UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF V-BOX SENSOR FOR AUTOMOTIVE APPLICATION

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

NUR AIDILFITRI ISKANDAR BIN JOHOR

Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

2021

DEVELOPMENT OF V-BOX SENSOR FOR AUTOMOTIVE APPLICATION

NUR AIDILFITRI ISKANDAR BIN JOHOR

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics)
with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Development of V-Box sensor for automotive application

Sesi Pengajian: 2021/2022

Saya Nur Aidilfitri Iskandar Bin Johor mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

Alamat Tetap: Blok B-1-3 Taman Dahlia,
Mukim Kuah, 07000 Langkawi, Kedah

(COP DAN TANDATANGAN PENYELIA)

AMINURRASHID BIN NOORDIN
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Elektrik
Fakulti Teknologi Kejuruteraan Elektrik Dan Elektronik
Universiti Teknikal Malaysia Melaka

Tarikh: 8 January 2022

Tarikh: 11/01/2022

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this project report entitled “Development of V-Box sensor for automotive application” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Student Name : NUR AIDILFITRI ISKANDAR BIN JOHOR

Date : 8 January 2022

اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

Signature :

Supervisor Name : AMINURRASHID BIN NOORDIN

Date : 11/01/2022

Signature :

Co-Supervisor Name (if any) :

Date :

اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEDICATION

To my beloved mother, NORIMAH BINTI NOFIAH and father, JOHOR BIN SALEH.

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRACT

Due to technological changes through time, humans are provided with varied conveniences. For tracking vehicle movements from anyplace the tracking device for a car is incredibly convenient. An automobiles efficient tracking system is developed to monitor the movement of fitted vehicles at all times. A V-Box is the instrument used to capture and analyse the performance of vehicles to improve stability, comfort and managing. This project focuses on the design of observers to estimate variables like acceleration and distance using the sensor to collect data and monitor the movement by low cost V-Box systems steering view. The difference between the transmission of the signal and the receiving signal time is calculated. It is mainly aimed at using complementary filter at IMU 6050, GPS to get the location, and raspberry pi as main controller. All of the components including GPS NEO 6M and MPU6050 is used to create for the V-Box sensor. In addition, drivers like to be in a hurry by recklessly pressing the oil pedal and like to press the brakes repeatedly without trying to control the vehicle by slowing down the vehicle or keeping distance while on the road. In fact, brake pads and tires are also easy to wear and need to be replaced frequently because that problem this system can reduce the cost of changing car spare parts because this system can display the speed and angle of the car tires and the driver can ensure good driving conditions. Therefore, a solution the v-box system, this system can record data and can analyze the driver's driving behaviour. This simulation is conducted on the gps and imu sensor. The simulation is conducted by testing the sensor in different destination. From TTU (Taman Tasek Utama))to FTKEE, FTKEE to Pertonas and Pertonas to Mydin. Also, the data are collected by comparing the measurement from the GPS and IMU 6050 This vbox also be able to offline analysis the control system for the cars based on the recorded data. In analysis, V-Box get data is the location such longitude, latitude, google map, stering behavior and speed with diffrence destination.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRAK

Disebabkan oleh perubahan teknologi melalui masa, manusia dibekalkan dengan pelbagai kemudahan. Untuk menjejaki pergerakan kenderaan dari mana-mana tempat, peranti pengesan untuk kereta adalah sangat mudah. Sistem pengesanan cekap kereta dibangunkan untuk memantau pergerakan kenderaan yang dipasang pada setiap masa. V-Box ialah instrumen yang digunakan untuk menangkap dan menganalisis prestasi kenderaan untuk meningkatkan kestabilan, keselesaan dan pengurusan. Projek ini memberi tumpuan kepada reka bentuk pemerhati untuk menganggar pembolehubah seperti pecutan dan jarak menggunakan sensor untuk mengumpul data dan memantau pergerakan dengan pandangan stereng sistem V-Box kos rendah. Perbezaan antara penghantaran isyarat dan masa isyarat penerimaan dikira. Ia terutamanya bertujuan untuk menggunakan penapis pelengkap di IMU 6050, GPS untuk mendapatkan lokasi, dan raspberry pi sebagai pengawal utama. Semua komponen termasuk GPS NEO 6M dan MPU6050 digunakan untuk mencipta bagi penderia V-Box. Selain itu, pemandu suka tergesa-gesa dengan menekan pedal minyak secara melulu dan suka menekan brek berulang kali tanpa cuba mengawal kenderaan dengan memperlahankan kenderaan atau menjaga jarak ketika berada di jalan raya. Malah, pad brek dan tayar juga mudah dipakai dan perlu kerap ditukar kerana masalah itu sistem ini dapat mengurangkan kos menukar alat ganti kereta kerana sistem ini dapat memaparkan kelajuan dan sudut tayar kereta serta pemandu dapat memastikan keadaan pemanduan yang baik. Oleh itu, penyelesaian sistem v-box, sistem ini boleh merekod data dan boleh menganalisis tingkah laku pemanduan pemandu. Simulasi ini dijalankan pada sensor gps dan imu. Simulasi dijalankan dengan menguji sensor di destinasi yang berbeza. Dari TTU (Taman Tasek Utama))ke FTKEE, FTKEE ke Pertonas dan Pertonas ke Mydin. Selain itu, data dikumpul dengan membandingkan ukuran dari GPS dan IMU 6050 vbox ini juga boleh menganalisis secara luar talian sistem kawalan untuk kereta berdasarkan data yang direkodkan. Dalam analisis, V-Box menunjukkan data ialah lokasi seperti longitud, latitud, peta google, tingkah laku stering dan kelajuan dengan destinasi yang berbeza.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACKNOWLEDGEMENTS

First of all, I should like to thank my Supervisor, Mr. Aminurrashid bin Noordin, for his invaluable advice, knowledge and patient work. I can be lost without him and escape the path I should take without him.

I also like to thank my professors for giving me all the valuable info. I would also want to convey my sincere gratitude for the support and assistance of all my colleagues in result of the process. I thank Mr. Abdul Wafi Bin Abdul Rahem and Mr. Muhammad Zahid Bin Zaharudin, who supported me in particular, for helping to develop mechanism and part.

I would want to thank my dear mother and my family, last but not least, for their support, understanding and patience for me. I could not have finished my job without their help.

