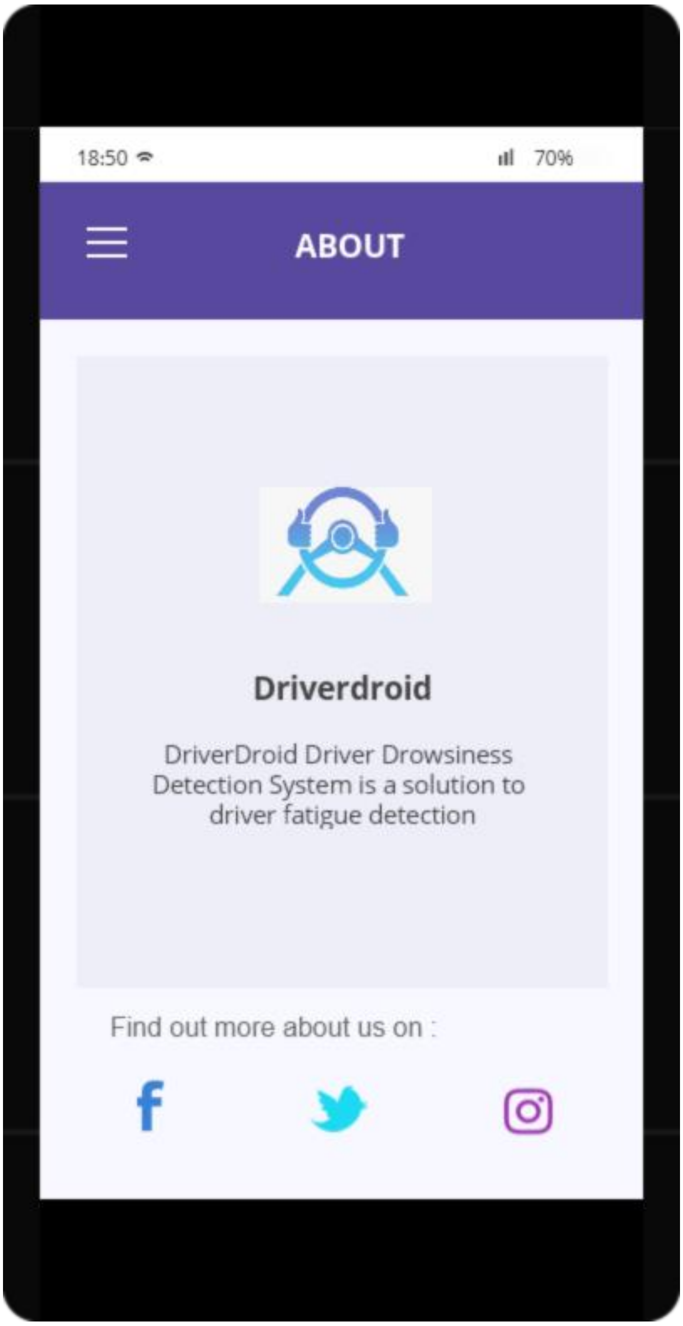


Figure 35: About Page

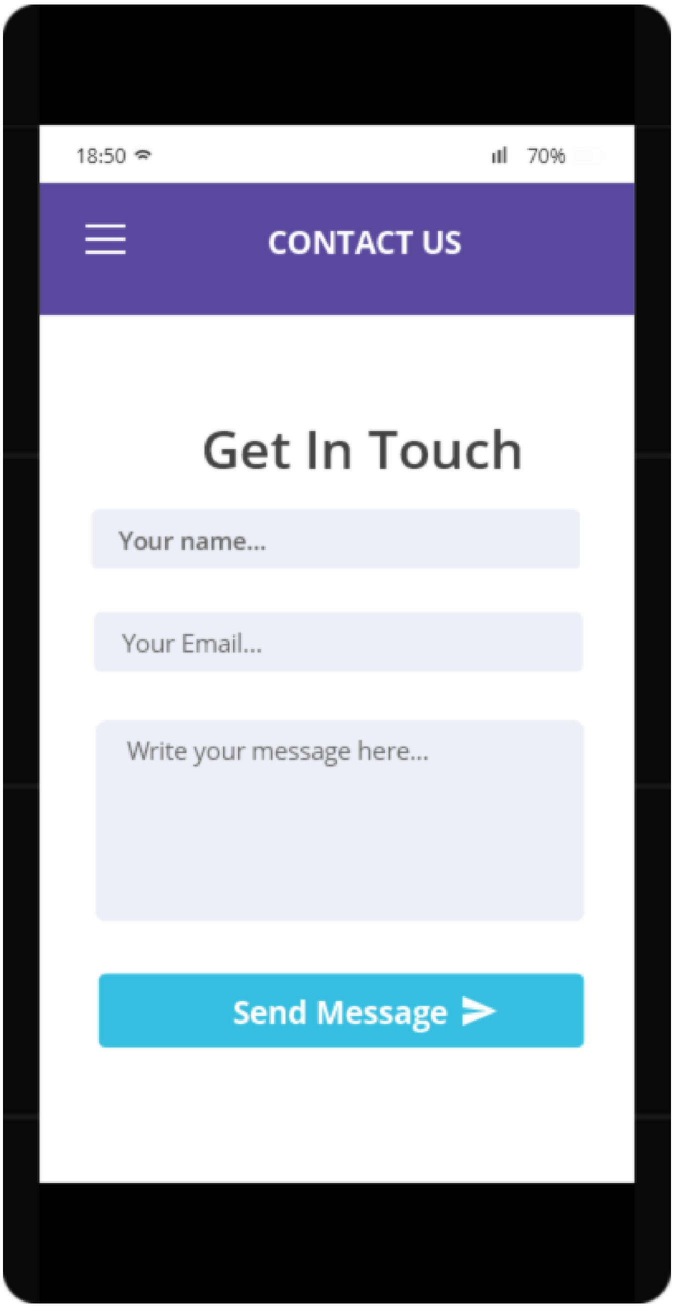


Figure 36: Contact Us Page

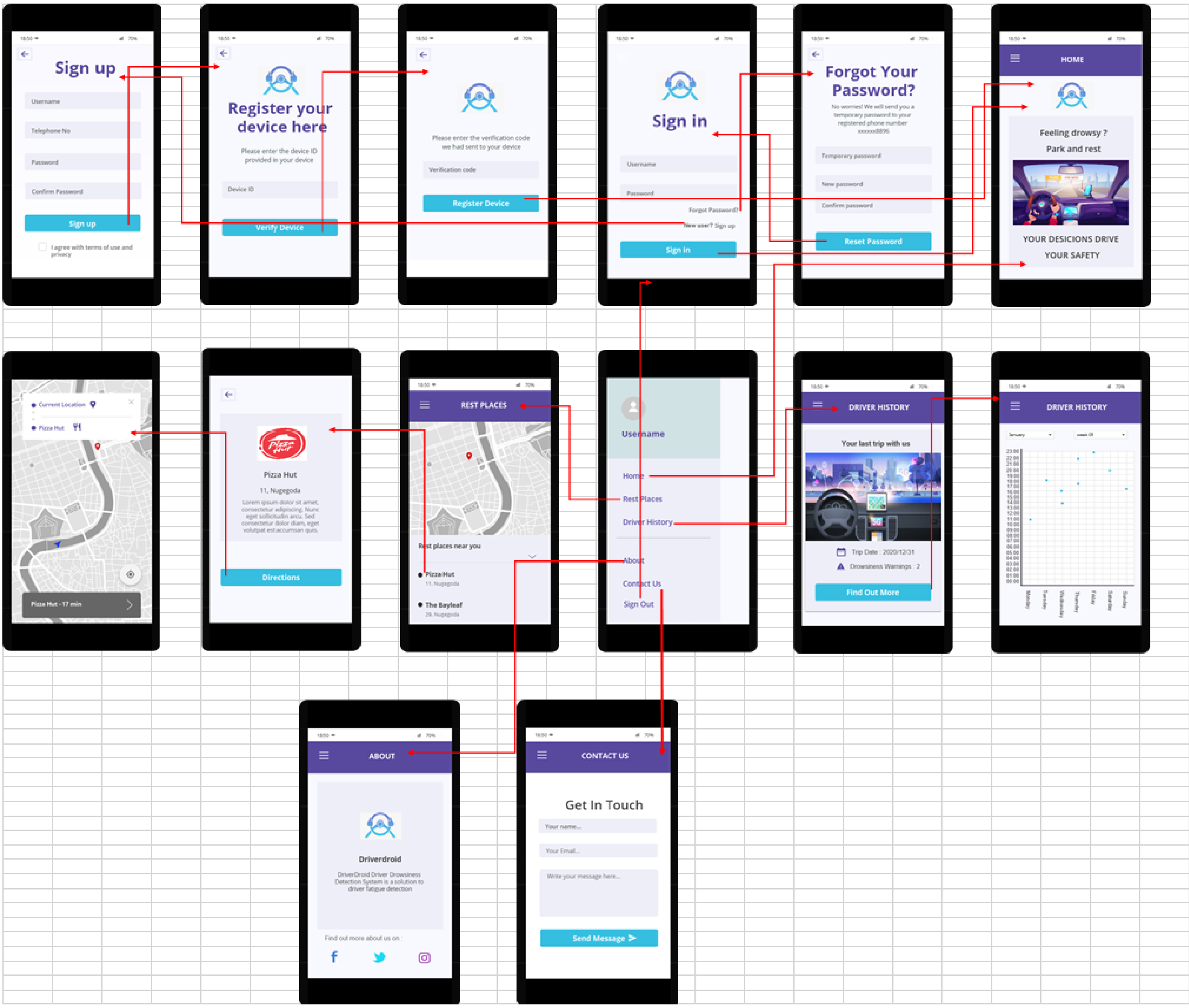


Figure 37: Mobile Application Navigation

Mobile Application Navigation chart:
https://drive.google.com/file/d/1KPoSs1zShikibtDUrDOkuxm7OMTh-3QX/view?usp=sharing

Team Contribution on the Report

Chapter 1 - Introduction

1.1 Chapter Overview - Rusiru

1.2 Project Background - Dilanka
 1.2.1 Introduction to problem
  1.2.1.1 Problem boundary
  1.2.1.2 Examples in the problem
  1.2.1.3 Attempted solutions of the Competitors - Sanduni
 1.2.2 Problem definition
 1.2.3 Research questions

1.3 Aim - Geethika

1.4 Scope - Odhil
 1.4.1 In-Scope
 1.4.2 Out of scope

1.5 Objectives - Rusiru
 1.5.1 Research Objectives
 1.5.2 Academic Objectives
 1.5.3 Operational Objectives

1.6 Proposed Solution - Geethika, Sanduni
 1.6.1 Rich picture diagram
