Raspberry Pi based Cyber Physical System for Driver Monitoring

BY

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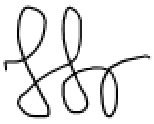

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I would like to express my sincere thanks and appreciation to my supervisor, Mr Teoh Shen Khang who has gave and provided opinions to me in choosing and testing components. Other than that, he has guided me in designing the PCB board by using the EAGLE software. Furthermore, he has also guided on the software part. Thank you very much.

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ABSTRACT

Nowadays, the rate of accident in Malaysia is very high. There are many factors cause the accident happened but the factor that focused on this project is the drunkenness and drowsiness of the driver. To decrease the accident rate, driver monitoring system is planned to develop in this project. The driver monitoring system is used to monitor the situation of the driver throughout the whole driving journey and reduce the occurrence of accident. The driver monitoring system contained driver authentication and monitoring functions. The microcontroller used in the driver monitoring system is Raspberry Pi 4 Model B. The camera in the system will identify and authenticate the driver before drive the car and monitor the driver. The system will produce action to notify the driver is not suitable to drive in the current situation like display warning messages on the screen, give alert for pilot and co-pilot and so on when it detects the eyes of driver closed over 4 seconds or sensed the alcohol is over 800ppm from the gas sensor. An internet connection is available on the driving monitoring system, and it can build a connection with the car owner through Telegram and Ubidots.

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LIST OF SYMBOLS

°C	Degree Celsius
%	Percentage

LIST OF ABBREVIATIONS

BAC	Blood Alcohol Consumption
GSM	Global System for Mobile Communication
GPS	Global Positioning System
ADC	Analog to Digital Converter
PCB	Printed Circuit Board
GPIO	General-Purpose Input/Output
HDMI	High-Definition Multimedia Interface
VGA	Video Graphics Array
OLED	Organic Light-Emitting Diode

Chapter 1
Introduction

In this project, we are aimed to build a driver monitoring system to monitor the situation of the driver whether he or she is in the drunkenness or tiredness condition. In addition, the driver monitoring system also used for decreasing the rate of road accident.

1.1 Problem Statement and Motivation

In Malaysia, it is very common that each household own a car or more. According to the research done by Malaysiakini [1], there are 93% household have a car in Malaysia. This causes the number of cars increased on the road and lead to the rate of accident increased. Based on the statistic from the Ministry of Transport Malaysia [2] in Figure 1.1, the number of road accident increased from 414,21 to 567,516 in year 2010 to 2020. In the accident, some people suffered minor injured, and some caused life in the worst. Every day in Malaysia, there are around 18 people lose their life in the accident according to data provided from the Ministry of Transport Malaysia [3]. There are many causes of road accident like car unmaintained regularly, running the red light, lane changing without putting the signals, speeding, did not focus while driving like using smartphone and so on. But there is a one root cause of accident that need to be focused is the driver which in the drowsy and drunk condition. Drive in drunk condition is one of the hot topics in Malaysia. Many drivers think that it should not be a problem to drive after drinking alcohol. The driver will enter drunk condition when the blood alcohol consumption (BAC) level is over 0.08% or above [4]. Rendering to Malay Mail [5], there are total of 2281 people involved in drunk driving accident from year 2010 to 2018 in Malaysia. From the figure 1.2, there are 539 people suffered from seriously injured, 595 people suffered from minor injured and 1147 people death in the drunk driving accident from year 2010 to 2018 in Malaysia. Moreover, the factor which lead the driver in drowsiness condition is lack of sleep or drive in night/midnight. In this project, the drowsiness and drunkenness condition of the driver can be decreased and dwindled the rate of accident by implementing the driving monitoring system into the car.

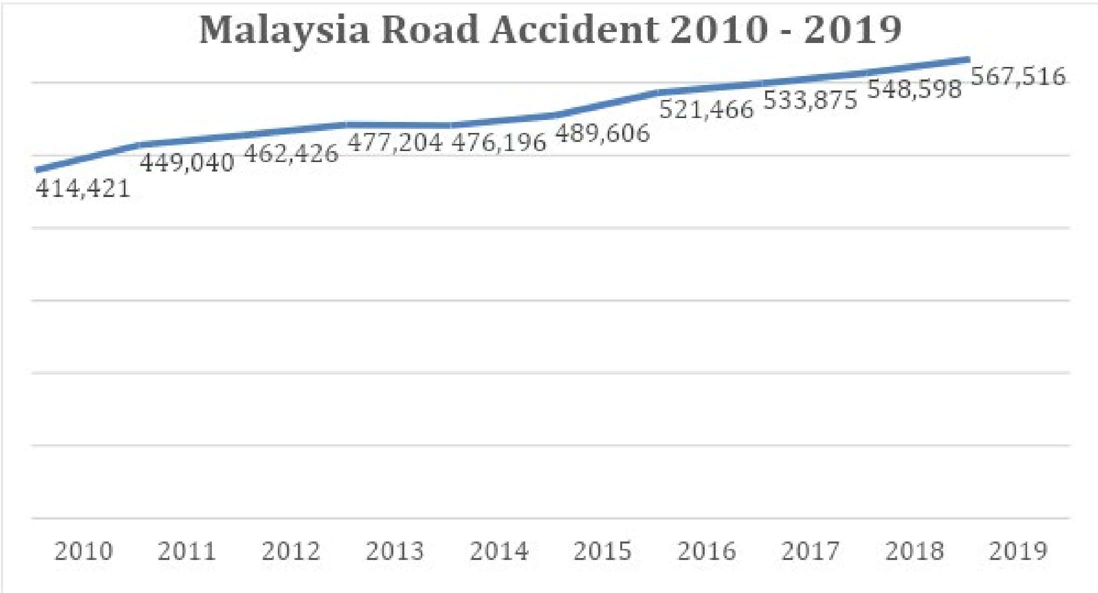


Figure 1.1: Statistical graph of Malaysia Road Accident from 2010 to 2019.

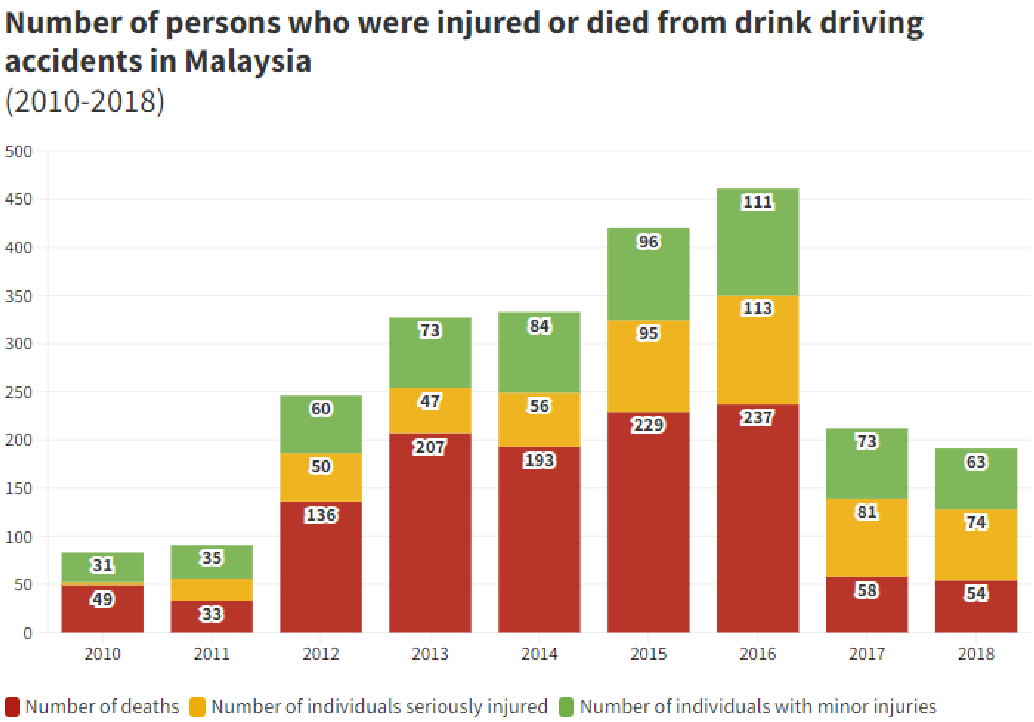


Figure 1.2: Histogram of number of persons who were injured or died from drink driving accidents in Malaysia from 2010 to 2018.

1.1.1 Problem Statement

Although there are many driver monitoring systems is available in this world, the accident rate is not decreased. Based on the previous version of the driver monitoring system that built before, there have some problems on it.

Some of the driver monitoring system is lack of the authentication for the driver. The driver authentication function is very important for the system because instead of identifying the driver and the system can prevent unknown people to drive the car which result in decrease of car stolen cases.

Furthermore, there are several driver monitoring systems is lack of gas sensor and it determines the driver is in drunk condition by monitoring the driver's eyes only. However, some of the drunk driver did not close their eyes frequently which made the systems is allowed the driver to drive in drunk condition. Gas sensor is very important component for the system which plays an important role in the system that used for sensing the alcohol.

Other than that, some of the system used the low-quality camera which cannot monitor the driver accurately. Low quality camera caused the system to determine the wrong result and produce the wrong action to the driver due to the blurry images captured by the camera especially in the dark. Low quality camera will easily be defeated after used for a period and cannot last for a long time due to frequently exposed by the sun particular in the afternoon which result the car has a very high internal temperature.

Moreover, the system built in the driver monitoring system is very simple and buggy. Simple system contains less functions and system failure will often happen due to the bugs that have not solved by the manufacturer. Many manufacturers also did not provide the future system updates to solve the bugs available in the system.

1.1.2 Motivation

The rate of accident is increased year to year due to the irresponsible driver and increase in numbers of car. The rise of road accident is a serious problem to the public in Malaysia. The is because many people have caused life in the road accident. Some of the families have lost their important family members or families' sole income from the road accident and lead life become harder. Furthermore, some people become people with disabilities like lost their legs, hands or so on from the road accident which made them inconvenience and difficult in their daily life. Based on the mentioned situation, it motivates me to develop this project which is a driver monitoring system that can reduce the mentioned situation happen. Moreover, the development of driver monitoring system is also aimed to decrease the accident rate by monitoring the driver's situation.

1.2 Research Objectives

The aim of the project is to build a driving monitoring system for monitoring the driver's situation whether he or she is in drunkenness or drowsiness condition. There are several objectives in this project need to be achieved.

First is the driver authentication. Before driving the car, the driving monitoring system need to capture and analyze the driver's face image. The system will then let the driver to drive the car after successfully analyze the image and authenticate the driver. However, if the driver is not authenticated, the system will send the captured image and alert message to the owner of the car through Telegram. This is used to prevent the unknown people to drive or steal the car.

Second is the monitoring the driver drunkenness and drowsiness. The system determines the driver whether is in the condition of drunkenness or drowsiness by detecting the eyes of the driver. If the driver's eye is closed more than 4 seconds, the system will judge the driver is in the condition of drunkenness or drowsiness and it will display warning messages and send alert to the co-pilot for indicating that the driver is not suitable for driving in current situation.

Third is the alcohol gas detection. When the alcohol gas is sensed by the gas sensor and over the 800ppm, the system will display the warning on the screen to notify the driver is not suitable to drive in this condition and suggest the driver to take a rest or let other people to drive the car. This action is used to avoid the driver drive in drunk condition and dwindle the rate of accident.

Fourth is provide connection between the driving monitoring system and the owner of the car. The internet connection is provided by the dongle with SIM card so that the system can stay connected with the car owner by using Telegram. When the owner of the car needs to know the temperature and humidity inside the car, he or she only needs to enter a command in Telegram, and it will display the value of temperature and humidity. In addition, a Telegram Bot will be created for assisting the driver by providing the commands and perform the functions from the driver's request.

1.3 Project Scope and Direction

In this project, the driver monitoring system is used for monitoring the driver only and avoid the driver to drive in drunkenness and drowsiness condition. The driver monitoring system is only available for car. The other kind of transportation like lorry is not supported by this driver monitoring system. The system also cannot monitor the driver with sunglasses, only can monitor the driver with wearing spectacles or no.

1.4 Contributions

The driver monitoring system able to identify and authenticate the driver before driving the car. If the driver is authenticating unsuccessful, the system will send the captured driver image to the car owner through Telegram. However, the system will continue to monitor the driver’s situation throughout the whole journey after authentication successfully. When the system detected the driver’s eyes closed more than 4 seconds or sensed the alcohol, the system will determine the driver is in drunkenness or drowsiness condition and it will display the warning messages and alert the co-pilot to notice that the driver is not suitable to drive in this situation.

1.5 Report Organization

The information and details are written in the following chapters. In Chapter 2, literature review of a few journals article is conducted for reviewing the previous work done by the authors. The strength and weakness of the previous work is listed down in this chapter too. Besides that, Chapter 3 contained the system architecture diagram for hardware and software. The use case diagram and description are included to explain the use cases of the system. The flow of driver monitoring system is displayed by the flowchart. In Chapter 4, the overall block diagram is attached in this chapter to provide overall view of the hardware in this system. The specification of system components is listed in this chapter. The circuits and components design are included to show the design of PCB for attaching the sensors on it. The connection of sensors to the mainboard is displayed on the system components interaction operations. Furthermore, Chapter 5 contained the hardware and software setup. All the components and sensors are tested to guarantee that they are all working and functioning. The software like Telegram and Ubidots are created and setup completely. In the setting and configuration, the operating system of Raspberry Pi is installed and configured. All the interface of Raspberry Pi is enabled, and the GPU memory is increased for the image processing. After that, the OpenCV library is installed to handle the process of face and eyes detection. The system operation is shown how the system operate it and the screenshots are provided for visualization. The implementation issues and challenges for the system design are listed. For the Chapter 6, system testing, and performance metrics are carried out to test the performance of the system. The image of testing setup is displayed on it and the results are provided for each test cases. The challenges of this project are listed out and the objective evaluation is evaluated in this chapter. Finally, the Chapter 7 is about the conclusion and recommendation of this project.

Chapter 2
Literature Review

2.1 Previous works on Driver Monitoring System

2.1.1 Automotive Driver Monitoring System

According to the driver monitoring system done by S. B. Sneha et al [6], the hardware contained in the system are LPC2148 microcontroller, power supply, gas sensor (MQ3), camera, pulse sensor, GSM, LCD display and buzzer. The languages used for the system are Embedded C and MATLAB. MATLAB is a powerful language which the algorithm is used for facial detection. First and foremost, the camera will start to detect the driver and the alcohol sensor which is MQ3 will sense for alcohol before the driver start to drive the car. If the alcohol sensor sensed the present of alcohol and the alcohol is higher than limited value, the system will cut off the power to prevent the driver for starting the car. The camera also used to detect and track the face of the driver. The system determines the driver is in drowsiness condition by using the eyeblink sensor to monitor the eye blinking rate of the driver. For instance, if the rate of the eyes blink is higher than the threshold set, the system will mark the driver is in drowsiness condition. Other than that, the pulse rate is monitored by using the optical sensor. A threshold is set to measure the heartbeat rate. When the system detected the driver is not suitable for driving, the buzzer will produce an alert as a warning to the driver. Furthermore, the communication is built between the driver and the driver's family by using the GSM module. An alert message will be sent to the driver's family when the system detected the driver is in drowsiness or heart attack.

2.1.2 Driver Monitoring System for Automotive Safety

Based on the research paper [7], the microcontroller connected with few sensors like light sensor and pressure/touch sensors. The pressure sensors are placed on the steering wheel, armrest, and gear knob to detect the driver hands and position. Moreover, the light sensor is placed on the dashboard for the system to determine the daytime or night. This is because driver will be more highly in drowsiness when driving at night. The graphical display is used to display the messages and the buzzer is used to produce the alert. When the driver started to drive, the system will count the driving time. From the research paper, it indicates that driver usually drive less time at night compared to daytime because of driver will enter weak condition in night. The system will notify the driver by sending the alert messages when there are no or at least one sensor not functioning. In addition, the position of the driver will be monitored every second by the pressure sensors. The driver will be warned by produce sound and alert messages from the buzzer and graphical display when the pressure sensors cannot sense the driver hands over 10 seconds.

2.1.3 Sensor Based Health Monitoring System for Driver Using Wireless Communication

Rendering to health monitoring system designed for driver by D. Susitra el at [8], the system is designed for monitoring the health of the driver by using the sensors. It is very important to monitor the driver health condition because several accidents happened due to the driver's health problem and the driving monitoring system is invented for decreasing the rate of accidents. The microcontroller used in this system is Arduino Atmega168. The sensors involved in the system are heartbeat sensor, temperature sensor (LM35), alcohol sensor (MK6), eye blinking sensor and oxygen sensor. First of foremost, the pulse rate of the driver is monitored by the heartbeat sensor. The alcohol sensor (MK6) will play the role to sense the alcohol vapor. Moreover, the eye blinking sensor is used monitored the eye blinking rate. The oxygen sensor is used to measure the percentage of the oxygen. Communication also provided from the GSM and GPS modem which supply the internet and location service. For instance, when the sensors sense the driver's oxygen, pulse rate and temperature of the body is abnormal, the buzzer will produce alert and the system will send alert message to the transport office or their family members. Other than that, the system will proceed the same action when the driver is in drowsiness that detected by the eye blinking sensor, or the gas sensor sense the availability of alcohol vapor.

2.1.4 Driver Monitoring System

According to the research paper [9], the system is built and designed to detect the drowsiness of the driver by monitoring the driver's heartbeat while driving. This is because most of the accident caused is due to the drowsiness of the driver based on the research done by the author. The hardware contained in the system are Arduino Uno, pulse rate sensor with led and piezoelectric buzzer. The Arduino Uno is the microcontroller of the system. The maximum and minimum threshold values of heartbeat are set and configured in the Arduino Uno. Other than that, the pulse rate sensor is attached on the finger of the driver to measure and monitor the heartbeat rate. When the pulse rate sensor sensed the heartbeat is in the range of the threshold value of heartbeat, the system will send a low signal to the buzzer to indicate that the driver is in normal condition. However, when the pulse rate sensor sensed the heartbeat rate is over the threshold value of heartbeat that set in the system, the system will send a high signal to the buzzer for indicating that the driver is in drossiness condition and the buzzer will produce sound for alerting and warning the driver that he or she is not suitable to driver in this moment. Moreover, the pulse rate sensor has a LED, and the LED will light up when the pulse rate is over the threshold value of heartbeat and off when the pulse rate is in the range of threshold value of heartbeat.