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TABLE OF CONTENTS

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF TABLES

اونيؤرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF FIGURES

UTeM
اونيۆرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UTeM
اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF SYMBOLS

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF SYMBOLS

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF ABBREVIATIONS

V - Voltage
-
-
-
-
-
-
-

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF APPENDICES

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 1

INTRODUCTION

1.1 Background

A V-Box is the instrument used to capture and analyse the performance of vehicles to improve stability, comfort and managing. The dynamics of the automobile, for example, longitudinal and lateral accelerations and a yaw speed, should always be known to these systems when different manoeuvres are carried out in order to function in the vehicles (brakes, steering and suspension) and to produce a satisfactory performance. In the IMU sensors measure the angular rates of yawing and accelerations directly through rate gyroscopes and accelerometers. This project focuses on the design of observers to estimate variables like (acceleration, distance, angle of laziness) using the sensor data of current cars and monitor the movement by means of low cost V-Box systems on steering and front tyre (left and right).

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The Raspberry is a small-scale microprocessor that offers a very popular alternative to Arduino, BASIC Stamps and other sorts of microcontrollers. It can be used to develop a virtual lab that can collect and store all data from IMU sensors, including the accelerometer, gyroscope and magnetometer, as well as GPS coordinates from the sensor and data fusion. In addition, the Global Positioning System (GPS) works with accurate location information. This allows tracking the traffic of a vehicle or person. For instance, a GPS system tracking the way in which a V-box system is progressing can be used.

1.2 Problem Statement

Nowadays, many research studies focus on the design of observers, so the data supplied by the sensors put on existing cars or low cost devices to tackle this problem may be utilised to estimate these variables. Now many new cars no have good car control systems. In addition, drivers like to be in a hurry by recklessly pressing the oil pedal and like to press the brakes repeatedly without trying to control the vehicle by slowing down the vehicle or keeping distance while on the road. In fact, brake pads and tires are also easy to wear and need to be replaced frequently because that problem this system can reduce the cost of changing car spare parts because this system can display the speed and angle of the car tires and the driver can ensure good driving conditions. Therefore, a solution the v-box system, this system can record data and can analyze the driver's driving behaviour.

1.3 Project Objective

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The objectives of this project are as follows:

a) To design a V-Box system using Raspberry Pi

b) To monitor and record data from the IMU sensor and the GPS via the V-Box

c) To analyze car motion from V-Box’s data

1.4 Scope of Project

By reducing the demands for this project, a number of guidelines are given to ensure that this project meets its targets. The scope of this project is:

a) The V-Box comprise of IMU sensor, GPS, and one camera to monitor automotive vehicle movement

b) Raspberry Pi is the main controller to process data from all sensor and camera.

c) In one vehicle locations a web camera type is fitted at seatbelt to monitor stering behavior.

d) A complementary filter is applied for IMU Sensor Fusion to determine vehicle speed and acceleration.

e) GPS is used to determine vehicle distance, speed and acceleration compare to IMU.

f) All the data will be analayze and camera be recorded and view offline for analysis.

UTeM
اونيۏرسيتي تيکنيکل مليسيا ملاک
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter discusses about the articles related to this project. It consists of the products that have been developed by institutions before this project. This chapter contains the theory and implementation of the component and equipment used in the previous project.

2.2 Vehicle Coordinate System

The reality is that the true misalignment cannot be measured simply. It is based on a very accurate INS/GNSS system, which is used as a basis for the movement variables. As indicated in Figure 2.1, two calibration approaches are given and confirmed experimentally to estimate the rotation of 3D between the ground and both the IMU and vehicle co-ordinate systems. The combination of these two revolutions offers a reference 3D to the vehicle coordination systems between the IMU and the GPS (Marco *et al.*, 2021).

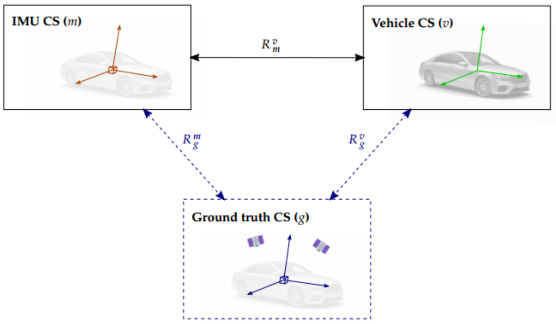


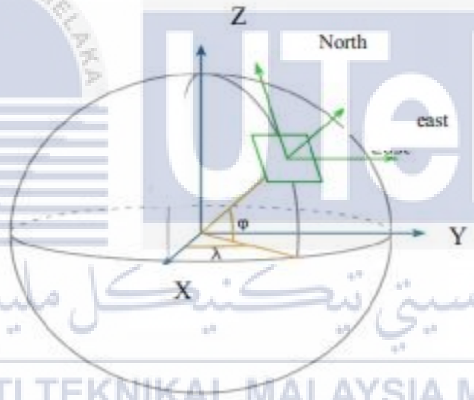
Figure 2.1 Car coordinate system

Besides that, in the use of the wheel speed information dead reckoning method, the vehicle trajectory is assumed to be circular according to the mileage and vehicle yaw angle

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

change to estimate the position change. At the same time, according to the GPS speed information dynamic estimation of wheel radius, to reduce the different driving conditions, wheel radius change of position calculation (Zhu *et al.*, 2017).

Improved localisation and mapping in autonomous vehicle systems, as indicated in Figure 2.2, are the continuous study topics. To avoid crashes and safely drive a car that is often divided into 4 basic aspects like perception, location and mapping, path planning and control it is essential for obtaining sub-decimeter precision level. The car uses an online sensor gaggle to detect, comprehend and interpret an environment that encompasses static and dynamic barriers, such as moving vehicles, pedestrian vehicles, road signs, signals and road curbs. (Fayyad *et al.*, 2020)



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 2.2 The horizontal system of local and geocentric coordinates

2.3 Camera in Autonomous Vehicle

The development of the AV called the monocardial view, stereo and camera mainly employs three camera types (built-in camera). For specific ADAS applications, including as forward-collition alarms, foot detection, traffic signal recognition, lane start alarm, progress monitoring and blind spot monitoring as well as intelligent headlight control, such as the images displayed in Figure 2.3, these cameras are all needed. The optimum way for blind spot sensing to enable for longer views is for the cameras to be mounted close to the side view mirror. In addition, at least 360 views from a stand-alone car on each side and on the front and back are taken from cameras (Herman and Ismail, 2017).