 1.6.2 Features of the prototype

1.7 Resource Requirements - Odhil, Ravindu
 1.7.1 Hardware requirements
 1.7.2 Software requirements
 1.7.3 Technology stack

1.8 Chapter Summary - Odhil

Chapter 2 - Literature Review

2.1 Chapter Overview - Dilanka

2.2 Project Domain – Odhil

2.3 Technological Review - Ravindu

2.4 Previous work related to the project domain - Ravindu

 2.4.1 Similar products

2.5 Research based on the Project domain - Geethika

2.6 Chapter Summary - Dilanka

Chapter 3 - Project Management

3.1 Chapter Overview - Odhil

3.2 Methodologies - Odhil, Ravindu

3.3 Risks and mitigations - Dilanka

3.4 Activity Schedule - Odhil

3.5 Work breakdown structure - Geethika

3.6 Gantt chart diagram - Sanduni

3.7 Chapter Summary - Rusiru

Chapter 4 - System Requirements Specification

4.1 Chapter Overview - Odhil

4.2 Stakeholder analysis - Ravindu
    4.2.1 Onion model
    4.2.2 Stakeholder descriptions

4.3 Requirements gathering - Sanduni
    4.3.1 Techniques for requirements gathering
    4.3.2 Questionnaire design

4.4 Analysis of gathered data - Sanduni

4.5 Models - Dilanka
    4.5.1 Use case diagram
    4.5.2 Use case description
    4.5.3 Domain Model - team

4.6 Functional requirements - Odhil

4.7 Non-Functional requirements - Geethika

4.8 Chapter Summary - Rusiru

Chapter 5 – Design

5.1 Chapter Overview - Odhil

5.2 High-Level architecture Diagram - Ravindu

5.3 Class Diagram - Odhil

5.4 Sequence Diagram - Dilanka

5.5 Activity Diagram - Rusiru

5.6 Wireframes – Sanduni, Geethika

5.7 Chapter Summary - Odhil

Chapter 6 - Conclusion

6.1 Chapter Overview - Dilanka

6.2 Dataset - Ravindu, Odhil

6.3 Legal, social, ethical, and professional issues – Sanduni, Geethika

6.3.1 Legal

6.3.2 Social

6.3.3 Ethical

6.3.4 Professional

6.4 Plans for implementation - Rusiru