2.1.5 IOT Based Driver Drowsiness Detection and Health Monitoring System

Based on the research paper [10], a driving monitoring system is built to decrease the rate of accident. This is because driver drowsiness condition is one of the accidents caused factor. The hardware involved in this system are Raspberry Pi 3, buzzer, GPS, speed limiter, heartbeat sensor, temperature sensor (DHT11), gas sensor (MQ3) and camera. The software used in this system are Python IDE, HTTP and Communication Protocol. The camera in this system play an important role in detecting and tracking the driver while driving. The system predicts the driver is in drowsiness condition by monitoring the eyes of the driver and the threshold value is set in 5 seconds. Other than that, the gas sensor (MQ3) is used to sense the present of alcohol and the heartbeat rate of the driver is monitored through the heartbeat sensor. When the system detected the driver’s eye closed more than 5 seconds, it will send signal to the buzzer to produce sound for warning the driver about not suitable to drive in this condition. This action will wake up the driver and avoid accident. Moreover, when the system detected the present of alcohol gas, the speed limiter will decrease the speed of the car to prevent the driver speeding in drunkenness condition. In the worst-case accident happened, the GPS able to provide current and accurate location of the accident and the data collected will be send to the server for contacting the driver’s family or friends which resulted convenient for them to locate it.

2.1.6 IOT Real-Time Drowsiness System for Driver Monitoring

Rendering to the research done by M Arunasalam [11], a driver monitoring system is designed and built to monitor the driver and avoid accident happen. This is because accident can cause people fall in injuries and cause life in the worst condition. Some of the people may lose some of the body parts in the accident which lead them inconvenient in their life. The hardware involved in this system are Arduino Mega 2560, eyeblink sensor, heartbeat sensor, LCD, buzzer, GPS module, GSM module, and dc motor. The threshold values of eye blink rate and heartbeat rate is set and configured in the system. The eyeblink sensors is attached on the glasses of the driver which lead to more accurate in measure the eye blink rate. When the system detected the values of eye blink rate and heartbeat rate are fall over or under the threshold values, the system will send the signal to the buzzer and lcd for producing sound and displaying warning message on the lcd to alert and warn the driver. Moreover, the system will control the dc motor to slow down the car until the car stop to ensure the driver safety. The communication function is available in this system which the GSM module and GPS module send the current location and SOS message to the driver's family or friends to contact them about the driver is in drowsiness condition.

2.2 Strengths and Weakness

2.2.1 Strengths

From the previous studies of the driver monitoring systems, there are some strengths that contained on the system.

First and foremost, some of the driver monitoring system has a pulse rate sensor. The pulse rate sensor able to monitor the heartbeat rate of the driver while driving. A threshold value of heartbeat can be set which act as standard value for monitoring the driver. Other than monitor the eyes of the driver, it can also assist the system to produce more accurate prediction on the driver. It can determine the driver is in drowsiness condition when the heartbeat rate of the driver is fall over or above the threshold values.

Second, GPS module is included in some of the driver monitoring system. GPS module is playing an important role in providing location. GPS module able to provide the most accurate current location to other people. From the research paper [], the driver monitoring system able to send the current location and message to the driver's family or friends to notify them the driver is in drowsiness condition. Furthermore, it can also provide location for rescuer to save people who cause in the accident and save their time to locate the place of the accident.

2.2.2 Weakness

From the previous studies of the driver monitoring systems, there are some function and components that did not included in the system.

First and foremost, the eye blinking rate of the driver is monitored by the driver monitoring system from S. B. Sneha et al [6]. The eye blinking rate cannot determine the drowsiness and drunkenness of the driver accurately. This is because when the drivers enter the drowsiness and drunkenness condition, their eyes will be closed and not increase the eye blinking rate. Based on the research done by Miah, if the driver falls into the drowsiness condition, the drivers' eyes blinking rate will be reduced, and their eyes will enter the closed state.

Second, a camera is not included in the driver monitoring system done by Lörincz, A E el at [7] and research paper [9]. This led to the system unable to monitor the driver while driving. A camera is used to detect and monitor the eyes of the driver which is an essential function for the driver monitoring system. Other than that, the system cannot detect the drunkenness of the driver because gas sensor is not contained in the system. The internet connection is also not provided to the system for transmitting the data.

Lastly, there is no face recognition from the six reviewed systems [6], [7], [8], [9], [10], and [11]. The face recognition is very important for the system. This is because it can authenticate the driver to prevent someone to steal the car and decrease the car stolen cases. Furthermore, there is also a lack of communication between the car and the owner of the car. A communication is needed between the car and the owner of the car because it can let the car owner know about the condition inside the car in anytime.

Chapter 3

System Methodology/Approach

3.1 System Design Diagram/Equation

3.1.1 System Architecture Diagram

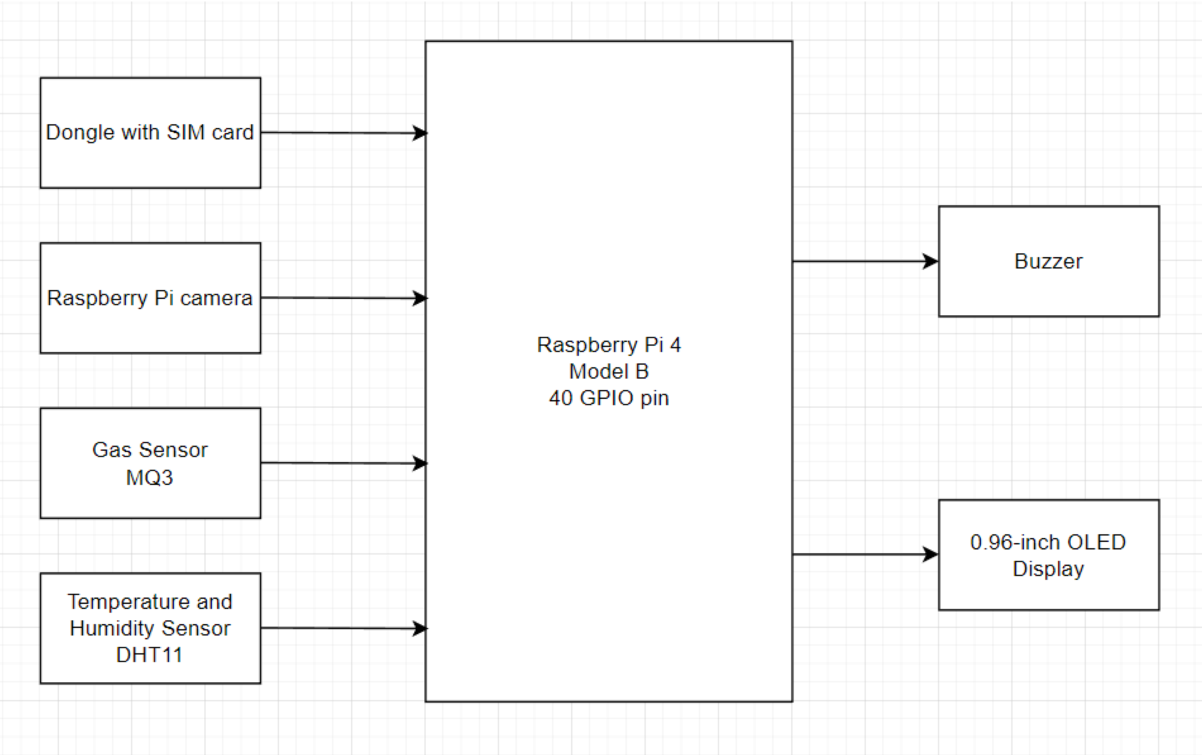


Figure 3.1.1 System Architecture Diagram for the Whole System.

Figure 3.1.1 is the overall block diagram of the system. The mainboard which is the Raspberry Pi 4 model B contained total 40 pins for GPIO and all the components and sensors like Raspberry Pi camera, Gas Sensor (MQ135), Temperature and Humidity Sensor (DHT11), Buzzer and 0.96-inch OLED Display are attached to them. The Raspberry Pi camera, Gas Sensor (MQ135) and Temperature and Humidity Sensor (DHT11) will collect data and input to the mainboard. After received the data, the mainboard will send the signals to the buzzer and display information on the 0.96-inch OLED display. The dongle with SIM card will supply the internet connection for the mainboard for connectivity. The dongle with SIM card also can be replaced by mobile hotspot in some cases.

3.1.2 Use Case Diagram and Description

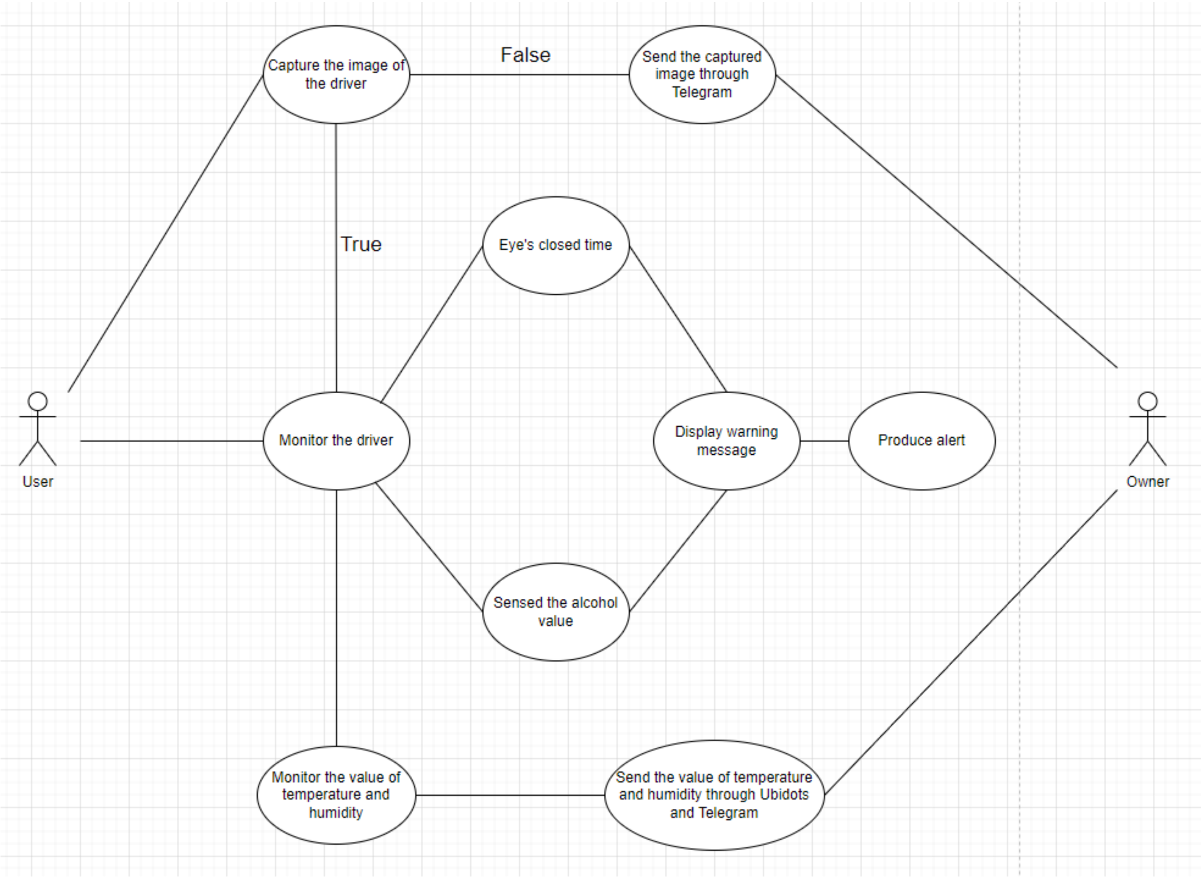


Figure 3.1.2 Use Case Diagram.

Figure 3.1.2 is the figure of the use case diagram. Based on the figure above, there are 3 use cases which is started from capture the user face, sensed the driver's alcohol value, and monitor the value of temperature and humidity. First and foremost is the capture the image of driver. If the driver is authenticated failed, the system will send the image of the driver to the car owner through Telegram. However, if the driver is authenticated successfully, the system will continue to monitor the driver about the alcohol value and eye's closed time throughout the whole journey. The system will display the warning message on the 0.96-inch OLED display and produce alert by using buzzer when it sensed the alcohol value reached the threshold or the driver's eyes closed more than 4 seconds. Second is the sensed the driver's alcohol value. If the system sensed the alcohol value reached the threshold at the beginning, the system will display the warning message on the 0.96-inch OLED display and produce alert by using buzzer. Third is monitoring the value of temperature and humidity. The car owner able to know the value of temperature and humidity by Telegram and Ubidots. For case in the Telegram, the car owner will receive the temperature and humidity values by sending the commands of /temperature and /humidity in the Telegram. For the case in Ubidots, the car owner can view the values of temperature and humidity in the Ubidots website or Ubidots android application.

3.1.3 Activity Diagram

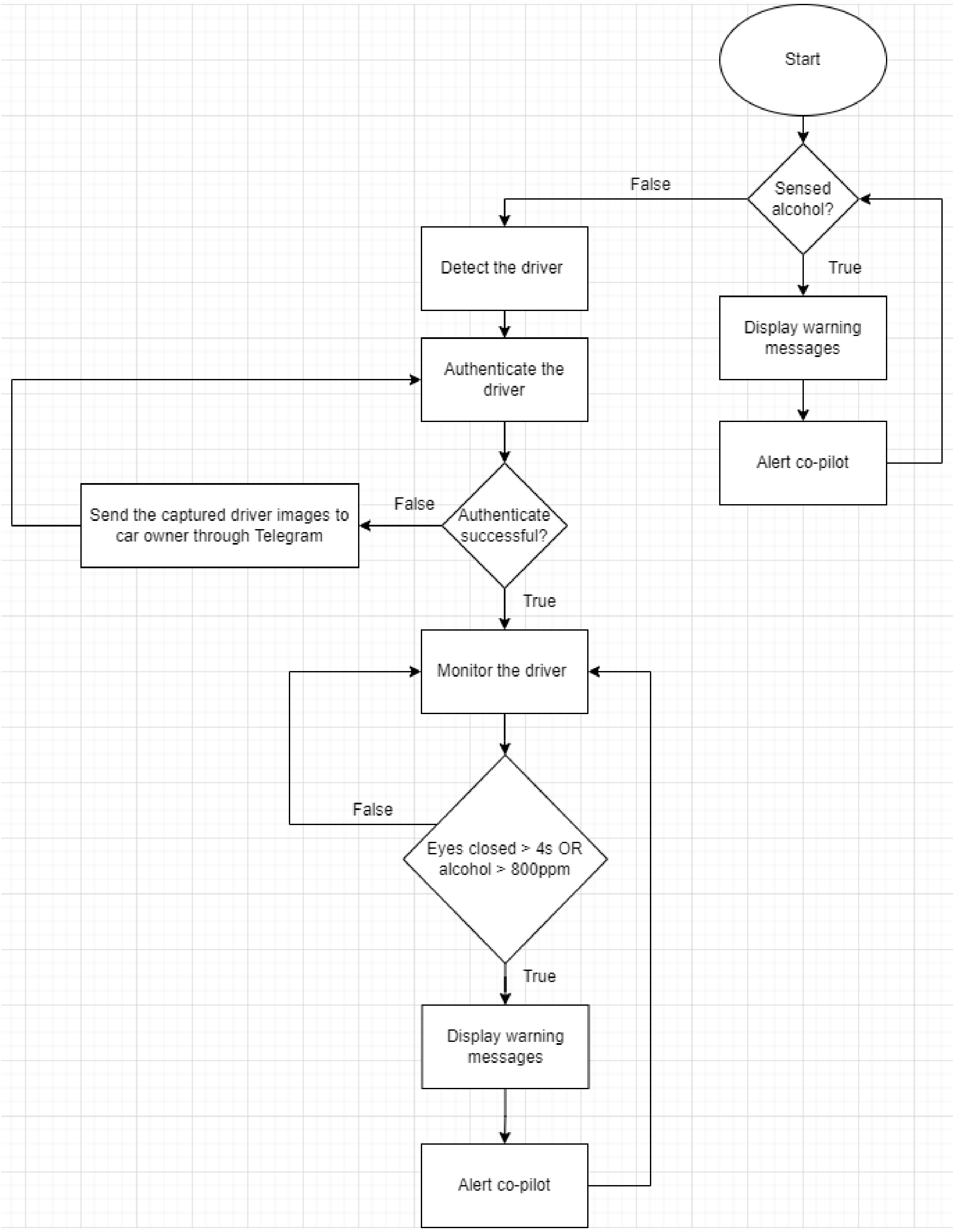


Figure 3.1.3 Activity Diagram

Chapter 4
System Design

4.1 System Block Diagram

4.1.1 Block Diagram for hardware architecture

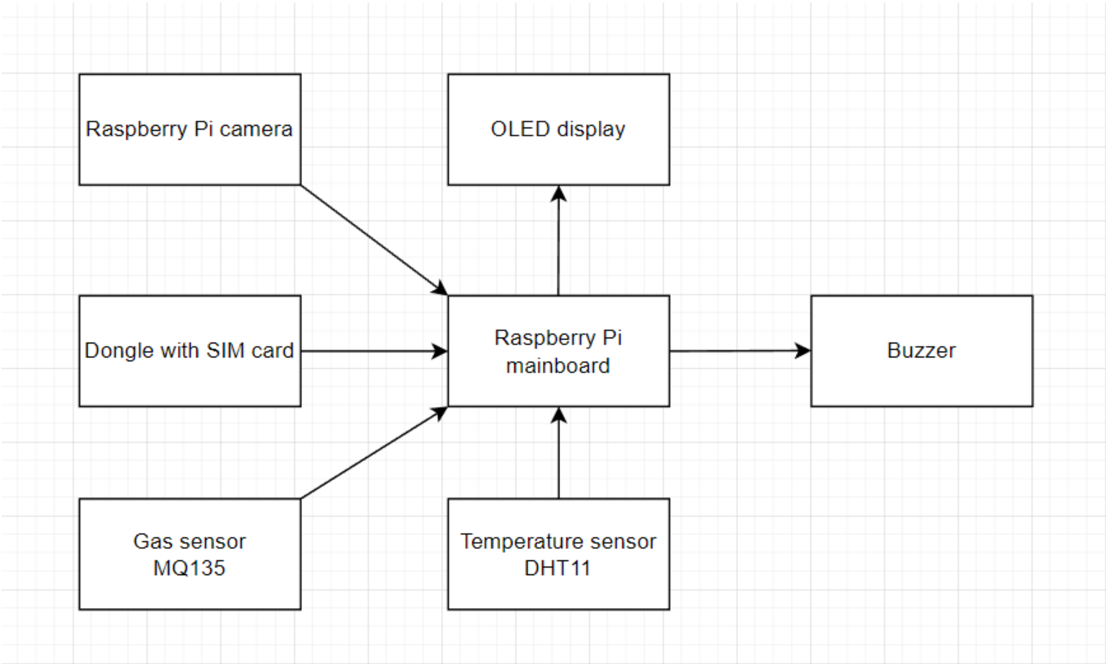


Figure 4.1.1: Block Diagram for Hardware Architecture.