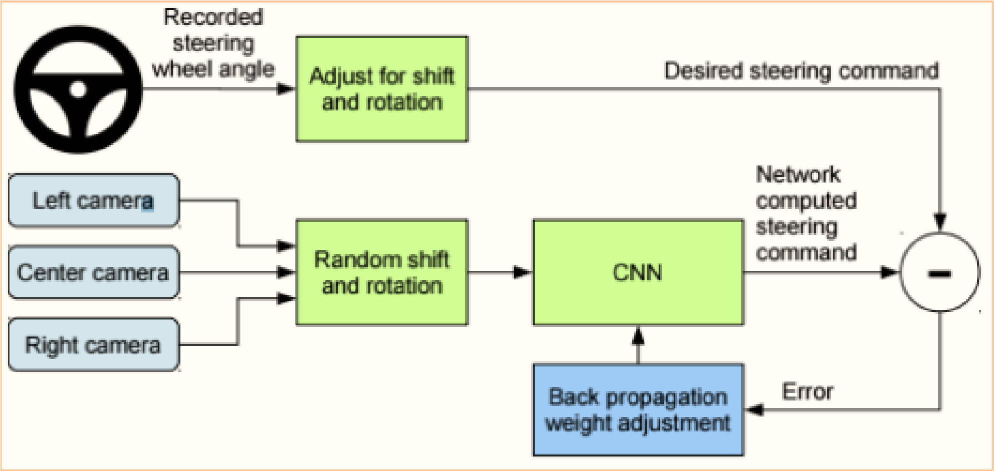


Figure 2.3 Camera training system

The strategy is based on combining data from many types of sensors at a basic level. The suggested technique, in particular, makes use of real-time LiDAR and camera data. The initial stage in the process is to calibrate the LiDAR and camera sensors, which entails estimating the extrinsic characteristics as well as the intrinsic characteristics of the camera. The intrinsic parameters of the camera were determined using the standard checkerboard calibration approach, and the extrinsic parameters of the LiDAR and camera were determined using a planar 3D marker board. Following that, using the calibration settings indicated in Figure 2.4, the LiDAR points are mapped onto the camera image. Finally, several performance evaluation methodologies were employed to verify the output of the LiDAR and camera in the form of fused data. The suggested data fusion approach's key benefit is that it provides an efficient depth estimation procedure for autonomous systems in driverless vehicles (Chu *et al.*, 2012).

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

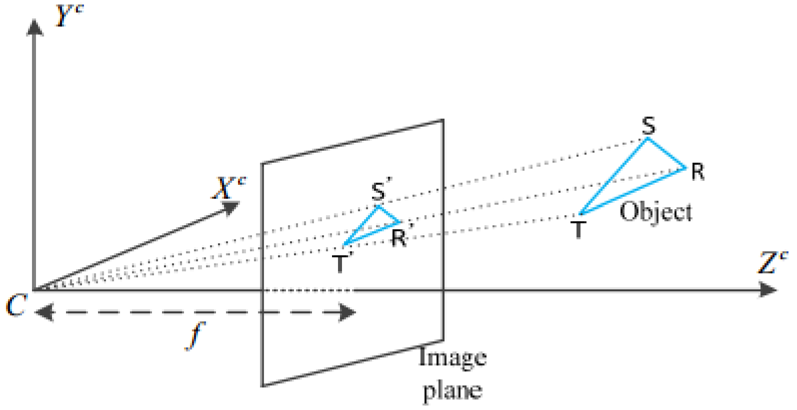


Figure 2.4 The pinhole projection model represents the camera frame

As perception in autonomous cars using a wide range of sensors and sensor systems is realised, cameras were one of the first types of sensors to be utilised in driverless cars. In autonomous driving the camera is an essential sensor. The camera use applications in self-driving vehicles are unlimited and the camera's drawback is the compute power required to process data. With 30 to 60 frame per second, the newest high-definition cameras are capable of producing a million pixels each frame to provide complex images. This causes the processing of multimegabytes of data in real time (Kocic, Jovicic and Drndarevic, 2018).

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2.4 Inertial Measurement Unit (IMU)

Advanced driver assistance and autonomous vehicle development are currently popular in the automobile industry in navigational systems. MPU-6000 is a popular IMU for several very low-cost Microelectromechanical systems applications (MEMS). The static analysis leads to the development of a real urban path that records an MPU-6000 IMU as shown in Figure 2.5, higher MEMS IMU and 2 GNSS receivers. In this preliminary study, a simple inertial sensor for low-cost integrated navigation systems has been concludes that the IMU mass-market may be regarded as acceptable for applications that tolerate a position error of around 2 meters and a heading angled error of around 3 degrees (4 degrees) approximately (Gonzalez and Dabove, 2019).

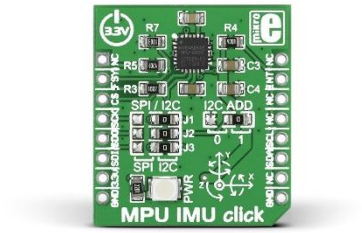


Figure 2.5 MPU-6000 6DOF IMU

The IMU composed of the gyroscope, accelerometer and magnetometer, as shown in Figure 2.6, is primarily a low cost attitude sensor. The IMU is designed for sampling and processing of microcontrollers in a size of 4 cm x 3 cm (MCU), a three-axis magnetometer (Mag) and a six-axis IMU. The three axis of asset sensors are generally orthogonal to each other and ideally attached to the UAV's centre of gravity (Yang *et al.*, 2020).

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 2.6 Magnetometer + 6DOF IMU

The trend of performance deterioration resulting from the decrease in cost is easily noticeable considering the TG6000 as the most expensive and MPU-6050 as the least as shown in Figure 2.7. Even a minimal gyroscope of car quality costs over USD 10,000. For both static and fast vehicles, several sensors such as the camera, LIDAR and GPS were employed extensively. These are nonetheless pricey and entail computer algorithms that are intense. The observer-based technique relies on a plant model estimate (i.e. the vehicle model) whereas the real-time estimate employs an on-board motion processor sensor to confirm the findings achieved by utilising filters (Mazhar *et al.*, 2020).

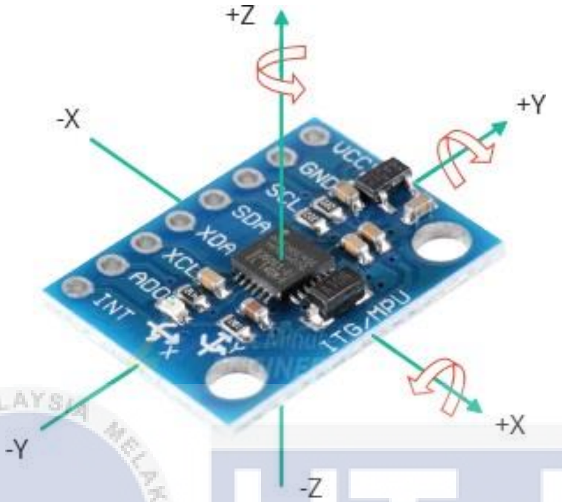


Figure 2.7 MPU-6050 6DOF IMU

2.5 Global Positioning System

The tracking system now is the person's most important system. That is the key cause for their auto safety. Therefore, car monitoring systems are becoming popular not just in urban regions, but also in small towns every day. The GPS-based vehicle monitoring system is meant to determine the exact location of every vehicle and inform the competent authorities of its whereabouts via an SMS. The system features an on-board module in the car to the tracked and downstation monitoring data from different cars. GPS GY-NEO6MV2 module was utilised as indicated in Figures 2.8 and SIM 900A GSM module. LCD, GSM modem and GPS Receiver are hardware interfaces to the microcontroller. MUX is used to link the controller to the GSM modem and the GPS receptor (Hlaing, Naing and Naing, 2019).

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

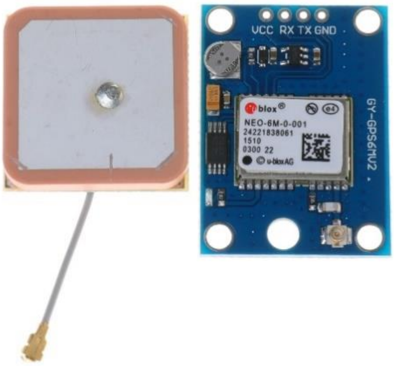


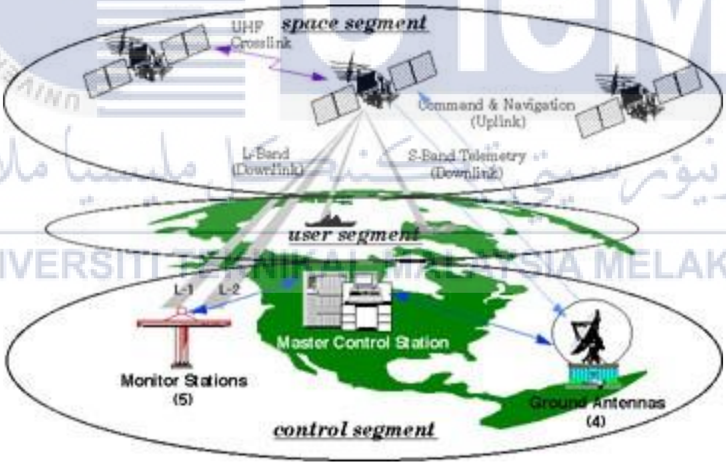
Figure 2.8 GY-NEO6MV2 GPS module

This is an autonomous vehicle mechatronic system. A route based on a GPS tracking system can be stored on the suggested system. It also contains the following features for more practical applications: Bump detection, collision avoidance. A model of the autonomous car with low-cost microcontrollers and sensors will contribute to a budget. The design proposal For autonomous travel of a specific course, the driver must drive the car in the desired path only one time while a GPS tracking system saves GPS waypoints from the onboard Android phone's GPS sensors and distances from the sensor as illustrated in Figure 2.9 (Zein, Darwiche and Mokhiamar, 2018).

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 2.9 Android GPS signal

A global positioning system is a 24-satellite constellation around the world. These satellites transmit location information via radio transmissions. A GPS tracking device (GPS receptor) located on the ground takes up the signals of satellite systems in order to identify the location of an entity in any part of the world. As illustrated in Figure 2.10, GPS is also known as NAVSTAR (Timing and Ranging Navigation System). On-Board Diagnostics port (OBD-II) is a common car protocol that is supported by modern cars to recover diagnostic faults over a microcontroller Controller Area Network (CAN) bus (MCU). The GSM module used is SIM900D, standardised AT command and several GSM networks compatible. The parameters for the transmission are: The baud rate is set at 19200 bps, the data is 8N1 and there is no flow control. The state of the engine can be shown for various metrics, such as RPM, engine coolant, speed and % throttle. The MediaTek MT3329 is the GPS receiver. Up to 10Hz upgrade rate is supported by the GPS module (Vanmore *et al.*, 2017).



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 2.10 NAVSTAR Global Positioning System

2.6 Sensor fusion in automotive

There are several sensors operating individually and unsynchronized, and each sensor tracking the data from the sensors themselves, before further processing it, it is necessary to first synchronies the data from the sensors. The Kalman Filter Prediction

Equations are implemented in order to forecast sensor and covariance data from the sensor measurement time to the fusion module calculation time, called data alignment. The position and cinematic variables of all sensors are composed. Each sensor uses the most suitable target description with its measurement principles. In tandem with the sensor axes, the viewing system describes an item through a cuboid surrounding the target identified. In this research, on the other hand, laser scanners are used to characterize an item utilizing three different points. These locations are the closest point of the object detected to the sensor, as well as the farther end of the item to the left and right. A succinct object representation is needed to ensure the sensors' real-time connection with the fusion system (Becker and Simon, 2000).

An extended Kalman filter reflects the features of each sensor during measurement. The two sensors were utilized to build an enlarged filter that reflected distance features by adding a reliability function, as illustrated in Figure 2.11. The experiment employed an actual automobile to test the efficiency of the approach. The system noise of the Kalman filter was compared to the distance calculated by the sensor characteristics by a fluid or by the approach presented. The study revealed that accurate measurement and distance error reflecting technique were enhanced in the construction of the extended Kalman filter, thanks to the LiDAR and Radar sensor fusion (Kim and Park, 2020).