4.1.1.1 Description for hardware architecture

First, the Raspberry Pi mainboard is acted as 'brain' or 'master' in this system which used to control the whole system operation. Second, the Raspberry Pi camera is used to detect and monitor the face of the driver. Third, the Internet connection is provided for the system from the dongle with SIM card. Fourth, the gas sensor (MQ135) is used to detect and sense the alcohol. Fifth, the temperature sensor (DHT11) is used to measure the temperature and humidity. Sixth, the buzzer is used to alert the co-pilot when the system detected the driver is not suitable to drive in the current situation. Seventh, the OLED display is used to display the messages for the driver.

4.1.2 Block Diagram for software architecture

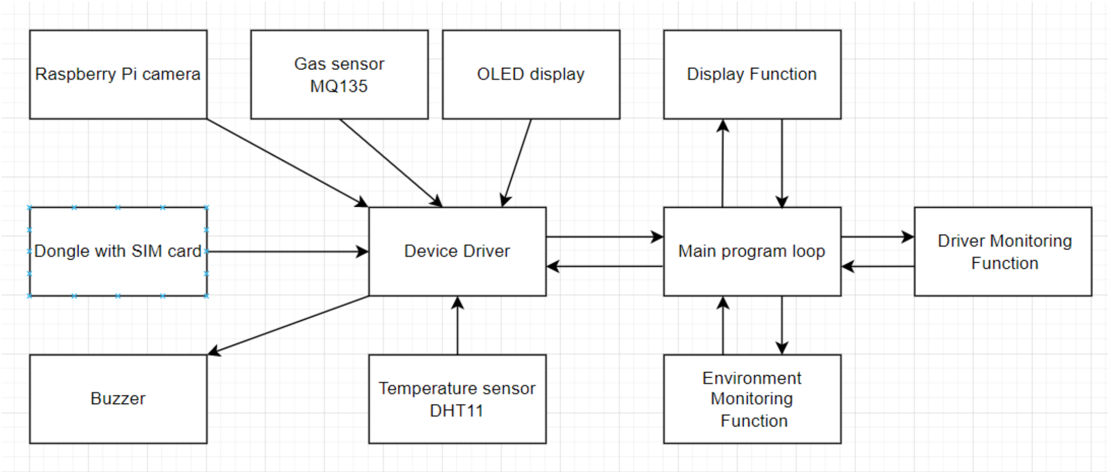


Figure 4.1.2: Block Diagram for Software Architecture.

4.1.2.1 Description for software architecture

The main program loop contained the operation code for the system. The device driver will control each of the component. First, the display function is used to display message for the driver. Second, the driver is monitored by the driver monitoring function. Third, the environment monitoring function is used to monitor the temperature, humidity and sense the alcohol.

4.2 System Components Specifications

There is several hardware needed to develop the driver monitoring system.

List of hardware:

- Raspberry Pi 4 Model B
  - Microcontroller used in the system for handling and controlling the processes.
- Raspberry Pi camera
  - Use to detect and monitoring the driver.
- Gas sensor MQ135
  - To detect and measure the alcohol.
- Temperature and Humidity sensor DHT11
  - Use to measure the temperature and humidity.
- Buzzer
  - Use to produce alert.
- 0.96-inch OLED display
  - Use to display the information.
- ADS1115 16-Bit ADC
  - Use for interfacing the display and sensors.
- Breadboard
  - Use to connect components and form a circuit.
- Jumper wires
  - Use for connecting two points together.
- GPIO extender
  - To extend the GPIO pin from the Raspberry Pi mainboard.
- Desktop / laptop
  - For writing and building the source code for the system.
- Smartphone
  - To run the Telegram application and use it to communicate with the system.

Description	Specifications
Processor	Intel Core i5 or above
Operating System	Windows 10 or above
Memory	8GB or above
Storage	256GB or above

Table 4.2.1 Minimum specification requirement of desktop / laptop

Description	Specifications
Model	Raspberry Pi 3 Model B+
SOC	Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @1.8Ghz
RAM	4GB LPDDR4-3200 SDRAM
WIFI	2.4Ghz and 5Ghz IEEE 802.11ac wireless LAN
Ethernet	Gigabit Ethernet
Bluetooth	Bluetooth 5.0
Video	2x micro-HDMI
USB ports	4 (2x USB 2.0, 2x USB 3.0)
Power	5V/3A DC power input
Operating system	Linux

Table 4.2.2 Specifications of Raspberry Pi

4.3 Circuit and Components Design

To make the hardware of the driver monitoring system tidier, a PCB board is designed to attach the components and sensors on the top of the Raspberry Pi mainboard. Moreover, PCB board able to avoid the amount of jumper wires because the 40 GPIO pins from Raspberry Pi mainboard is connected to the PCB board by using the pin headers and connected with the copper lines of PCB board.

To design the PCB board, the software called EAGLE which is a PCB design and electrical schematic software from Autodesk is used. Before design the PCB board, each part of the components and sensors such as buzzer, temperature, and humidity sensor (DHT11), ADC ADS1115, gas sensor (MQ135) and 0.96-inch OLED display need to be created and customized. After created the modules, we need to join each module to the GPIO module. The schematic part is successfully designed when all the modules are connected correctly without error.

The PCB board layout will be automatically generated after the schematic is done. The dimension of the PCB board layout is adjusted to the length of 85mm and height of 56mm. The copper lines are divided into top and bottom layer. The top layer is red color line, and the bottom layer is blue color line which shows in the Figure 4.3.2.

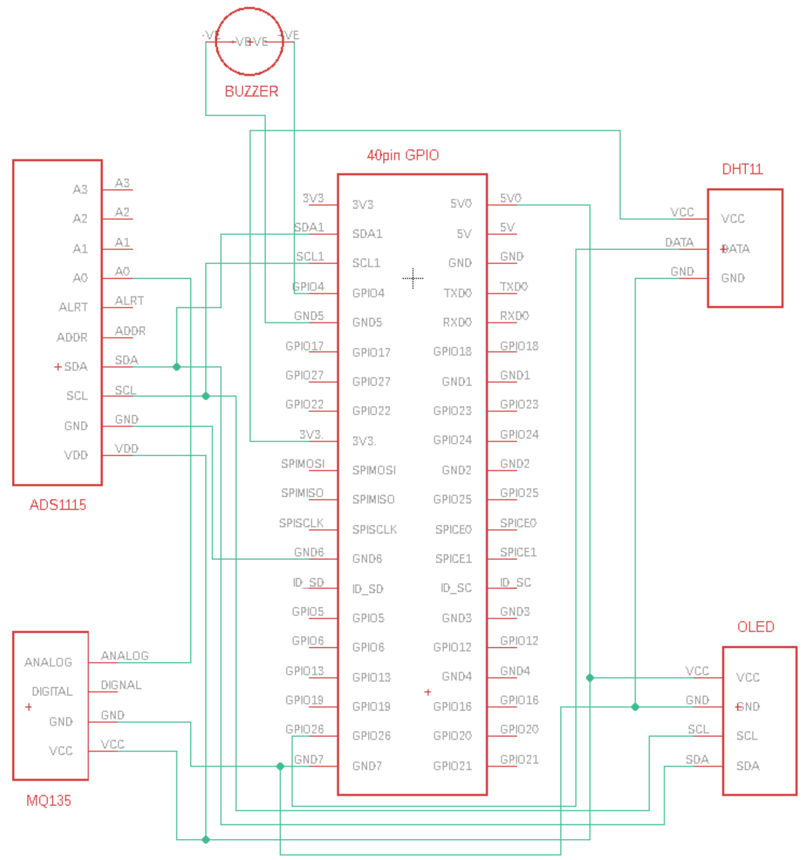


Figure 4.3.1 Schematic of the PCB Board.

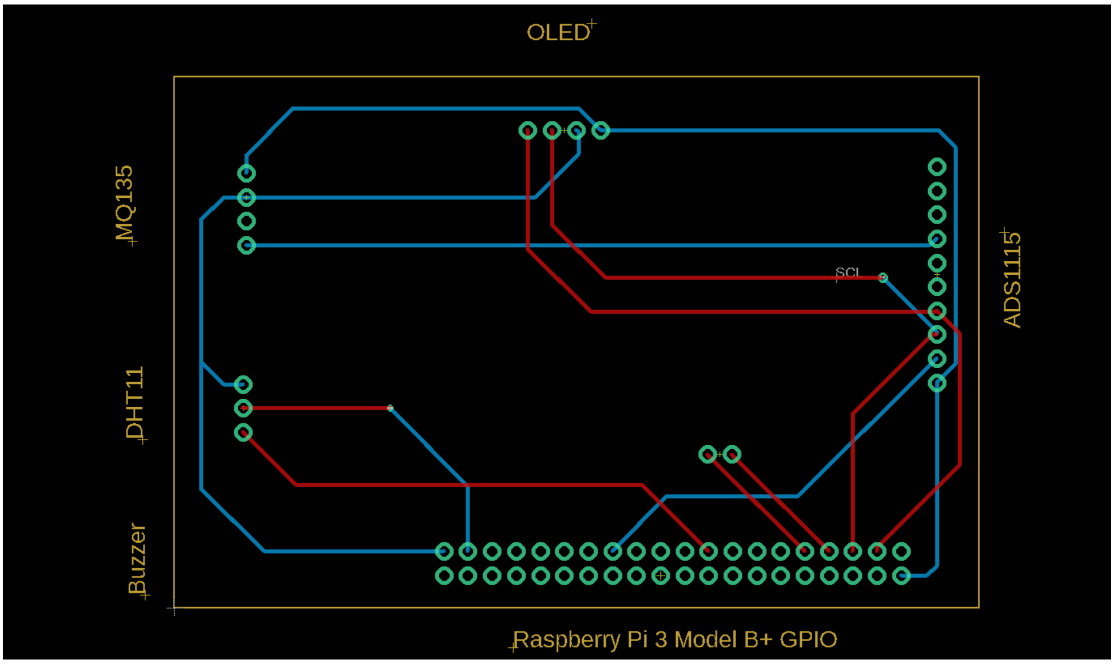


Figure 4.3.2 Layout of the PCB Board.

4.4 System Components Interaction Operations

Hardware	Connection
Buzzer	Positive pin connected to GPIO24 pin; negative pin connected to GND pin.
Temperature and Humidity Sensor DHT11	Vcc pin connected to 3.3V pin; Data pin connected to GPIO23 pin; Ground pin connected to GND pin.
0.96-inch OLED Display	Vcc pin connected to 5V pin; Ground pin connected to GND pin; SCL pin connected to ADS1115 SCL pin; SDA pin connected to ADS1115 SDA pin.
Gas Sensor MQ135	Vcc pin connected to 5V pin; Ground pin connected to GND pin; A0 pin connected to ADS1115 A0 pin.
ADS1115 16-Bit ADC	Vcc pin connected to 5V pin; Ground pin connected to GND pin; SDA pin connected to mainboard SDA pin and 0.96-inch OLED Display SDA pin; SCL pin connected to mainboard SCL pin and 0.96-inch OLED Display SCL pin; A0 pin connected to MQ135 A0 pin.

Table 4.4 Interaction of the system components.

Chapter 5

System Implementation

5.1 Hardware Setup

Before implement all the hardware to develop the system, we need to ensure that all the components are working fine and no faulty parts. The testing process is conducted for testing all the components.

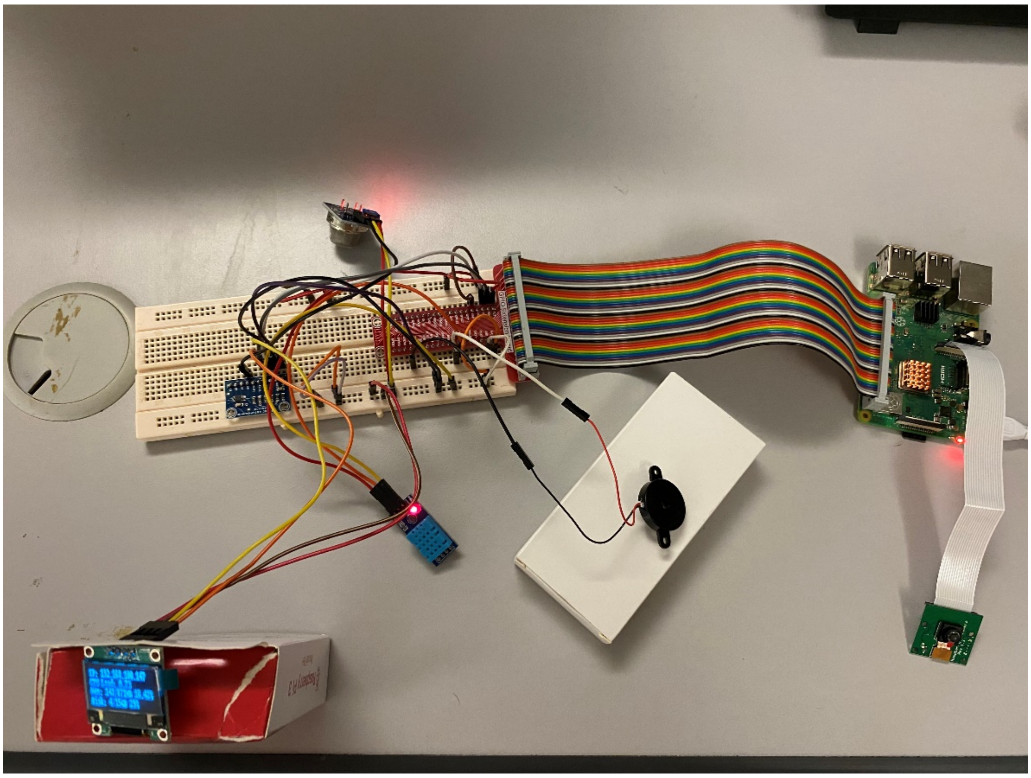


Figure 5.1.1: Circuit for the Testing Phase

The keyboard and mouse are connected to the USB port of the Raspberry PI mainboard for controlling. Other that than, a HDMI to VGA converter is used to connect the mainboard to the monitor. The 40 GPIO pins of Raspberry Pi mainboard is extended by the GPIO extender to the breadboard which show in Figure 5.1.1. The purpose using the GPIO extender to the breadboard is for making more convenient in connecting the components on the breadboard and avoid breaking the pins of the mainboard. The components and sensors are connected on the breadboard by using jumper wires.

List of hardware:

- Raspberry Pi camera
  - The Figure 5.1.2 is showing the Raspberry Pi camera connected on the mainboard. We use the command vcgencmd get_camera to test whether the camera is working or functioning. In the Figure 5.1.3, the supported and detected are replied 1 which mean the camera is connected correctly and working fine. The sample picture is captured in Figure 5.1.3 by using the command of raspistill -o pic.jpg.

Figure 5.1.2: Connectivity of Raspberry Pi Camera.

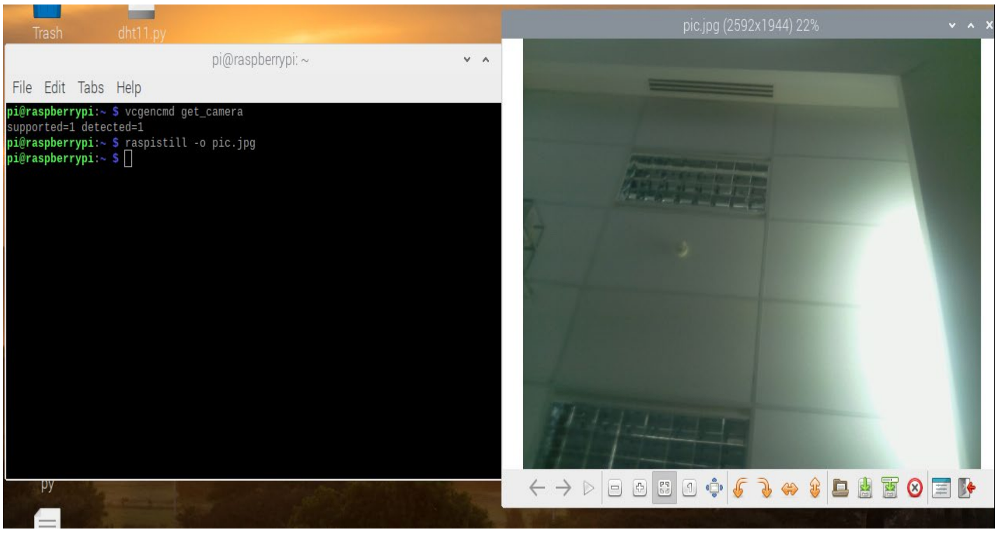


Figure 5.1.3: Sample Images Captured by Raspberry Pi Camera.

- Gas sensor MQ135
  - The Figure 5.1.5 is showing the percentage of air quality from the gas sensor MQ135. In normal air quality, the gas sensor MQ135 will not light up the green LED which showed in Figure 5.1.4 and the value range is lower than 50. However, when it sensed the changes in air quality, the green LED will light up to indicate that the air quality changes for example it sensed alcohol in Figure 4.6 and the value range is above 100 in Figure 5.1.7.

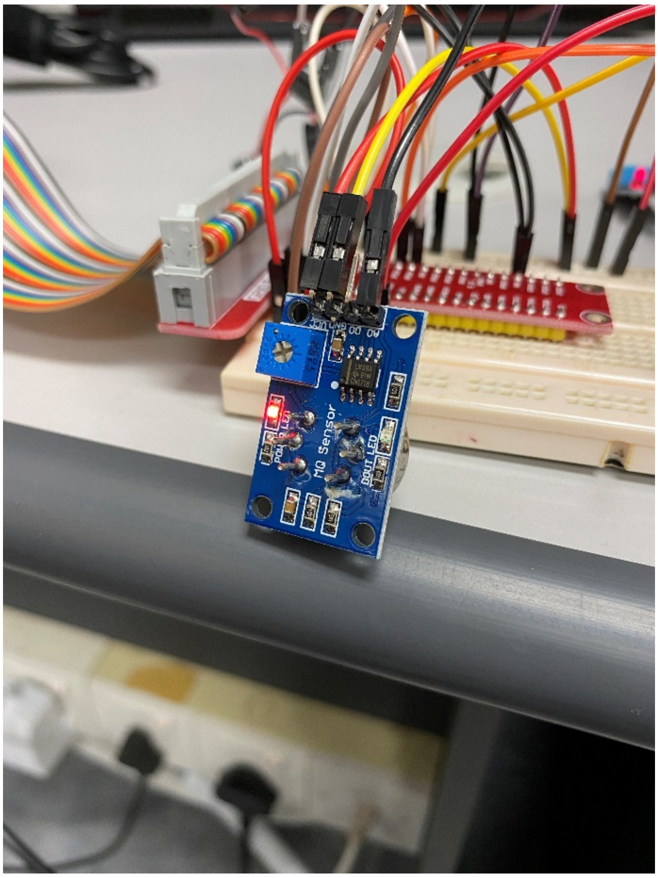


Figure 5.1.4: Gas Sensor MQ135.