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

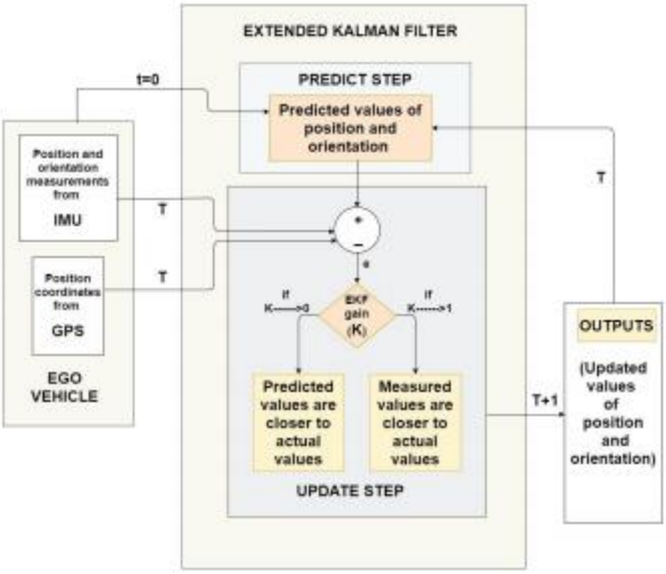


Figure 2.11 Extended kalman filter

Additional filter-based fusion sensor for applications of attitude estimation. Data from the accelerometer, gyroscope and sensor fusion magnetometer are taken into consideration in the system. It cascades into the linear and non-linear form of an additional filter and is influenced by Kalman cascading filter topologies. In order to compute online the gyroscope bias, the proportional integrated, non-linear version of CF is employed and the linear version is utilised to predict the attitude parameters. For selecting filter settings the architecture provided requires no tweaking (manual or adaptive) and is computer-cheap. In order to demonstrate its effectiveness, the CCF technology has been compared with other current algorithms and an adaptive variation of complementary filters. The accuracy of the system with a very little deviation in change of gain parameters shows the success of this system on diverse data sets is similar to that of the other systems. While the framework offered does not enhance estimation precision, it is an appropriate alternative to an estimate of attitude without reliance on adjusting filter parameters (Sofwan, 2018).

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2.7 Comparison between related projects

Table 2.1 Type of sensor and method used in previous research

No.	Reference	Sensor	Method
1.	(Gonzalez and Dabove, 2019)	MPU-6000 IMU GPS	Gaussian distribution
2.	(Yang *et al.*, 2020)	Magnetometer + 6DOF IMU GPS	Error-state kalman filter
3.	(Mazhar *et al.*, 2020)	MPU-6050 IMU GPS	Complementary filter and kalman filter
4.	(Vanmore *et al.*, 2017)	6DOF IMU GPS	Kalman filter and Error-state kalman filter
5.	(Thesis and Bader,2017)	MPU-6050 IMU LiDAR	Kalman filter and extended kalman filter

اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2.8 Summary

This project also concerns the conception and development of the IMU and GPS-integrated V-Box system. It is based on earlier studies in this area. complementary filter is used as sensor fusion technique between gyroscope and accelerometer in MPU-6050 to get a more stable reading. A 3.5" TFT touch screen is used to display system information for this project. The Raspberry Pi 4 model B is implemented as the V-Box system control. The GPS technology is used for the positioning of the autos. Finally, the MPU-6050 is used to collect accelerometer and gyroscope data.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 3

METHODOLOGY

3.1 Introduction

Generally speaking, a reconstruction vehicle or vehicle with a comparable dynamic property must frequently be examined for inspections by traffic accident experts when the vehicle involved in the accident is unavailable due, for example, to considerable damage. The most frequently examined parameter is braking deceleration, while acceleration must sometimes be measured or the speed trajectory must be identified during a given manoeuvre. Vehicle dynamics testing was reserved until recent times for automakers, certified institutions and institutes of research. Apparently, it has been possible to develop satellite navigation systems which not only apply to research, but also to the activities of an expert in traffic accident reconstruction. Such a V-Box appliance produced which, especially for data acquisition, has the incontestable advantages of rapid installation, small dimensions and usability.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.2 Methodology

This thesis presents a new and integrated analytical approach sensor IMU to use consept sensor fusion. This system approach used in this project is centered on the concepts of complementary filter. The approach chosen is based on a quantitative type, which aims to develop an analytical model for calculating and analyzing a acceleration and distance on the components of the V-box. The method (design) is experimental, using empirical modeling and statistical approaches.

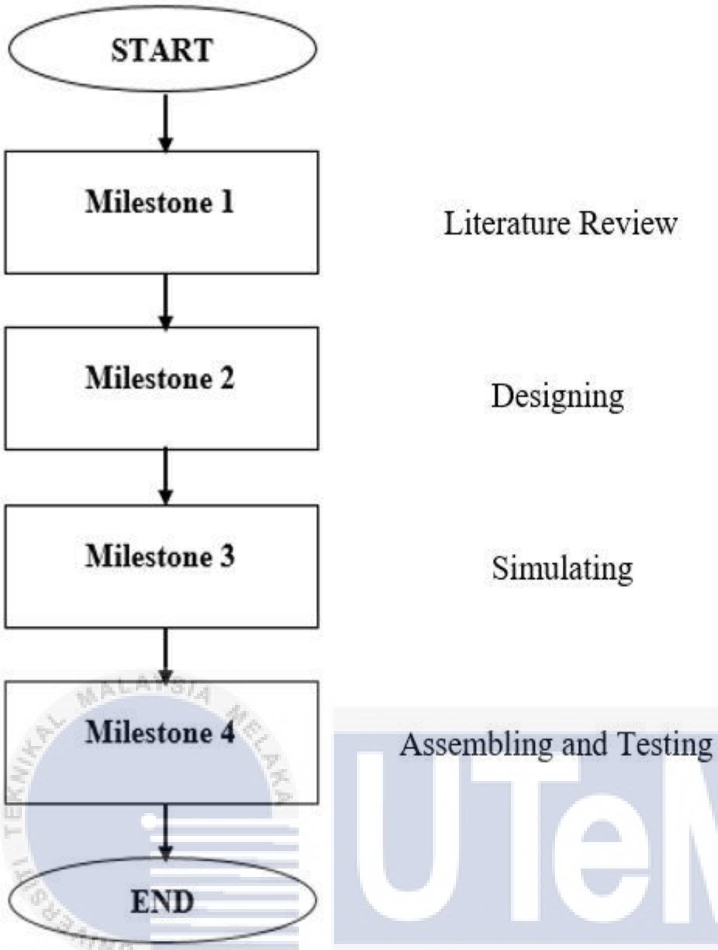


Figure 3.1 Methodology flowchart

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.3 Milestone

To ensure that this project is carried out successfully, the process of performing is divided into a few stages. Figure 3.10 shows how the flowchart of this project.

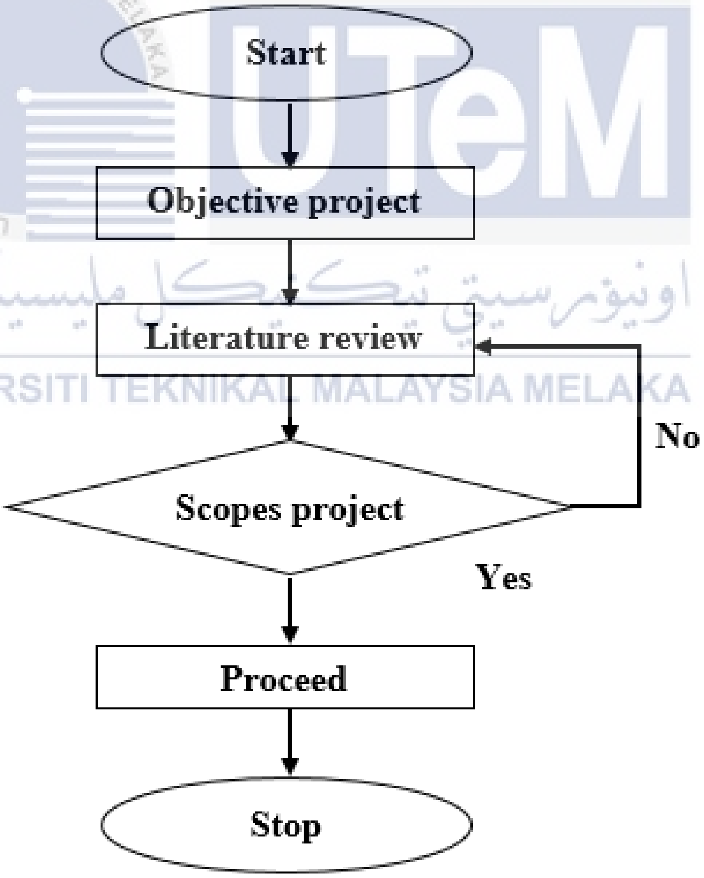
3.3.1 First Milestone: Literature Review

- **Activity 1 : Project Objectives**

In order to guarantee that the project meets the criteria of the research project, the objectives were addressed with the supervisor. This project involves the development of a V-Box that can deliver angular rate measurements and data from the IMU sensor as well as the GPS of the V-Box.

- **Activity 2: Literature Review**

To gain ideas and knowledge about the development of the V-Box from the previous project and research done by other researchers in other places or academic institution. The information from the published papers had been studied to come out with the scopes for this project in order to narrow down the research medium. Figure 3.2 shows the flow of the literature review done for this project.



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 3.2 Literature review flowchart

3.3.2 Second Milestone: Designing

This section discuss the component that has been chosen. Based on the study on previous research in chapter 2 which is literature review, this component is chosen. The selected component also is choose based on requirement needed to achieve the objective of the project. Furthermore, I also has learnt about the software design and mechanical design as well that been used on the previous research and apply it on this project. Based on the objectives of the V-box, the comparison of several components in term of gyroscope and accelerometer, gps and camera were done. The best complement specification of the component with the needs of this project was selected.

3.3.2.1 Electronic design

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The list of component use in the project is shown in Table 3.1

No	Component	Quantity
1	Raspberry Pi 4	1
2	IMU MPU-6050	1
3	GEO-6M GPS module	1
4	3.5-Inch TFT Touch Screen	1
5	Web Camera	1

Table 3.1 List of electronic component

1. Raspberry Pi 4

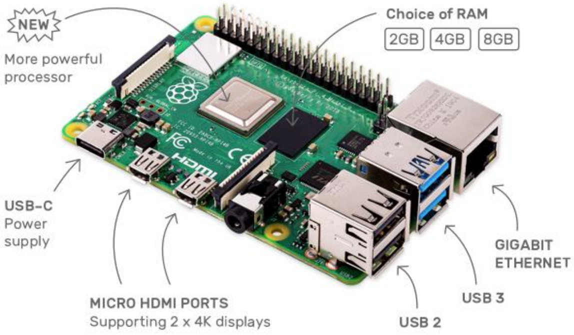


Figure 3.3 Raspberry Pi 4

The BCM2711 SoC with an ARM Cortex-A72 1.5 GHz 64-bit quad-core CPU with 1 MB of shared L2 cache is used by the Pi Raspberry Pi 4. In opposition to previous models, which all use a customised interrupting controller that is not very suitable for virtualization, the interrupting controller on this SoC is compatible with the GIC architecture 2.0, which supports hardware to distribute interrupts with the use of ARM virtualization capacities. On models B or B+, an integrated USB Ethernet adapter with the LAN9514 SMSC chip is offered with an Ethernet Port. For Model B and B+, an embedded USB Ethernet adapter with the LAN9514 SMSC chip can offer the Ethernet port.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2. IMU MPU-6050

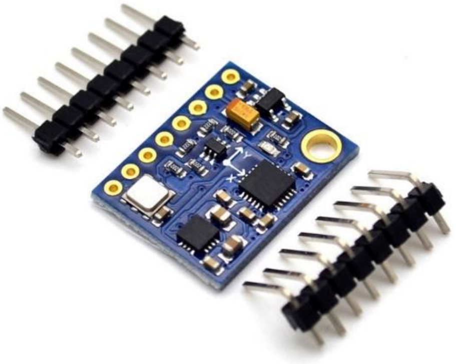


Figure 3.4 IMU MPU-6050

As IMU sensors, two or more parts are usually utilised. Priorities include the accelerometer, gyroscope, magnetometer and altimeter. The MPU 6050, or 6-axis IMU sensor, consists of six values for the output, three values of the accelerometer, and three values of the gyroscope. The MPU 6050 is a MEMS-based mechanical sensor. Both the gyroscope and the accelerometer are integrated into one chip. This chip employs a communications protocol for I2C (interintegrated circuit). The gyroscope and accelerometer are accessible in the form of an addition of 2 on X, Y and Z axes. The readings of gyroscopes are in degrees per second (dps) and the values for accelerometers are in g.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3. NEO-6M GPS module

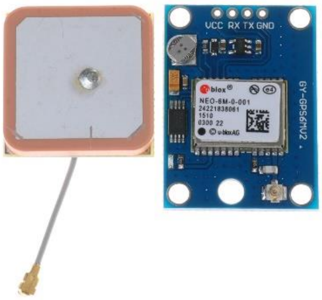


Figure 3.5 NEO-6M GPS module

The GPS module NEO-6M is a good performing, fully integrated GPS receiver that delivers powerful satellite search capacity with a 25x25x4 mm ceramic antenna. With these, it can check the status of the module using the power and signal indicators.