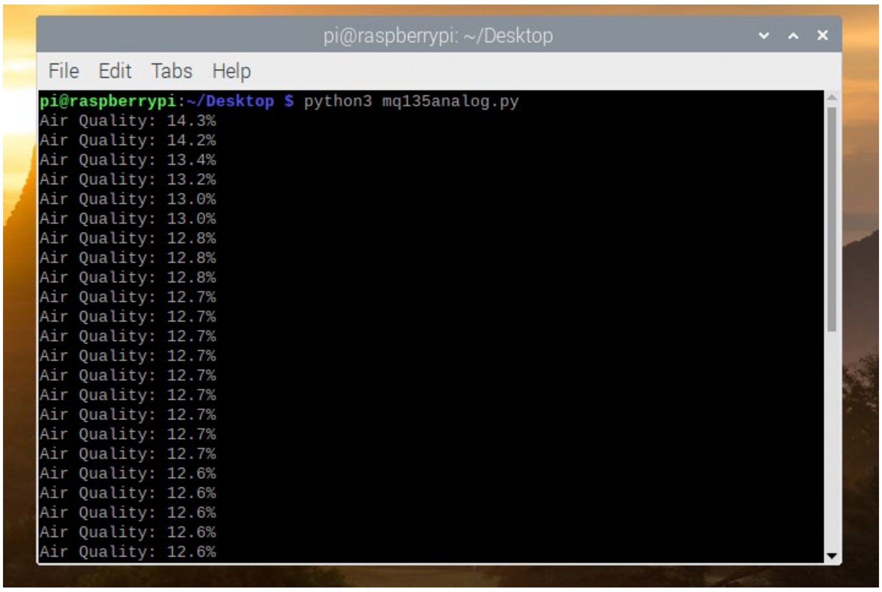


Figure 5.1.5: Sample output in Normal Air Quality.

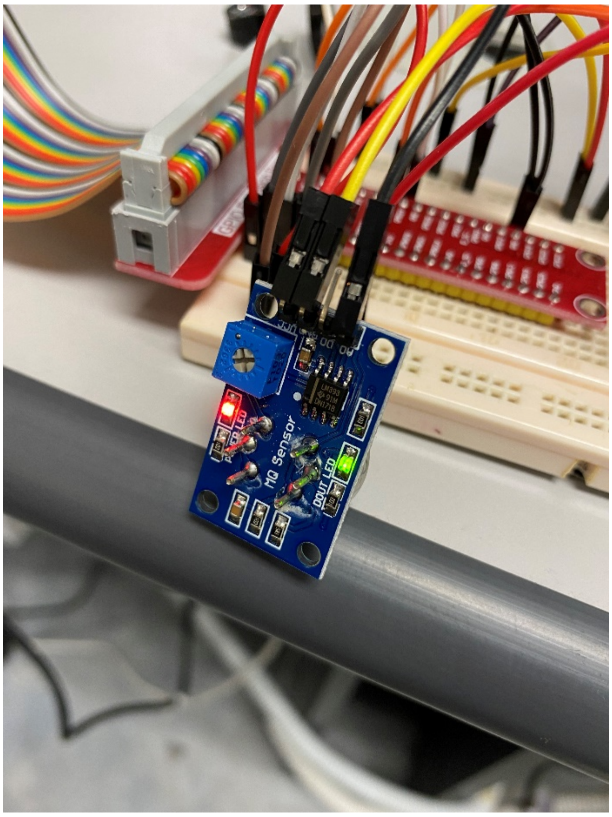


Figure 5.1.6: Green LED lighted up in MQ135.

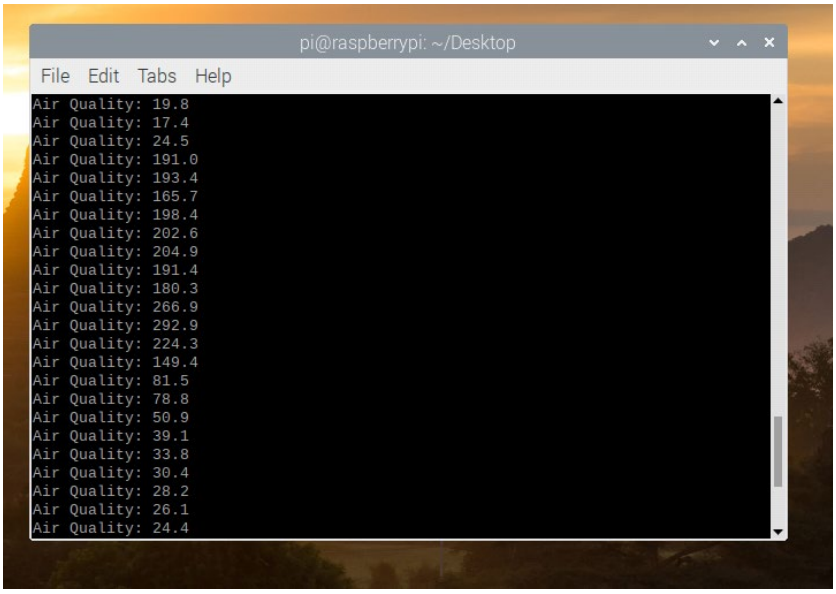


Figure 5.1.7: Sample Output When Sensed Alcohol.

- Temperature and Humidity sensor DHT11
  - The connection of temperature and humidity sensor DHT11 is showing in Figure 5.1.8. The Figure 5.1.9 is showing the values of temperature and humidity that measured by temperature and humidity sensor DHT11. The value of temperature is measured in Celsius °C and the value of humidity is measured in percentage %.

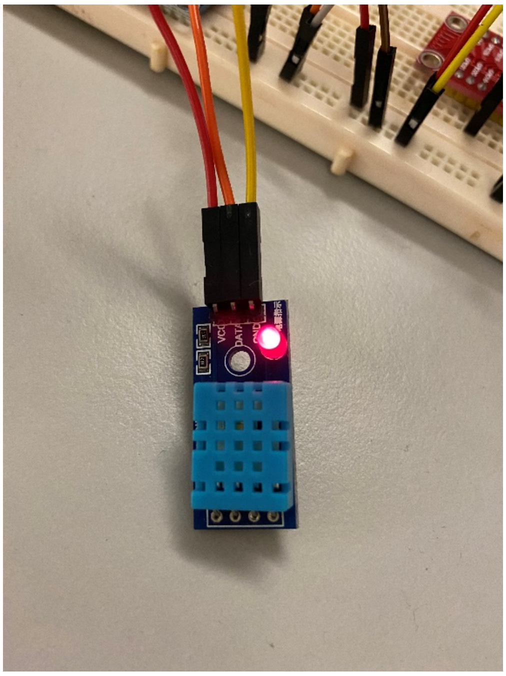


Figure 5.1.8: Temperature and Humidity Sensor DHT11.

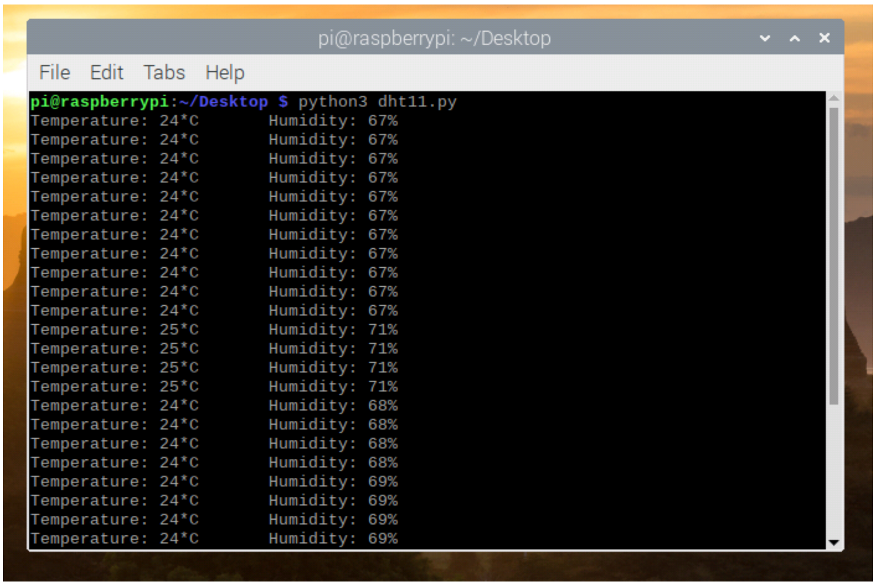


Figure 5.1.9: Sample Output from Temperature and Humidity Sensor DHT11.

- Buzzer
  - The connection of buzzer is showing in Figure 5.1.10. The buzzer is working fine which can produce sound and alert when running the testing code in Geany by using terminal.

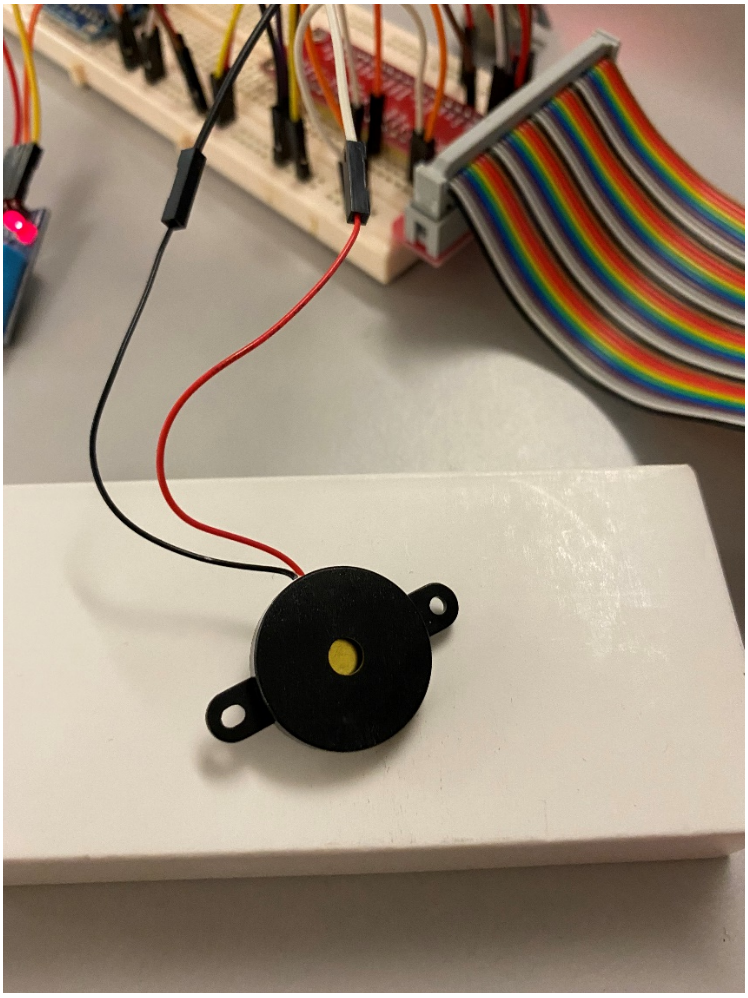


Figure 5.1.10: Buzzer.

- 0.96-inch OLED display
  - To test the OLED display, a library is needed to function the OLED display. The library is downloaded from Adafruit website and installed successfully. The Figure 5.1.11 is the sample output from the sample test code from the Adafruit library.

Figure 5.1.11: Sample Output from 0.96-inch OLED Display.

- ADS1115 16-Bit ADC

  The ADC is tested by connecting the Gas Sensor MQ135 for converting the digital value to analog value. Other than that, the 0.96-inch OLED display is connected to the ADC for displaying the information on it.

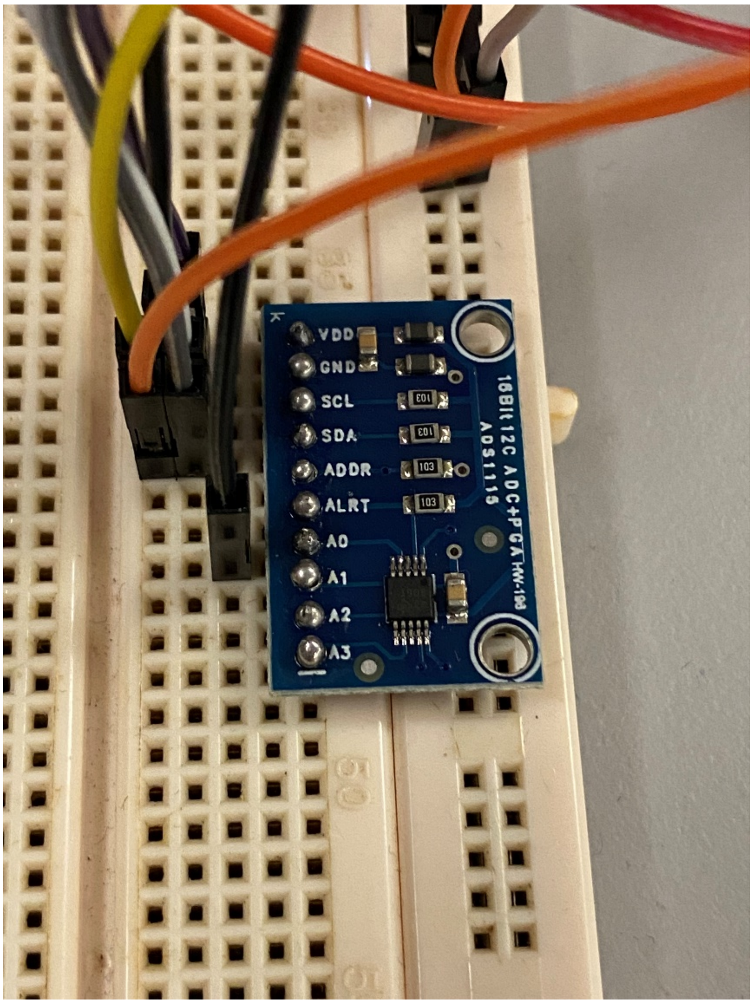


Figure 5.1.12: ADS1115 16-Bit ADC.

After we tested all the components and ensured they are in working condition, all the components are removed from the breadboard and will be soldered on the PCB board to make it tidier.

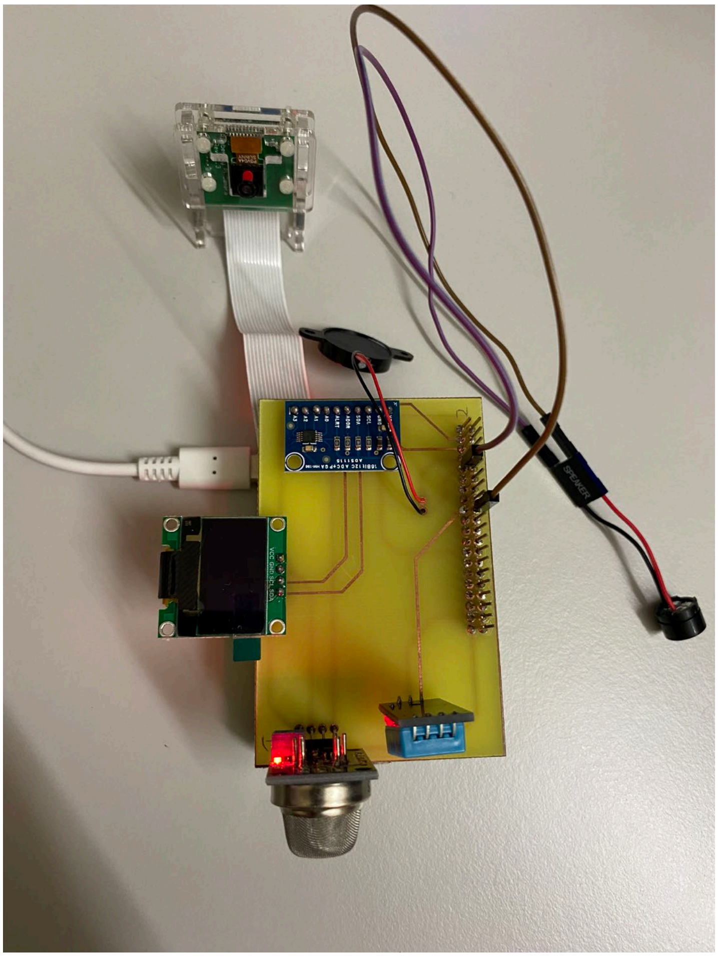


Figure 5.1.13 Overall system.

Figure 5.1.13 is all the components of the overall system. All the components are soldered on the PCB board and working in good condition. The PCB board also connected with the Raspberry Pi 4 Model B by using the GPIO pin header. However, there are two buzzers on the board is because one of the buzzers which designed to connect with GPIO 5 and GND in the PCB board has delay on the system. Therefore, to solve this problem, another buzzer is connected with GPIO 24 and GND. In addition, the raspberry pi camera is covered with the case which used to add some extra protection to the camera and let it to stand.

5.2 Software Setup

In this project, there are total 3 software involved.

- Geany
  - It is a build in compiler in the Raspberry Pi OS and the language used to develop the system is Python Tkinter.

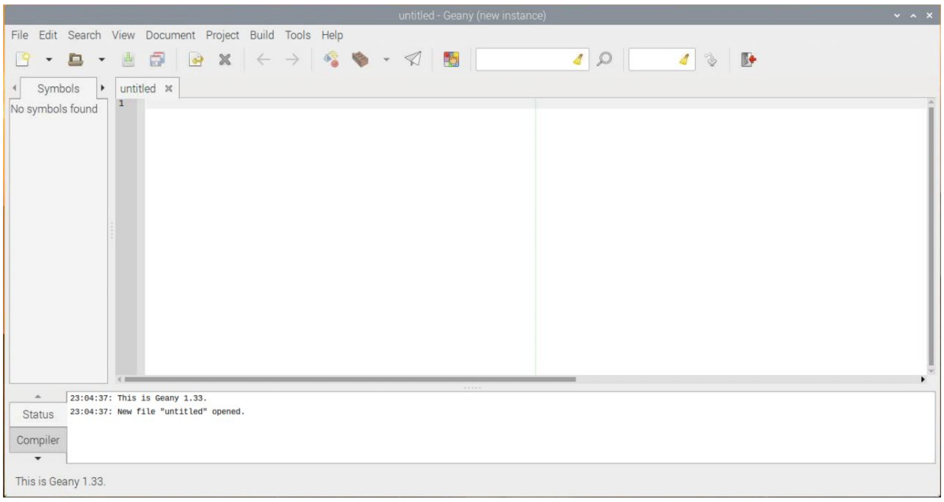


Figure 5.2.1 Geany.

- Telegram
  - It is a communication application that provides messaging service. The system needs a bot to manage the service in the Telegram. To create a bot, we use the BotFather by sending the /newbot command to it and named the bot as pi_b0t. After that, it will generate an API and Bot ID to implement them in the code to control the bot.

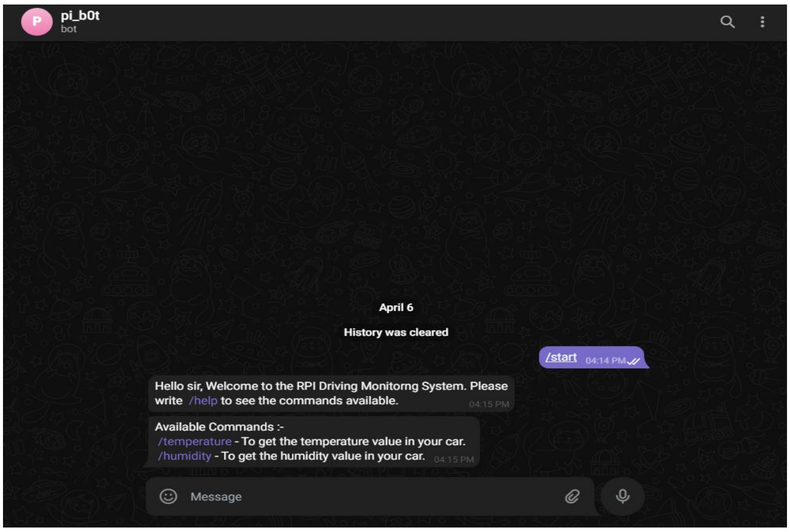


Figure 5.2.2 Telegram Bot.

- Ubidots
  - It is a website which provide the service for the device with internet connection to send the data to the cloud and control action or produce alert based on the data. To set up the Ubidots, we created a new device for this system, and it will provide the API and the tokens that use to store the temperature and humidity value for us to implement them into the code.

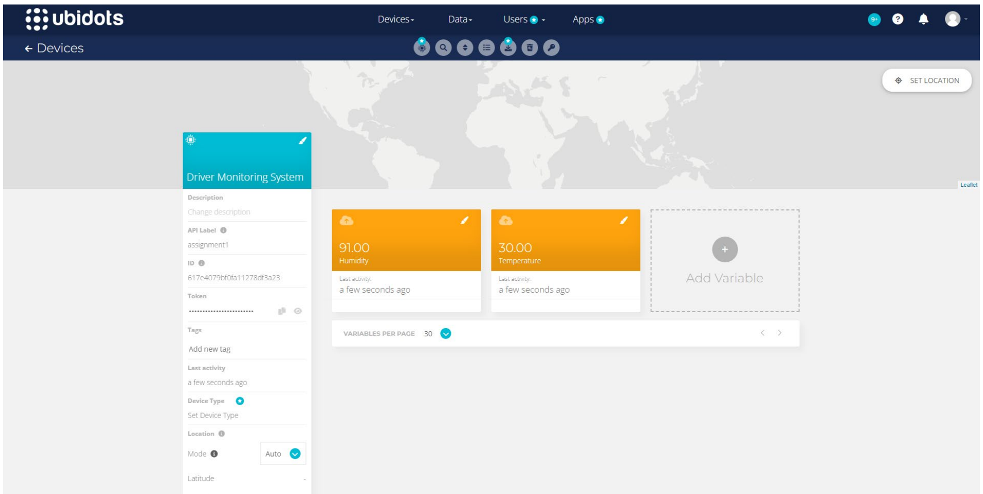


Figure 5.2.3 Ubidots Dashboard.

5.3 Setting and Configuration

Before starting to process the development of driving monitoring system, the operating system of the Raspberry Pi needs to be reflash:

The following are the steps of the reinstall the operating system of the Raspberry Pi

i. Eject the microSD card from the Raspberry Pi mainboard.
ii. Format the microSD card by using the software "SDFormatter".
iii. Download the disc image of Raspberry PI from the website https://downloads.raspberrypi.org/raspbian/images/
iv. Write the disc image into the microSD card by using the software "Win32 Disk Imager".
v. Insert back the microSD card into the Raspberry Pi mainboard.
vi. Boot up and setting up the operating system.

After reflash the operating system, we need to update and upgrade the system by using the command sudo apt-get update and sudo apt-get upgrade for the system to up to date. Then, we enabled the interfaces in the Raspberry Pi Configuration in the figure 5.3.1 to connect with the components.

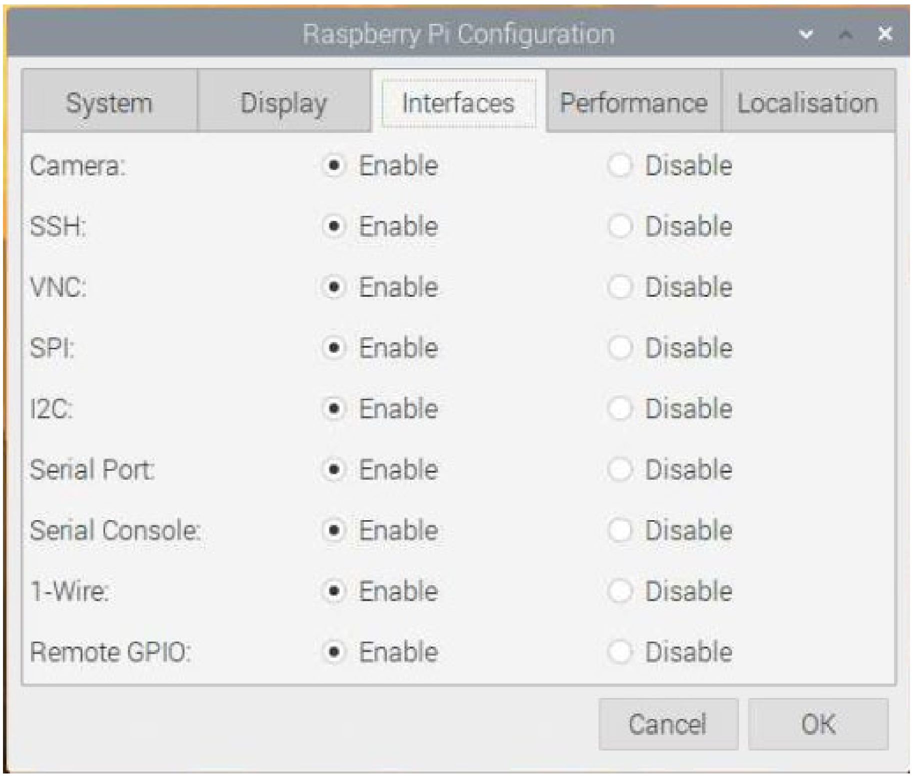


Figure 5.3.1 Raspberry Pi Interface.

Furthermore, we increased the GPU memory of the Raspberry Pi from 64MB to 256MB for the image processing of this system. This is because the image processing part required a large amount of GPU memory to do the processing. In addition, increased GPU memory able to let the system to run more smoothly.

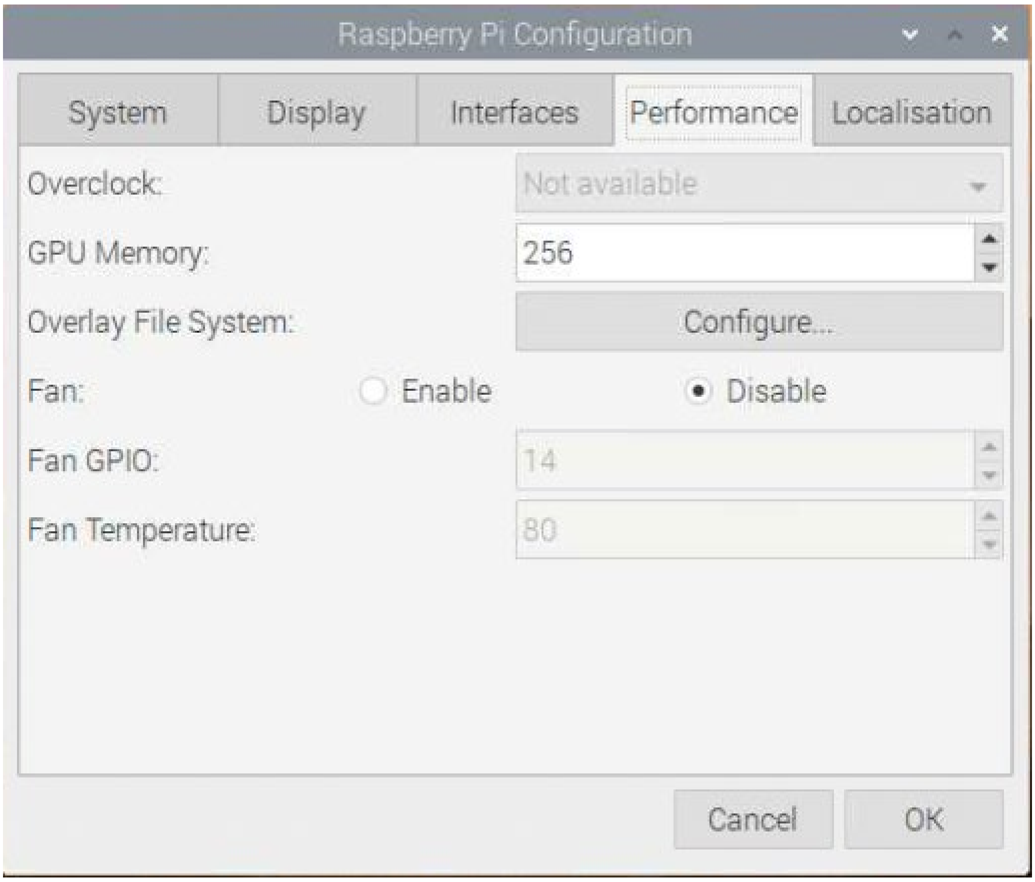


Figure 5.3.2 GPU Memory.

After that, we need to install the libraries needed for this project such as numpy, OpenCV, face_recognition, imutils. Adafruit for ADC (ADS1115), temperature and humidity sensor (DHT11), and OLED display, Ubidots, and Telegram. For the image processing part, there are a lot of libraries available to handle it, but we chose the OpenCV library to handle the image processing. This is because OpenCV is open source and licensed free. According to OpenCV [12], OpenCV is known as Open-Source Computer Vision library which is open-source software library of computer vision and machine learning. In addition, OpenCV library is not heavy as the Tensorflow library. To verify the installation of OpenCV library, we entered the import cv2 and cv2.__version__ in the python compiler to check the version of the installed OpenCV library.

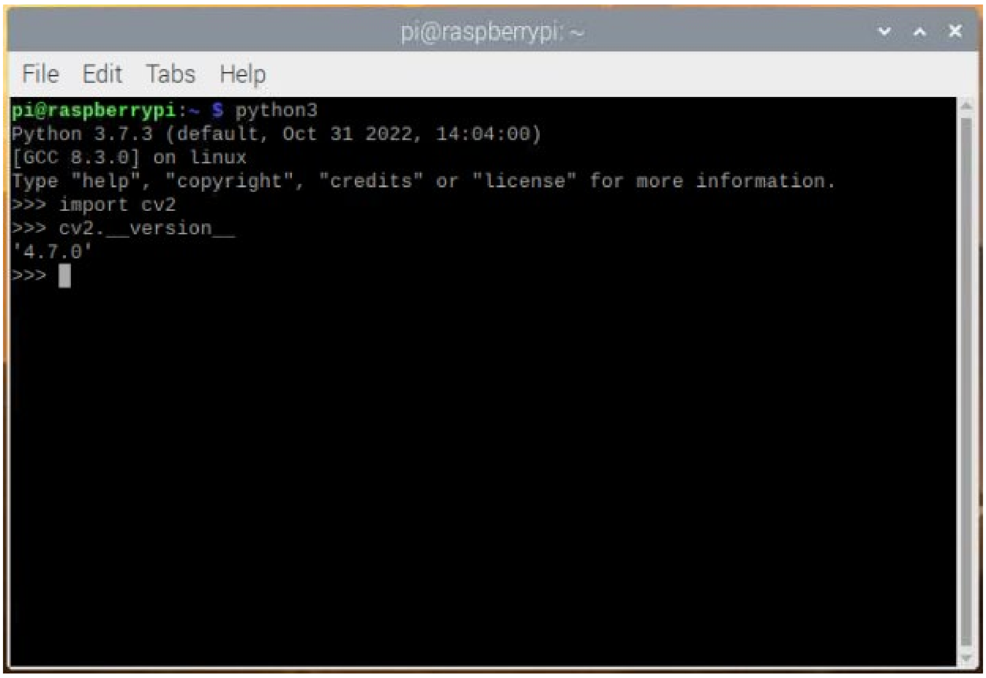


Figure 5.3.3 OpenCV Version.

5.4 System Operation (with Screenshot)

In this Driving Monitoring System, it is designed to run with the flow which displayed in Figure 3.1.3. For the whole program, all the files needed are saved and stored in the Example directory.

There are two conditions when the system starts. First and foremost, the system will capture the driver's face for face recognition[13] in figure 5.4.1 when the system starts in the beginning. For face recognition, the system will store and compare the captured driver's image (image.jpg) with the image of the car owner (me.jpg) which stored in the capture directory which shows in figure 5.4.2. If the driver is verified successfully in figure 5.4.3, the system will continue to monitor the driver's eye closed time and alcohol value throughout the whole journey until the system off. If the driver is verified unsuccessfully in figure 5.4.4, the system will send the captured image of the driver to the car owner through Telegram in figure 5.4.5 to alert the driver.

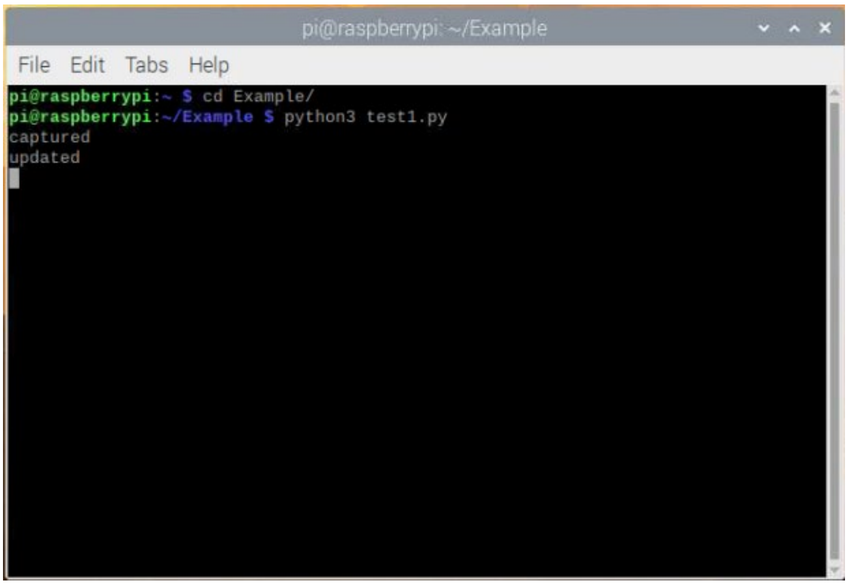


Figure 5.4.1 Capture the driver's image.

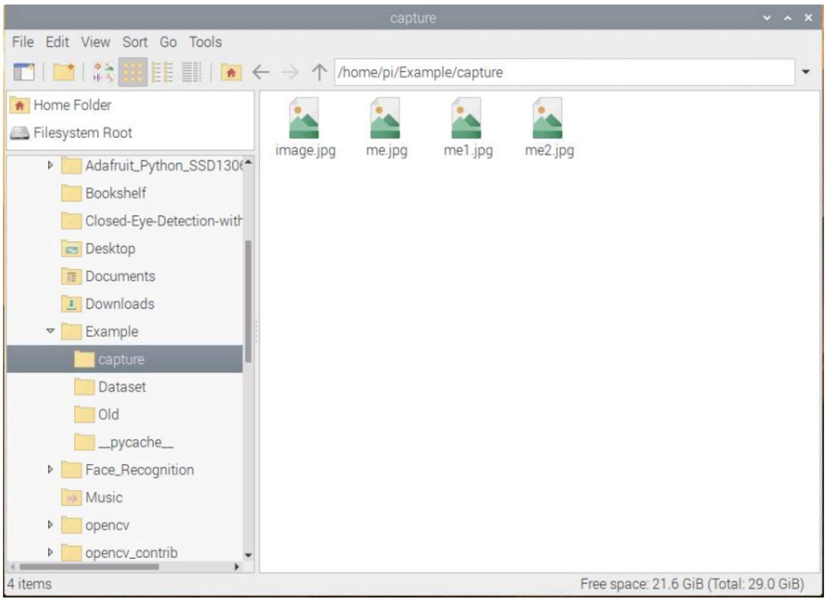


Figure 5.4.2 Capture Directory.

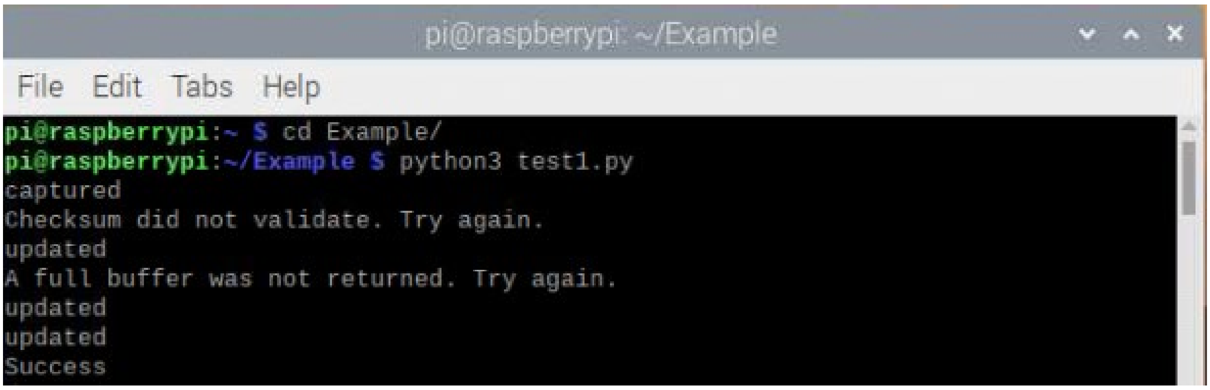


Figure 5.4.3 Verification Success.

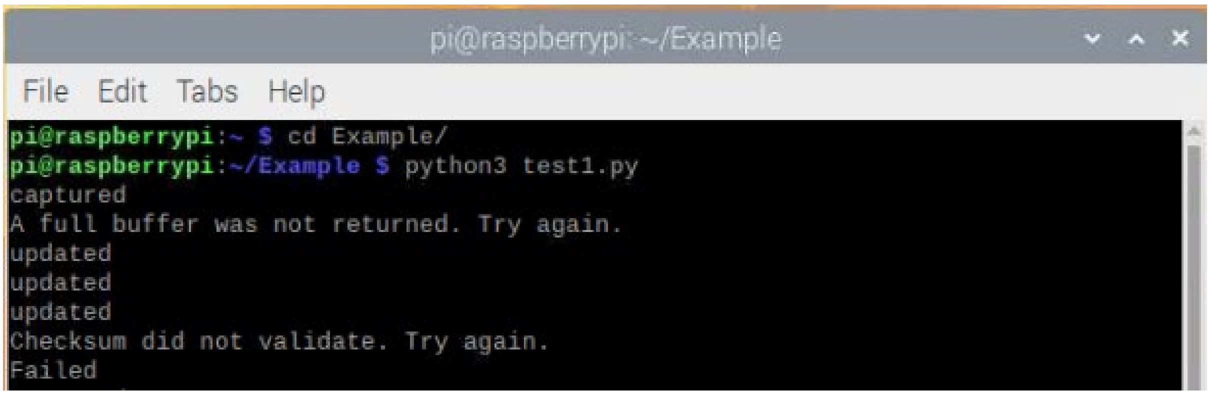


Figure 5.4.4 Verification Failed.