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA
اونيۏرسيتي تيكنيكل مليسيا ملاك

4. 3.5-Inch TFT Touch Screen

Figure 3.6 3.5-Inch TFT Touch Screen

It has a 3.5-inch display with a 16-bit colour pixel 480x320 and a little greater touch-overlay than the Raspberry Pi board that can cover it perfectly. The platform uses a high rate SPI interface on the Pi to display images or videos, etc. The small display can be used as consoles, X windows port. It is best to plug the Raspberry Pi board immediately on top. The screen is powered by a single Raspberry Pi electricity. The Raspberry Pi GPi Pin is easily stacked on the Rpi board since it uses the SPI and Powers pin.

5. Web camera

Figure 3.7 Web camera

A webcam is a video camera that feeds or streams an image or video in real time to or through a computer network, such as the Internet. Webcams are typically small cameras that sit on a desk, attach to a user's monitor, or are built into the hardware. Webcams can be used during a video chat session involving two or more people, with conversations that include live audio and video. Webcams can be installed at places such as childcare centres, offices, shops and private areas to monitor security and general activity.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.3.2.2 Software Development

1. Raspberry Pi OS

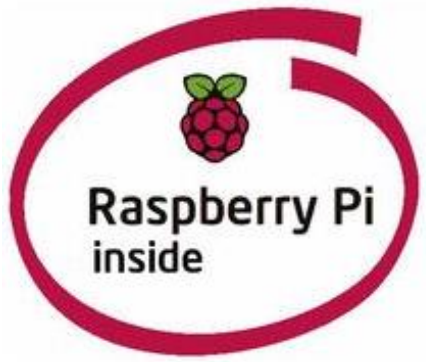


Figure 3.8 Raspberry Pi OS

Raspberry Pi OS has been specifically designed for the Raspberry Pi range of small single-board computers powered by ARM CPUs. Except for the Pico microcontroller, it operates on all Raspberry Pi models. Raspberry Pi OS's desktop environment is a modified LXDE with the Openbox stacking window manager and a unique look. The desktop environment of Raspberry Pi OS, PIXEL, resembles several common desktops, such as macOS and Microsoft Windows, and is based on LXDE. The menu bar is located at the top and features an application menu as well as shortcuts to Terminal, Chromium, and File Manager. A Bluetooth menu, a Wi-Fi menu, volume control, and a digital clock may be seen on the right.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2. Thonny Python

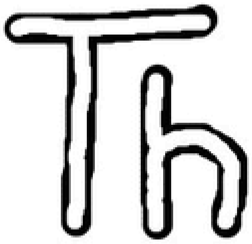


Figure 3.9 Thonny Python

The desktop environment of Raspberry Pi OS, PIXEL, resembles several common desktops, such as macOS and Microsoft Windows, and is based on LXDE.[7] The menu bar is located at the top and features an application menu as well as shortcuts to Terminal, Chromium, and File Manager. A Bluetooth menu, a Wi-Fi menu, volume control, and a digital clock may be seen on the right. The application is compatible with Windows, macOS, and Linux. It is offered as a binary package that includes the most latest Python interpreter or as a pip-installable package. On Debian, Raspberry Pi, Ubuntu, and Open CV, it may be installed via the operating system's package manager.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3. Fritzing

Figure 3.10 Fritzing

Fritzing is an open-source effort that aims to create amateur or hobby CAD software for the design of electrical hardware in order to assist designers and artists who are ready to progress from experimenting with a prototype to developing a more permanent circuit. Fritzing is free software licenced under the GPL-3.0-or-later licence, with the source code accessible for free on GitHub

3.3.2.3 Mechanical Design

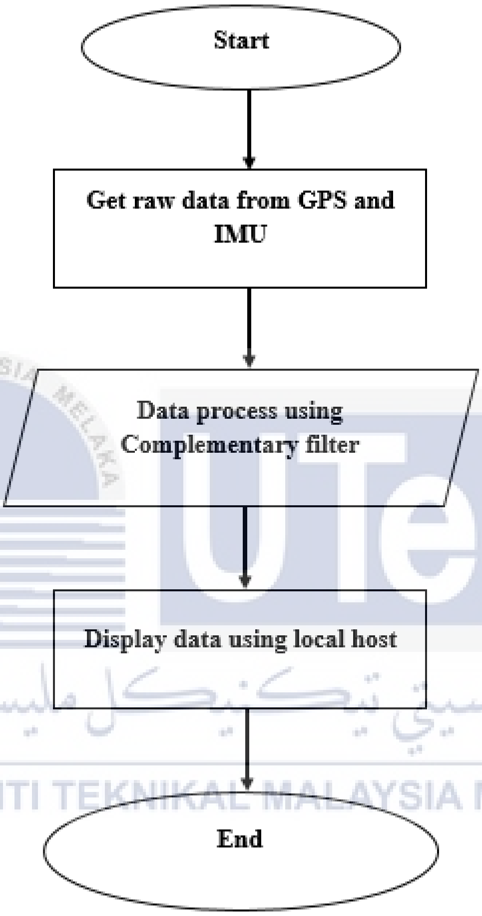
Figure 3.11 Basic design of the project

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

This section discusses the mechanical design for this project. The design must be able to fit all the electronic circuits and components.. The V-Box design structure also must be quite sturdy for installation in cars and component used. Figure 3.10 show basic design of this project.

3.3.3 Third Milestone: Simulation

The third milestone indicate the project or process flow chart from initial which is get data and information from V-Box. This section also cover the final product of V-Box and consist of different part that be combine to complete this project. The part is divided to three which is electronic design, software design and mechanical design. Figure 3.12 show flow chart of project program in order to planning the sequence for completing this project. Figure 3.13 and Figure 3.14 show the final prouct of V-Box and Figure 3.15 show the interface display the V-Box system using raspberry pi operating system.