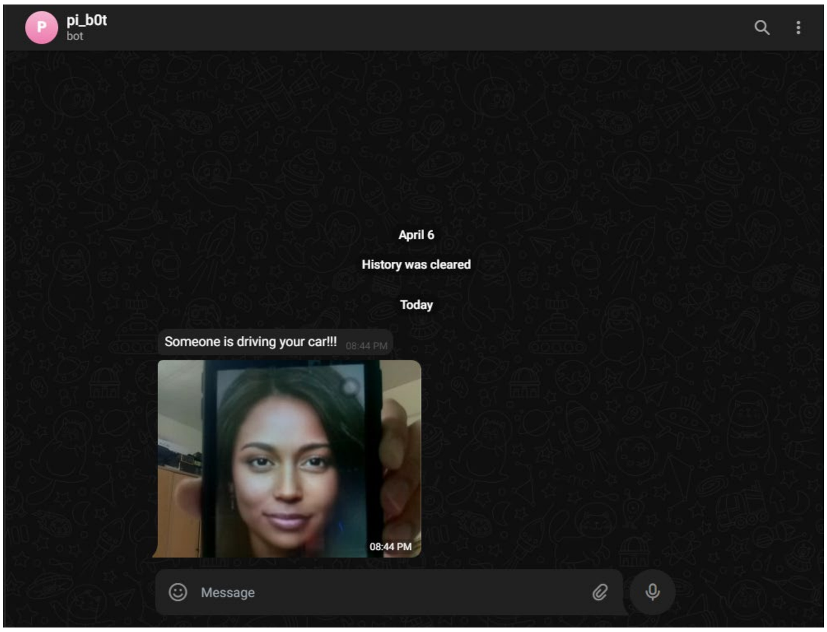


Figure 5.4.5 Telegram alert.

Second condition is sensed the alcohol value of the driver at the beginning in figure 5.4.6. If the system sensed the alcohol value more than 50%, it would display the alcohol value in the terminal and produce alert from the buzzer in figure 5.4.8 and display the warning message in figure 5.4.7 to alert the driver that he or she is not suitable to drive at this moment. If the alcohol value is less than 50%, it will continue to monitor the driver throughout the whole journey until the system off.

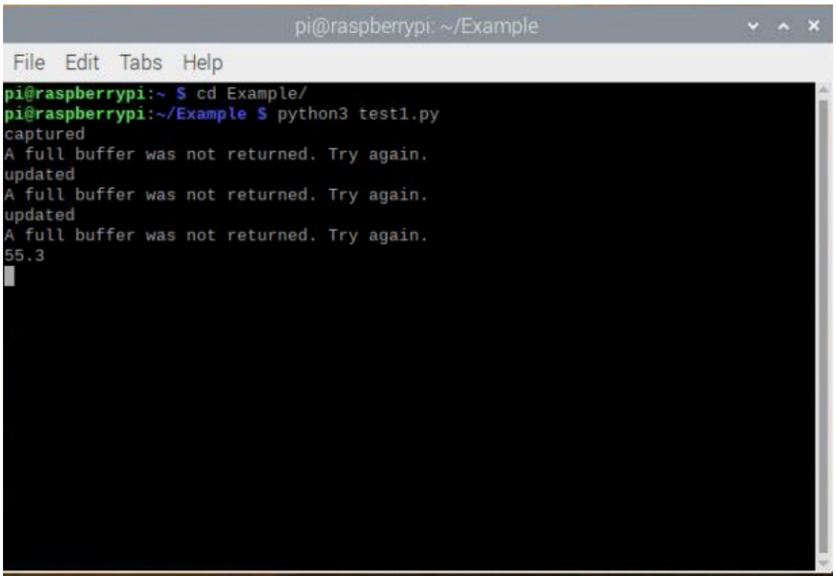


Figure 5.4.6 Alcohol Sensed.

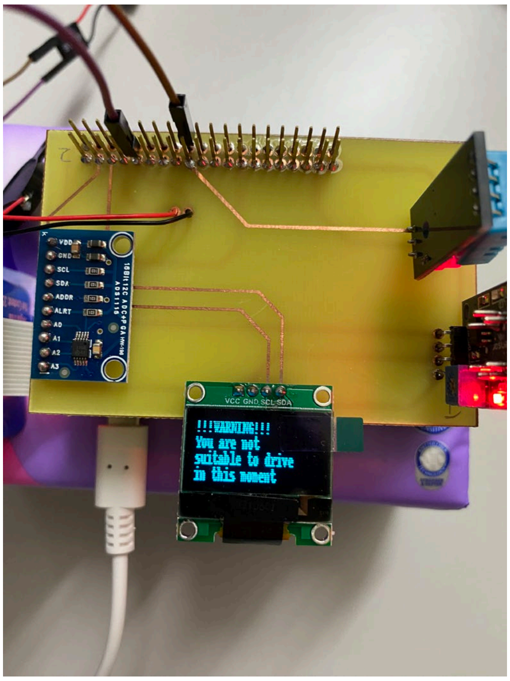


Figure 5.4.7 Warning Message.

Figure 5.4.8 Buzzer Produce Alert.

At the same time, the system will also display the values of temperature and humidity on the OLED display in figure 5.4.9. In addition, the car owner able to check the values of temperature and humidity in Telegram with the command /temperature and /humidity in figure 5.4.10 or in Ubidots in figure 5.4.11 when outside the car.

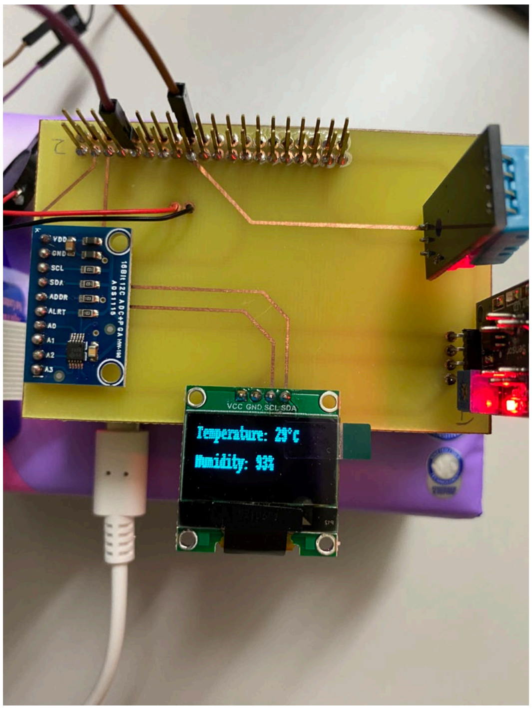


Figure 5.4.9 Display for Temperature and Humidity values

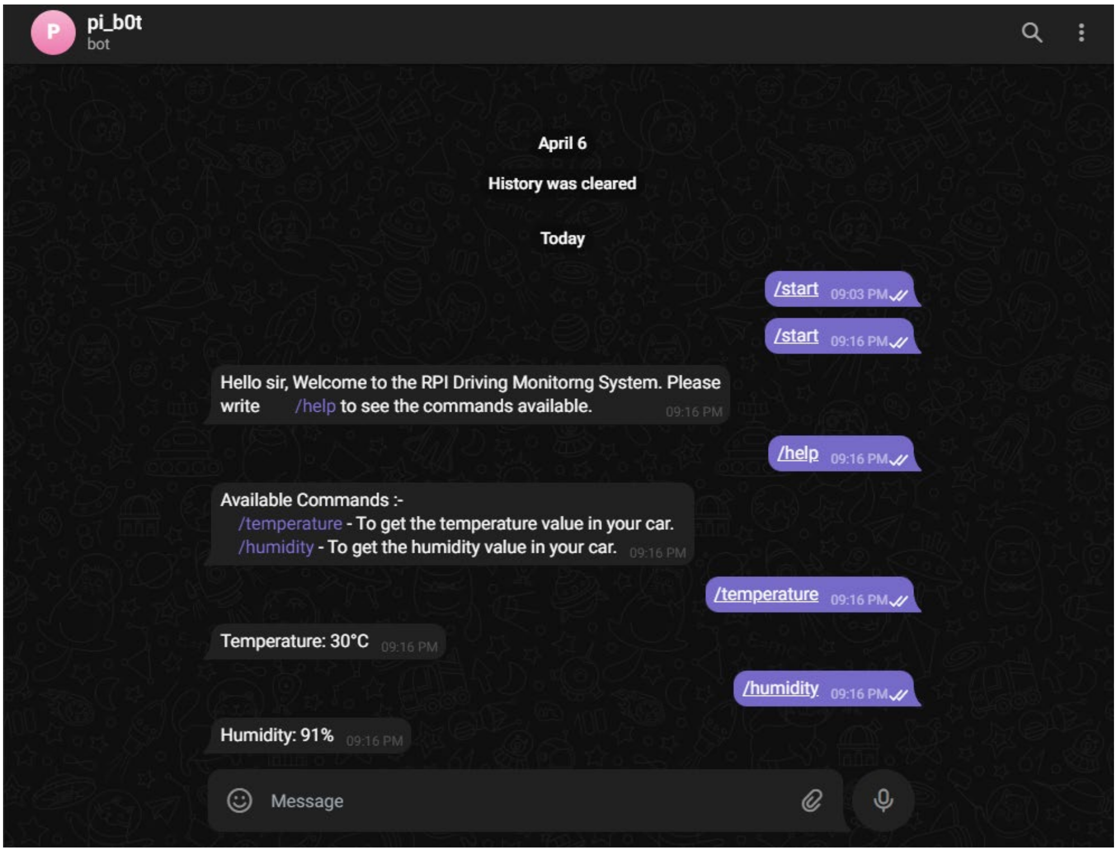


Figure 5.4.10 Telegram for Temperature and Humidity values.

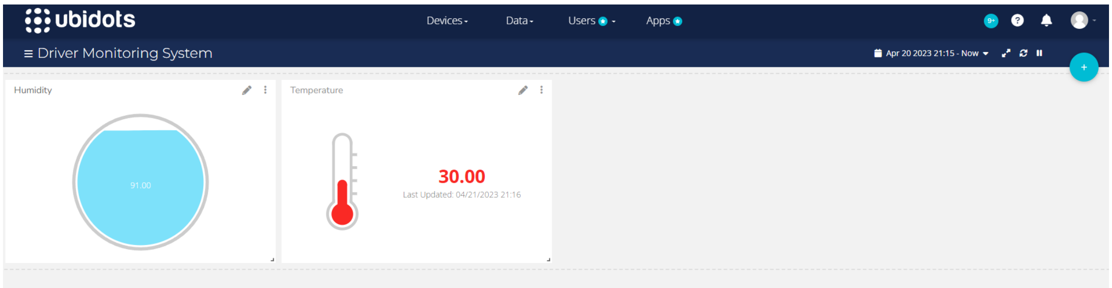


Figure 5.4.11 Ubidots for Temperature and Humidity values.

After passed the face recognition and alcohol value, the system will monitor the driver's eye closed time. The system will track the face and eyes of the driver [14]. The system drawn a blue box when detected the driver's face and a green box when detected the driver's eyes in figure 5.4.14. When the system unable to detect the face and eyes of the driver in figure 5.4.12, it will show detecting in the terminal. If the system unable to detect the eyes of the driver in figure 5.4.13, it will produce alert from the buzzer in figure 5.4.8 and display the warning message in figure 5.4.7 to alert the driver that he or she is not suitable to drive at this moment.

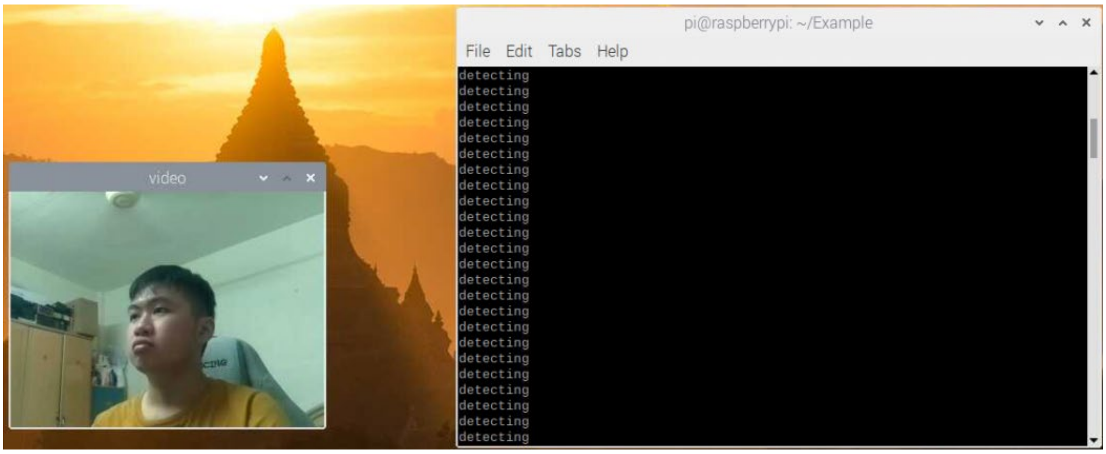


Figure 5.4.12 Detecting Face.

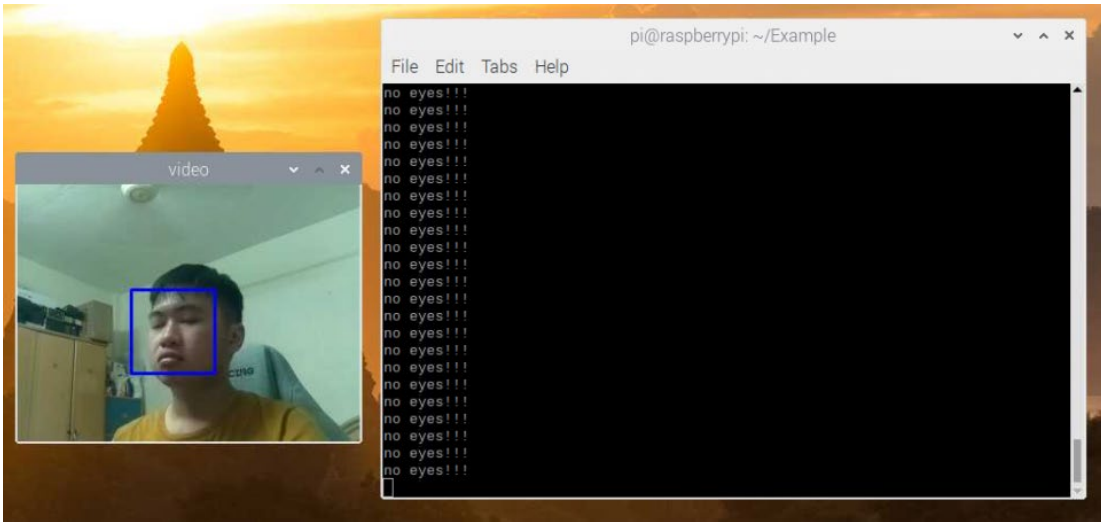


Figure 5.4.13 Eyes Closed.

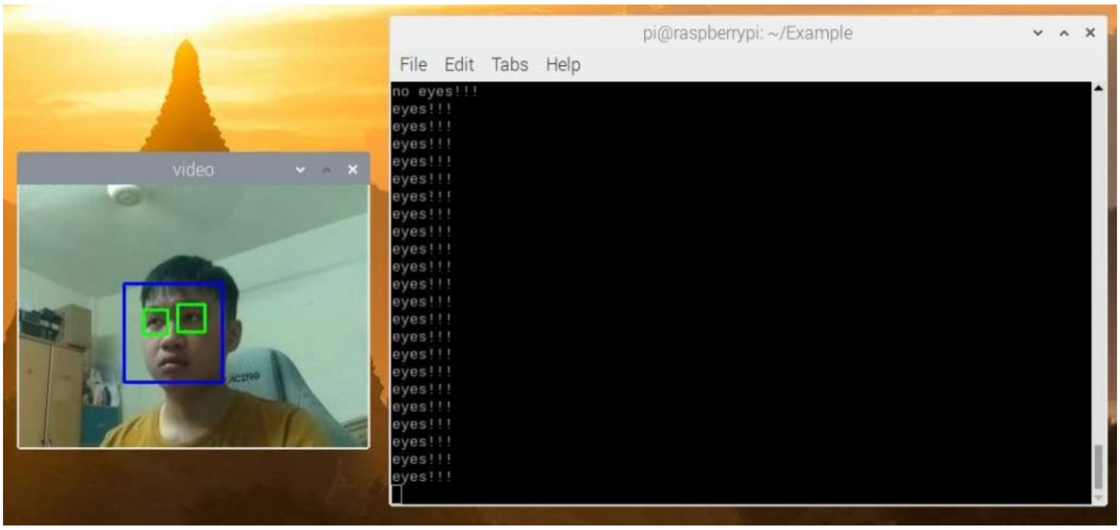


Figure 5.4.14 Eyes Opened.

5.5 Implementation Issues and Challenges

In this project, there are some issues and challenges faced.

First and foremost, the breadboard from the FYP lab is not in good condition that there are some of the holes in the breadboard unable to function. For instance, when I installed the ADS1115 16-Bit ADC into the breadboard, there are a few times that the mainboard unable to detect the ADC and need to change the position for placing the ADC. Other than that, some holes also unable to insert in the connection of jumper wires.

Second is the process of solder. During the process of soler for the components with the PCB board, the heat of the soldering pencil is not consistent which resulted in sometimes need to wait the soldering pencil to reheat again in soldering process.

Third is the Raspberry Pi camera. In the beginning, the latest version of Raspberry Pi operating system is installed. However, the latest version of Raspberry Pi operating system is not stable which contained a bug and lead to no configuration for camera in the system. After installed the Raspberry Pi camera in the mainboard, it cannot open the camera for taking picture although it shows detected the Raspberry Pi camera. For solving this issue, an older version of Raspberry Pi operating system is used.

5.6 Concluding Remark

As a conclusion in Chapter 5, all of the hardware like sensors and components are soldered and connected completely with the Raspberry Pi mainboard. The needed software is also set up correctly to implement on the system. In addition, the older version of operating system is used for supporting the Raspberry Pi camera. The all the needed interface of Raspberry Pi is enabled, and the GPU memory is increased to 256MB. Other than that, all the needed libraries especially OpenCV library is installed successfully. For the overall system, the function is working normally and smoothly.

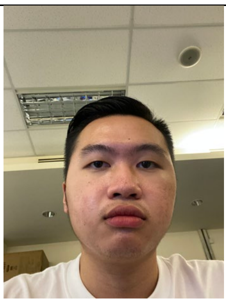
Chapter 6

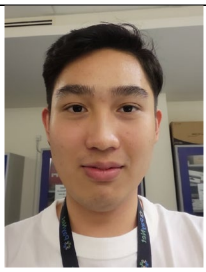
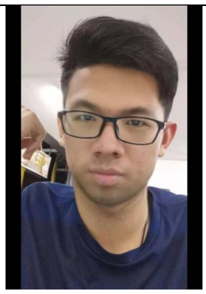
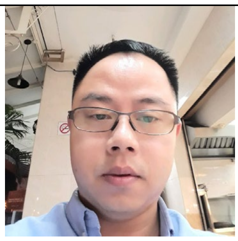
System Evaluation and Discussion

6.1 System Testing and Performance Metrics

In this system, there are a few tests need to be conducted for testing the system.

1. Face Recognition.
    - In face recognition, the system needs to verify successfully for the car owner and failed for other peoples to ensure the safety of the car.
    - There is total 10 images (3 images are the car owner and 7 images are other peoples) to verify the face recognition performance of this system.

Faces	Expected Result
	Pass
	Pass
	Pass

	Fail
	Fail
	Fail
	Fail
	Fail
	Fail

	Fail

Table 6.1.1 Table for Face Recognition.

2. Face and Eyes Detection and Tracking.
    - The system needs to track and monitor the driver's face and eyes to ensure that the eyes of the driver are not closed for more than 4 seconds.
    - There is total 3 situations need to be tested for the verification of the system performance.

Situation	Expected Result
Full light (Morning and Afternoon)	Able to detect and monitor
Medium light (Evening)	Slightly detect and monitor
Low light (Night)	Slightly detect and monitor

Table 6.1.2 Table for Face and Eyes Detection and Tracking.

3. Alcohol Detection.
    - For the alcohol detection, the gas sensor MQ135 of the system need to sense the alcohol when the alcohol gas is present.
    - To test the system, we divided into 3 distances for sensing the alcohol.

Distance	Expected Result
2cm	Able to detect the present of alcohol
10cm	Able to detect the present of alcohol
30cm	Slightly detect the present of alcohol
50cm	Unable to detect the present of alcohol

Table 6.1.3 Table for Alcohol Detection.

4. Communication.
   - The system needs to stay connected with the car owner when the car owner is away from the car.
   - There are two platform to test the communication between the system and the car owner.

Platform	Expected Result
Telegram	Able to response the car owner when received commands and also receive the image of unknown driver.
Ubidots	Able to update the values of temperature and humidity.

Table 6.1.4 Table for Communication.

5. Information display in normal condition and warning condition.
   - In normal condition, the OLED display of the system need to display the values for the temperature and humidity and the buzzer need to be quiet condition.
   - In warning condition, the OLED display of the system need to display the warning message and the buzzer need to produce alert sound.

Condition	Expected Result
Normal	OLED display – display values of temperature and humidity. Buzzer – Quiet
Warning	OLED display – display message. Buzzer – Produce alert

Table 6.1.5 Table for Information Display in Normal and Warning Condition.

6.2 Testing Setup and Result

Before testing the system, we need to setup the system like in the real car situation.

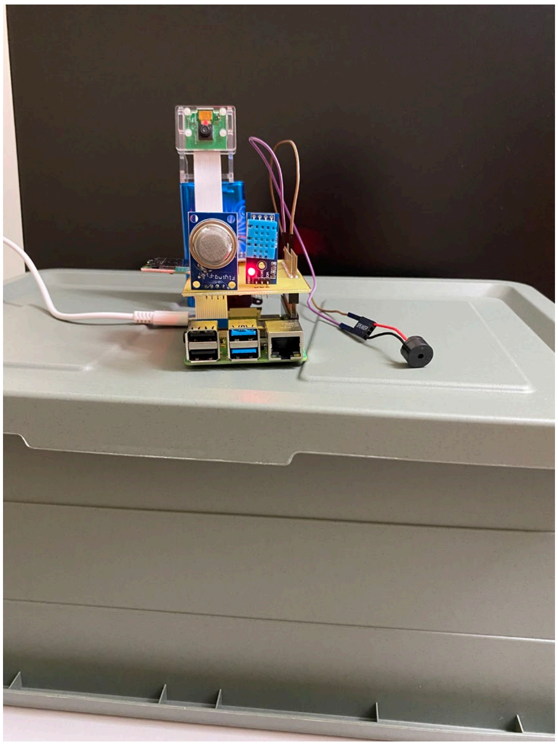


Figure 6.2.1 System Setup 1.

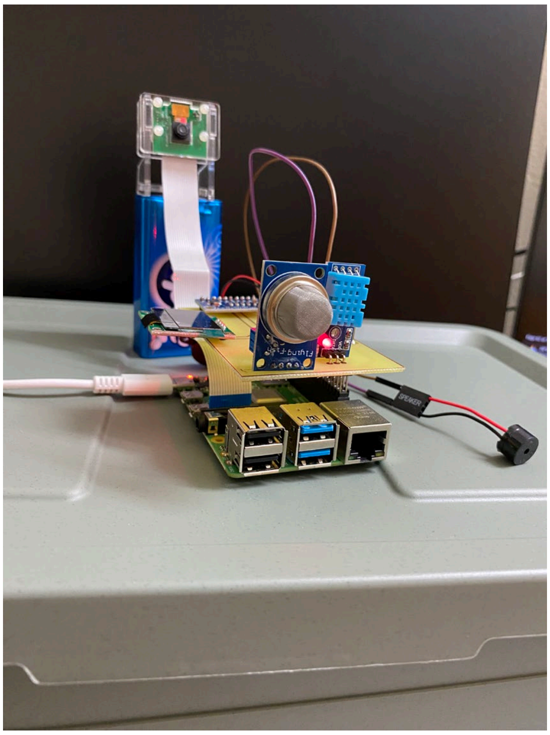
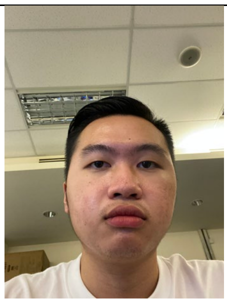
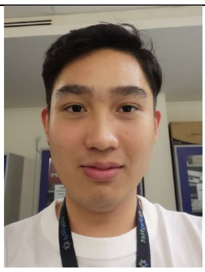


Figure 6.2.2 System Setup 2.

The figure 6.2.1 and 6.2.2 is the system setup. The whole system is placed above on the box to increase the height. This is because the box is used to represent the dashboard of the car for attaching the system on it. In addition, the system is faced the driver with the 30 degrees for monitoring the driver. Furthermore, the power supply for the system is supplied by using power bank. This is because there is no socket and 3 pin plugs in the car and power bank is used for supplying electric to the system or used to represent the car charger.

1. Face Recognition.

Faces	Expected Result	Actual Result	Test Result
	Success	Success	Pass
	Success	Success	Pass
	Success	Success	Pass
	Unsuccess	Success	Fail

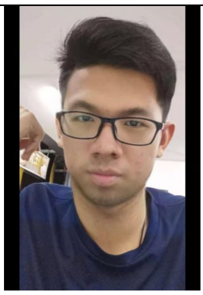
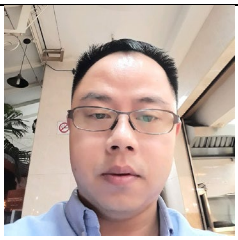
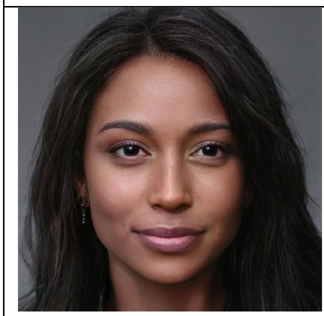
	Unsuccess	Success	Fail
	Unsuccess	Unsuccess	Pass
	Unsuccess	Unsuccess	Pass
	Unsuccess	Unsuccess	Pass
	Unsuccess	Unsuccess	Pass
	Unsuccess	Unsuccess	Pass

Table 6.2.1 Result for Face Recognition.

2. Face and Eyes Detection and Tracking.

Situation	Expected Result	Actual Result	Test Result
Full light (Morning and Afternoon)	Able to detect and monitor	Able to detect and monitor	Pass
Medium light (Evening)	Slightly detect and monitor	Slightly detect and monitor	Pass
Low light (Night)	Slightly detect and monitor	Unable to detect and monitor	Fail

Table 6.2.2 Result for Face and Eyes Detection and Tracking.

3. Alcohol Detection.

Distance	Expected Result	Actual Result	Test Result
2cm	Able to detect the present of alcohol	Able to detect the present of alcohol	Pass
10cm	Able to detect the present of alcohol	Unable to detect the present of alcohol	Fail
30cm	Slightly detect the present of alcohol	Unable to detect the present of alcohol	Fail
50cm	Unable to detect the present of alcohol	Unable to detect the present of alcohol	Fail

Table 6.2.3 Table for Alcohol Detection.

4. Communication.

Platform	Expected Result	Actual Result	Test Result
Telegram	Able to response the car owner when received commands and also receive the image of unknown driver.	Able to response the car owner when received commands and also receive the image of unknown driver.	Pass
Ubidots	Able to update the values of temperature and humidity.	Able to update the values of temperature and humidity.	Pass

Table 6.2.4 Table for Communication.

5. Information display in normal condition and warning condition.

Condition	Expected Result	Actual Result	Test Result
Normal	OLED display – display values of temperature and humidity. Buzzer – Quiet	OLED display – display values of temperature and humidity. Buzzer – Quiet	Pass
Warning	OLED display – display message. Buzzer – Produce alert	OLED display – display message. Buzzer – Produce alert	Pass

Table 6.2.5 Table for Information Display in Normal and Warning Condition.

6.3 Project Challenges

In this project, there are faced two challenges. First of all is the alcohol detection. The gas sensor MQ135 able to detect the present of alcohol when the driver is very close to the gas sensor and it unable to detect the present of alcohol when the driver is far from it. However, there is a challenge in sensing the alcohol during the driver in driving condition in reality. Second is the face and eye detection. The Raspberry Pi camera has a limitation which it unable to detect anything in low light condition. In low light condition, it will display a black image which resulted unable to capture the face of driver and detect the driver when driving especially at nighttime. In addition, it can only detect one eye or detect other things else in low light condition for some cases.

6.4 Objective Evaluation

1. Driver authentication.

Objective	Expected Result	Actual Result	Test Result
Driver Authentication	Driver can continue to driver after authenticating successfully. The system will send the captured image and alert message to the owner of the car through Telegram after authenticating unsuccessfully.	Driver can continue to driver after authenticating successfully. The system will send the captured image and alert message to the owner of the car through Telegram after authenticating unsuccessfully.	Pass

Table 6.4.1 Table for Driver Authentication.

2. Monitoring the driver drunkenness and drowsiness.

Objective	Expected Result	Actual Result	Test Result
Monitor the driver drunkenness and drowsiness by detecting the eyes of the driver.	If the driver's eye is closed more than 4 seconds, it will display warning messages and send alert to the co-pilot.	If the driver's eye is closed more than 4 seconds, it will display warning messages and send alert to the co-pilot.	Pass

Table 6.4.2 Table for Monitoring the Driver Drunkenness and Drowsiness.

3. Alcohol gas detection.

Objective	Expected Result	Actual Result	Test Result
Detect alcohol gas.	If the alcohol gas is sensed by the gas sensor and over the 800ppm, the system will display the warning on the screen to notify the driver.	If the alcohol gas is sensed by the gas sensor and over the 50%, the system will display the warning on the screen to notify the driver.	Pass

Table 6.4.3 Table for Alcohol Gas Detection.

4. Provide connection between the driving monitoring system and the car owner.

Objective	Expected Result	Actual Result	Test Result
Provide connection between the driving monitoring system and the owner of the car	It will display the value of temperature and humidity when received commands.	It will display the value of temperature and humidity when received commands.	Pass

Table 6.4.4 Table for Provide Connection Between the Driving Monitoring System and The Car Owner.

6.5 Concluding Remark

As a conclusion for this chapter, all the test cases are generated to test the performance and verification of this system. The system is setup completely for testing it and the results are showed on the tables provided. The overall result of the system is acceptable. There are also some challenges and limitation of this system.

Chapter 7
Conclusion and Recommendation

7.1 Conclusion

In conclusion, the driver monitoring system is completely developed and normally functioned. The system able to verify the driver and sense the present of alcohol when the driver entered the car. During the driving process, the system able to monitor the driver's eyes closed time to prevent driver causing accident when fell into drunkenness and drowsiness condition. When the system detected the driver's eyes closed more than 4 second, the system will display the warning message on the OLED display and produce alert from the buzzer to alert the driver and co-pilot. In normal condition, the OLED display will show the values of temperature and humidity. In addition, the system also stays connected with the driver all the time by using Telegram and Ubidots.

7.2 Recommendation

In the project, I will recommend the system to upgrade a good quality camera. The 8 Raspberry Pi camera used for the current project is working fine on the situation that are enough brightness. However, the Raspberry Pi camera unable to capture and stream in the dark condition especially during the nighttime. For example, the Raspberry Pi camera will display and capture the black image when in the low or no brightness environment which caused the system unable to monitor the driver. For the good quality camera, it able to handle the capturing and streaming process in the dark environment. Furthermore, I will also recommend the system to use a more sensitive gas sensor. This is because the gas sensor MQ135 used in the system unable to sense the present of alcohol when the driver is far from it. When using a more sensitive gas sensor, it can sense the present of alcohol although the driver is far from the it.

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APPENDIX

Datasheet

A1 ADS1115 16-Bit ADC

ELECTRICAL CHARACTERISTICS

All specifications at –40°C to +125°C, VDD = 3.3V, and Full-Scale (FS) = ±2.048V, unless otherwise noted.
Typical values are at +25°C.

PARAMETER	TEST CONDITIONS	ADS1113, ADS1114, ADS1115			UNIT
		MIN	TYP	MAX	
ANALOG INPUT					
Full-scale input voltage[1]	V_{IN} = (AIN_P) – (AIN_N)		±4.096/PGA		V
Analog input voltage	AIN_P or AIN_N to GND	GND		VDD	V
Differential input impedance			See Table 2		
Common-mode input impedance	FS = ±6.144V[1]		10		MΩ
	FS = ±4.096V[1], ±2.048V		6		MΩ
	FS = ±1.024V		3		MΩ
	FS = ±0.512V, ±0.256V		100		MΩ
SYSTEM PERFORMANCE					
Resolution	No missing codes	16			Bits
Data rate (DR)			8, 16, 32, 64, 128, 250, 475, 860		SPS
Data rate variation	All data rates	–10		10	%
Output noise			See Typical Characteristics		
Integral nonlinearity	DR = 8SPS, FS = ±2.048V, best fit[2]			1	LSB
Offset error	FS = ±2.048V, differential inputs		±1	±3	LSB
	FS = ±2.048V, single-ended inputs		±3		LSB
Offset drift	FS = ±2.048V		0.005		LSB/°C
Offset power-supply rejection	FS = ±2.048V		1		LSB/V
Gain error[3]	FS = ±2.048V at 25°C		0.01	0.15	%
Gain drift[3]	FS = ±0.256V		7		ppm/°C
	FS = ±2.048V		5	40	ppm/°C
	FS = ±6.144V[1]		5		ppm/°C
Gain power-supply rejection			80		ppm/V
PGA gain match[3]	Match between any two PGA gains		0.02	0.1	%
Gain match	Match between any two inputs		0.05	0.1	%
Offset match	Match between any two inputs		3		LSB
Common-mode rejection	At dc and FS = ±0.256V		105		dB
	At dc and FS = ±2.048V		100		dB
	At dc and FS = ±6.144V[1]		90		dB
	f_{CM} = 60Hz, DR = 8SPS		105		dB
	f_{CM} = 50Hz, DR = 8SPS		105		dB
DIGITAL INPUT/OUTPUT					
Logic level					
V_{IH}		0.7VDD		5.5	V
V_{IL}		GND – 0.5		0.3VDD	V
V_{OL}	I_{OL} = 3mA	GND	0.15	0.4	V
Input leakage					
I_H	V_{IH} = 5.5V			10	µA
I_L	V_{IL} = GND	10			µA

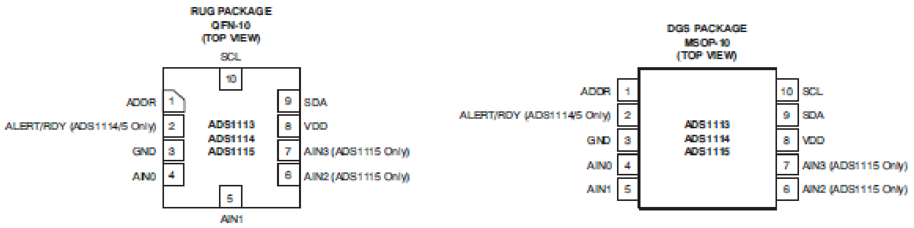
(1) This parameter expresses the full-scale range of the ADC scaling. In no event should more than VDD + 0.3V be applied to this device.
(2) 99% of full-scale.
(3) Includes all errors from onboard PGA and reference.

ELECTRICAL CHARACTERISTICS (continued)

All specifications at –40°C to +125°C, VDD = 3.3V, and Full-Scale (FS) = ±2.048V, unless otherwise noted.
Typical values are at +25°C.

PARAMETER	TEST CONDITIONS	ADS1113, ADS1114, ADS1115			UNIT
		MIN	TYP	MAX	
POWER-SUPPLY REQUIREMENTS					
Power-supply voltage		2		5.5	V
Supply current	Power-down current at 25°C		0.5	2	μA
	Power-down current up to 125°C			5	μA
	Operating current at 25°C		150	200	μA
	Operating current up to 125°C			300	μA
Power dissipation	VDD = 5.0V		0.9		mW
	VDD = 3.3V		0.5		mW
	VDD = 2.0V		0.3		mW
TEMPERATURE					
Storage temperature		–60		+150	°C
Specified temperature		–40		+125	°C

PIN CONFIGURATIONS



PIN DESCRIPTIONS

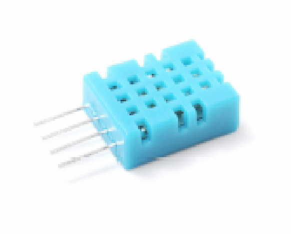
PIN #	DEVICE			ANALOG/ DIGITAL INPUT/ OUTPUT	DESCRIPTION
	ADS1113	ADS1114	ADS1115		
1	ADDR	ADDR	ADDR	Digital Input	I²C slave address select
2	NC[1]	ALERT/RDY	ALERT/RDY	Digital Output	Digital comparator output or conversion ready (NC for ADS1113)
3	GND	GND	GND	Analog	Ground
4	AIN0	AIN0	AIN0	Analog Input	Differential channel 1: Positive input or single-ended channel 1 input
5	AIN1	AIN1	AIN1	Analog Input	Differential channel 1: Negative input or single-ended channel 2 input
6	NC	NC	AIN2	Analog Input	Differential channel 2: Positive input or single-ended channel 3 input (NC for ADS1113/4)
7	NC	NC	AIN3	Analog Input	Differential channel 2: Negative input or single-ended channel 4 input (NC for ADS1113/4)
8	VDD	VDD	VDD	Analog	Power supply: 2.0V to 5.5V
9	SDA	SDA	SDA	Digital I/O	Serial data: Transmits and receives data
10	SCL	SCL	SCL	Digital Input	Serial clock input: Clocks data on SDA

(1) NC pins may be left floating or tied to ground.

A2 Temperature and Humidity Sensor DHT11

AOSONG

Your specialist in innovating humidity & temperature sensors



Digital relative humidity & temperature sensor DHT11

1. Feature & Application:

*Good precision
*Resistive type
*Full range temperature compensated
*Relative humidity and temperature measurement
*Calibrated digital signal
*Outstanding long-term stability
*Extra components not needed
*Long transmission distance, up to 100 meters
*Low power consumption
*4 pins packaged and fully interchangeable

2. Description:

DHT11 output calibrated digital signal. It applys exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements is connected with 8-bit single-chip computer.

Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in type of programme in OTP memory, when the sensor is detecting, it will cite coefficient from memory.

Small size & low consumption & long transmission distance(100m) enable DHT11 to be suited in all kinds of harsh application occasions. Single-row packaged with four pins, making the connection very convenient.

3. Technical Specification:

Model	DHT11	
Power supply	3.3-5.5V DC	
Output signal	digital signal via Aosong 1-wire bus	
Sensing element	Polymer humidity resistor	
Operating range	humidity 20-90%RH;	temperature 0~50Celsius
Accuracy	**humidity +-5%RH;**	temperature +-2Celsius
Resolution or sensitivity	humidity 1%RH;	temperature 1Celsius
Repeatability	humidity +-2%RH;	temperature +-1Celsius
Humidity hysteresis	+-1%RH	
Long-term Stability	+-1%RH/year	
Interchangeability	fully interchangeable	

4.Dimensions: (unit----mm)

Aosong Electronics Co., Ltd.
http://www.aosong.com
Thomas Liu (Sales Manager)
Email: thomasliu198518@aliyun.com , sales@aosong.com

A3 Gas Sensor MQ135

TECHNICAL DATA MQ-135 GAS SENSOR

FEATURES

Wide detecting scope Fast response and High sensitivity
Stable and long life Simple drive circuit

APPLICATION

They are used in air quality control equipments for buildings/offices, are suitable for detecting of NH3,NOx, alcohol, Benzene, smoke,CO_2 ,etc.

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remarks
Vc	Circuit voltage	5V±0.1	AC OR DC
V_H	Heating voltage	5V±0.1	ACOR DC
R_L	Load resistance	can adjust	
R_H	Heater resistance	33Ω±5%	Room Tem
P_H	Heating consumption	less than 800mw	

B. Environment condition

Symbol	Parameter name	Technical condition	Remarks
Tao	Using Tem	-10□-45□	
Tas	Storage Tem	-20□-70□	
R_H	Related humidity	less than 95%Rh	
O_2	Oxygen concentration	21%(standard condition)Oxygen concentration can affect sensitivity	minimum value is over 2%

C. Sensitivity characteristic

Symbol	Parameter name	Technical parameter	Ramark 2
Rs	Sensing Resistance	30KΩ-200KΩ (100ppm NH_3)	Detecting concentration scope： 10ppm-300ppm NH_3 10ppm-1000ppm Benzene 10ppm-300ppm Alcohol
α (200/50) NH_3	Concentration Slope rate	≤0.65	
Standard Detecting Condition	Temp: 20□±2□ Vc:5V±0.1 Humidity: 65%±5% Vh: 5V±0.1		
Preheat time	Over 24 hour		

D. Structure and configuration, basic measuring circuit

	Parts	Materials
1	Gas sensing layer	SnO_2
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	Ni-Cr alloy
5	Tubular ceramic	Al_2O_3
6	Anti-explosion network	Stainless steel gauze (SUS316 100-mesh)
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

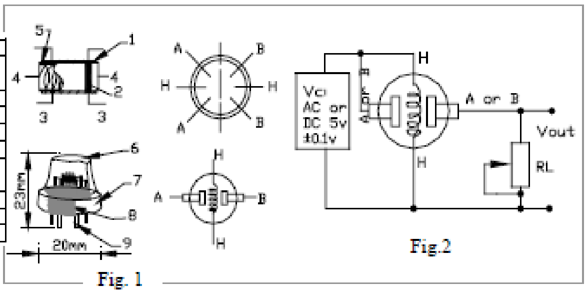
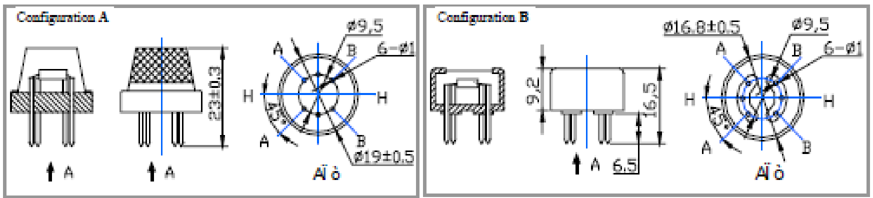


Fig. 1



Structure and configuration of MQ-135 gas sensor is shown as Fig. 1 (Configuration A or B), sensor composed by micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	Study week no.: 1
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **Explore on image processing for face detection and recognition.**
2. WORK TO BE DONE **Need to decide on choosing the library and install on the Raspberry Pi to handle image processing.**
3. PROBLEMS ENCOUNTERED **There are some image processing libraries are too heavy for the Raspberry Pi.**
4. SELF EVALUATION OF THE PROGRESS **I think I will explore more on the image processing library.**

TEOH
Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	Study week no.: 2
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **Installed the OpenCV library to handle the image processing parts like face recognition and detection.**
2. WORK TO BE DONE **Need to use OpenCV library for detecting face and eyes.**
3. PROBLEMS ENCOUNTERED **In the installation of OpenCV, there are a lot of steps and commands for installing the library. During the installation process, there are some steps failed to install due to the incompatible version.**
4. SELF EVALUATION OF THE PROGRESS **I need to explore and study how to use OpenCV for detecting face and eyes.**

TEOH

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.: 3**
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **Use OpenCV library for face recognition to recognize the car owner of the system.**
2. WORK TO BE DONE **Use OpenCV library for face detection and tracking to track the driver during the driving process.**
3. PROBLEMS ENCOUNTERED **The face recognition by using OpenCV library recognized incorrectly in sometimes like recognize unknown people as the car owner.**
4. SELF EVALUATION OF THE PROGRESS **I need to explore how to increase some knowledge for face recognition on OpenCV library.**

TEOH

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	Study week no.: 4
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **Use OpenCV library for face detection to detect the face of the driver. A blue square box is drawn when detected the driver's face.**
2. WORK TO BE DONE **Use OpenCV library for eye detection to detect the eyes of the driver.**
3. PROBLEMS ENCOUNTERED **During the face detection, the preview of detecting the face is not smooth and laggy.**
4. SELF EVALUATION OF THE PROGRESS **I need to explore more on OpenCV library for eyes detection and tracking.**

TEOH

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	Study week no.: 5
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **Use OpenCV library for eye detection to detect the eyes of the driver. A green square box is drawn when detected the eyes of the driver.**
2. WORK TO BE DONE **Combine the whole image processing parts together like face and eyes detection and tracking.**
3. PROBLEMS ENCOUNTERED **During the eye's detection and tracking, the OpenCV library able to detect one eye in sometimes. In addition, the OpenCV library detected some object as "eye" in some cases.**
4. SELF EVALUATION OF THE PROGRESS **I think I need to reduce the framerate of the face and eyes detection to ensure the process is smooth.**

TEOH

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.: 6**
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **The image processing parts such as face detection and eye's tracking are combined.**
2. WORK TO BE DONE **Solder the sensors and components on the PCB board to make the hardware of the system tidier.**
3. PROBLEMS ENCOUNTERED **When combine each part into the system, the detection of eyes and face will miss detection and detected wrongly in sometimes.**
4. SELF EVALUATION OF THE PROGRESS **I need to explore on how to solder nicely for the sensors and components on the PCB board.**

TEOH

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.: 7**
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **All the sensors and components are soldered nicely on the PCB board. The PCB board also connected with the Raspberry Pi mainboard by using GPIO pin header.**
2. WORK TO BE DONE **Test all the sensors and components after soldered on the PCB board.**
3. PROBLEMS ENCOUNTERED **In the solder process, the heat on the tip of the soldering pencil is not stable which resulted very hard to solder. Furthermore, there is a problem of connecting PCB board with the Raspberry Pi mainboard due to the longer pins of the sensors.**
4. SELF EVALUATION OF THE PROGRESS **I have found out the way to connect the PCB board with the Raspberry Pi mainboard by using double GPIO pin header to increase the height.**

TEOH
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Supervisor's signature

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Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.: 8**
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **All the sensors and components are tested and completely function.**
2. WORK TO BE DONE **Need to configure the OLED display to display values for temperature and humidity in normal condition and display warning message in warning condition.**
3. PROBLEMS ENCOUNTERED **The buzzer connected with GPIO 5 in PCB board has some delay on produce alert and unable to produce sound in sometimes.**
4. SELF EVALUATION OF THE PROGRESS **I have found out the way to solve the buzzer problem by connecting another buzzer with the original designed GPIO24.**

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Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.: 9**
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **OLED display is configured to display values for temperature and humidity in normal condition and display warning message in warning condition.**
2. WORK TO BE DONE **To setup Telegram and Ubidots for providing connection between the system and the car owner.**
3. PROBLEMS ENCOUNTERED **In the configuration for the OLED display, the system prompted out the Remote IO Error in sometimes due to the problem of the code.**
4. SELF EVALUATION OF THE PROGRESS **I need to explore how to create a bot for Telegram for handling commands from the car owner.**

TEOH

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	Study week no.: 10
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **Telegram and its bot are setup completely and able to response after received commands. The Ubidots is created to display the temperature and humidity values.**
2. WORK TO BE DONE **Combine all the functions of each part into the main program.**
3. PROBLEMS ENCOUNTERED **The Ubidots has some delay when updating the values for temperature and humidity.**
4. SELF EVALUATION OF THE PROGRESS **I have found out the delay issues of Ubidots is because of the connection with their server.**

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Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.: 11**
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE

Combined all the functions of each part into the main program. The whole system is functioned as normal and working well.

2. WORK TO BE DONE

Create test case and conduct for the whole system to test the system performance.

3. PROBLEMS ENCOUNTERED

After the combination of each part functions, the main program resulted a huge delay when execute each function.

4. SELF EVALUATION OF THE PROGRESS

I have figured out and solved the huge delay problem by using multi-threading to let each function run parallel at the same time.

TEOH
Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.: 12**
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **A few test cases are created to test the performance of the whole system. The face recognition and face, eyes detection and tracking are tested for this system.**
2. WORK TO BE DONE **Conduct testing for testing the part for communication between the system and the car owner, alcohol gas detection and information display in normal and warning condition.**
3. PROBLEMS ENCOUNTERED **In the low brightness environment, the system unable to detect and monitor the eyes of the driver.**
4. SELF EVALUATION OF THE PROGRESS **I think I need to be more hardworking to test all the test cases for the system.**

TEOH
Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	Study week no.: 13
Student Name & ID: Ho Jeng Hung 19ACB02998	
Supervisor: Mr Teoh Shen Khang	
Project Title: Raspberry Pi based Cyber Physical System for Driver Monitoring	

1. WORK DONE **The testing for communication between the system and the car owner, alcohol gas detection and information display in normal and warning condition are conducted to the system performance.**
2. WORK TO BE DONE **To put comments and arrange orderly for the code.**
3. PROBLEMS ENCOUNTERED **The driver needs to be very close to the gas sensor for sensing the present of alcohol.**
4. SELF EVALUATION OF THE PROGRESS **I have figured out the problem is because of the limitation of the gas sensor.**

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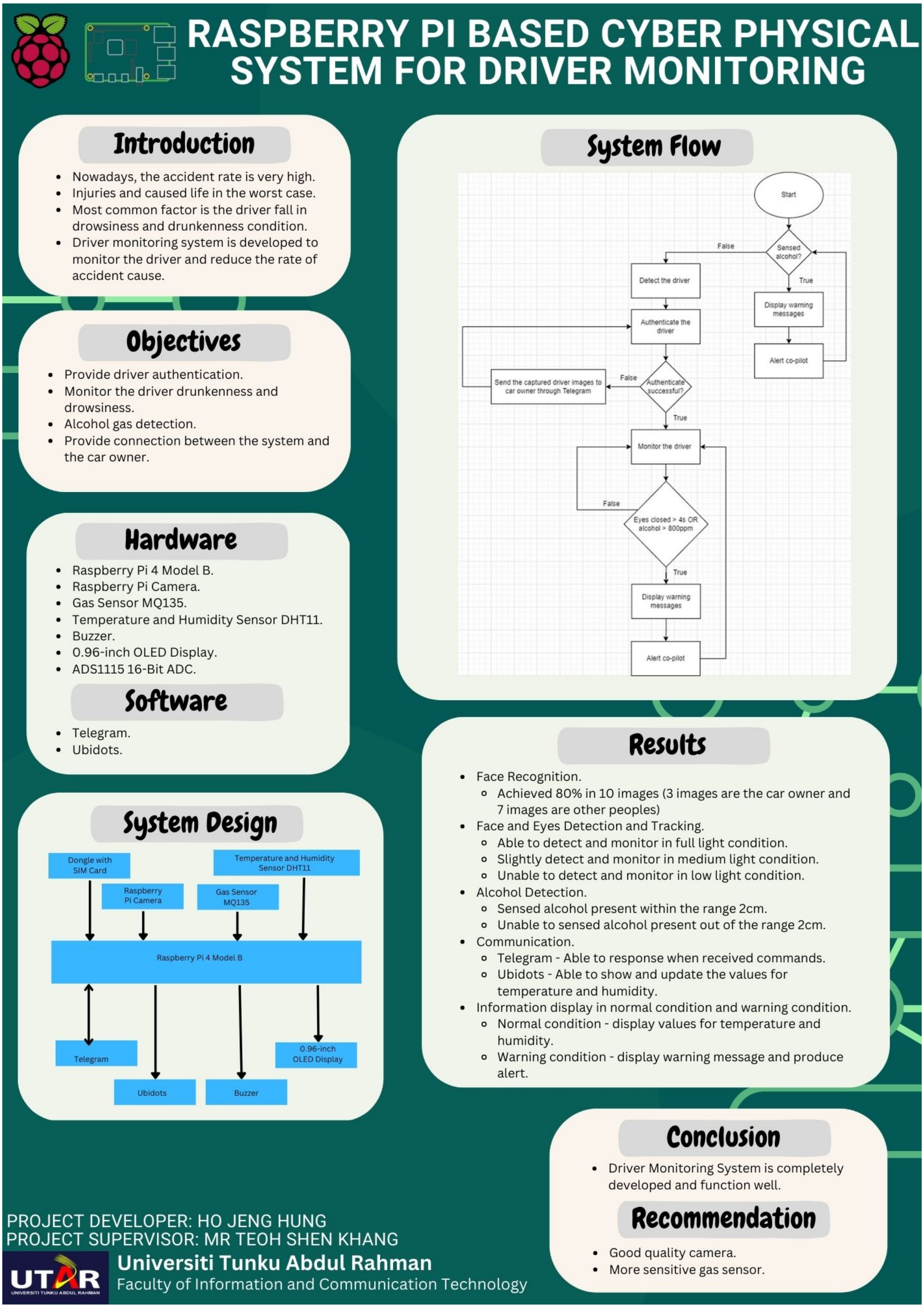
Student's signature

POSTER


RASPBERRY PI BASED CYBER PHYSICAL SYSTEM FOR DRIVER MONITORING
Introduction
Nowadays, the accident rate is very high.
Injuries and caused life in the worst case.
Most common factor is the driver fall in drowsiness and drunkenness condition.
Driver monitoring system is developed to monitor the driver and reduce the rate of accident cause.
Objectives
Provide driver authentication.
Monitor the driver drunkenness and drowsiness.
Alcohol gas detection.
Provide connection between the system and the car owner.
Hardware
Raspberry Pi 4 Model B.
Raspberry Pi Camera.
Gas Sensor MQ135.
Temperature and Humidity Sensor DHT11.
Buzzer.
0.96-inch OLED Display.
ADS1115 16-Bit ADC.
Software
Telegram.
Ubidots.
System Design
Dongle with SIM Card
Temperature and Humidity Sensor DHT11
Raspberry Pi Camera
Gas Sensor MQ135
Raspberry Pi 4 Model B
Telegram
0.96-inch OLED Display
Ubidots
Buzzer
System Flow
Start
Sensed alcohol?
False
True
Display warning messages
Alert co-pilot
Detect the driver
Authenticate the driver
Authenticate successful?
Send the captured driver images to car owner through Telegram
Monitor the driver
Eyes closed > 4s OR alcohol > 800ppm
Display warning messages
Alert co-pilot
Results
Face Recognition.
Achieved 80% in 10 images (3 images are the car owner and 7 images are other peoples)
Face and Eyes Detection and Tracking.
Able to detect and monitor in full light condition.
Slightly detect and monitor in medium light condition.
Unable to detect and monitor in low light condition.
Alcohol Detection.
Sensed alcohol present within the range 2cm.
Unable to sensed alcohol present out of the range 2cm.
Communication.
Telegram - Able to response when received commands.
Ubidots - Able to show and update the values for temperature and humidity.
Information display in normal condition and warning condition.
Normal condition - display values for temperature and humidity.
Warning condition - display warning message and produce alert.
Conclusion
Driver Monitoring System is completely developed and function well.
Recommendation
Good quality camera.
More sensitive gas sensor.
PROJECT DEVELOPER: HO JENG HUNG
PROJECT SUPERVISOR: MR TEOH SHEN KHANG
UTAR
Universiti Tunku Abdul Rahman
Faculty of Information and Communication Technology

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Full Name(s) of Candidate(s)	Ho Jeng Hung
ID Number(s)	19ACBB02998
Programme / Course	Bachelor of Information Technology (Honours) Computer Engineering
Title of Final Year Project	Raspberry Pi based Cyber Physical System for Driver Monitoring

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TEOH
Signature of Supervisor

Name: Mr Teoh Shen Khang

Date: 27 April 2023

Signature of Co-Supervisor

Name:

Date:

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