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 3.12 Program Flow Chart

Figure 3.13 Final Product V-Box

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
UTeM

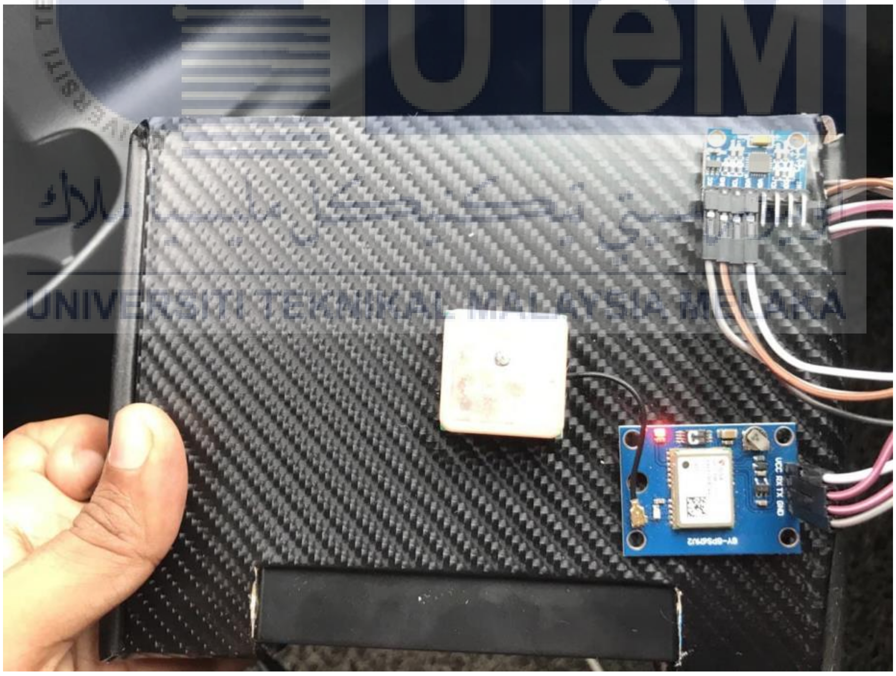
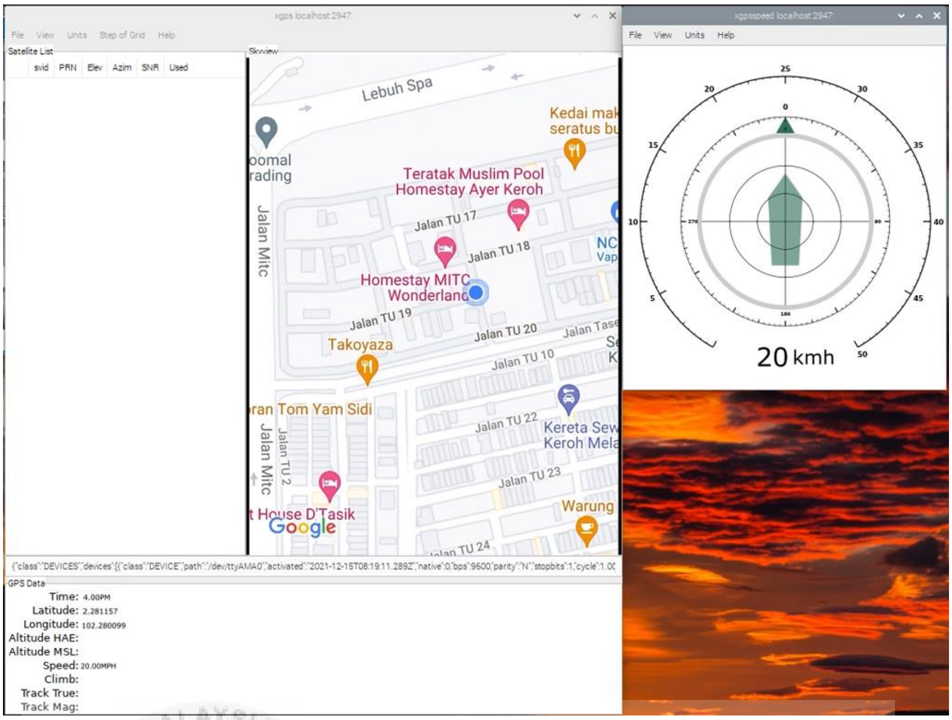


Figure 3.14 Top view V-Box system



```
{"class":"DEVICES","devices":[{"class":"DEVICE","path":"/dev/ttyAMA0","activated":"2021-12-15T08:19:11.289Z","native":0,"bps":9600,"parity":"N","stopbits":1,"cycle":1.0(
```

```
GPS Data
        Time: 4.00PM
    Latitude: 2.281157
   Longitude: 102.280099
Altitude HAE:
Altitude MSL:
       Speed: 20.00MPH
       Climb:
  Track True:
   Track Mag:
```

Figure 3.15 Interface Local Host for GPS and IMU 6050

3.3.4 Fourth Milestone: Assembling and Testing

In this section, explain how to implement and test and analyse the component. The procedure starts with the testing of the functionality of the component and data analysis. The electronic components and the power supply will be integrated inside the V-Box when the V-Box frame and component base have been completed. Figure 3.10 clearly shows the procedure of implementation and Table 3.1 is for testing functionality of item.

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

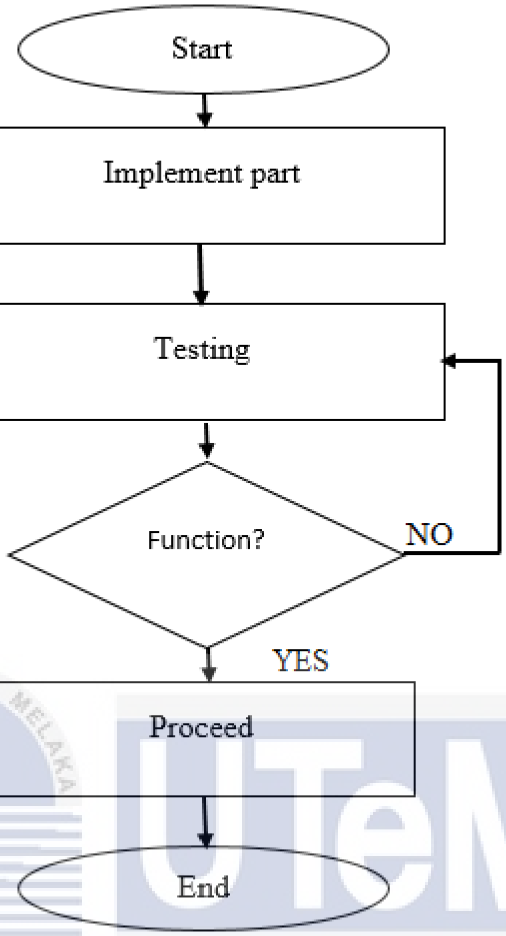


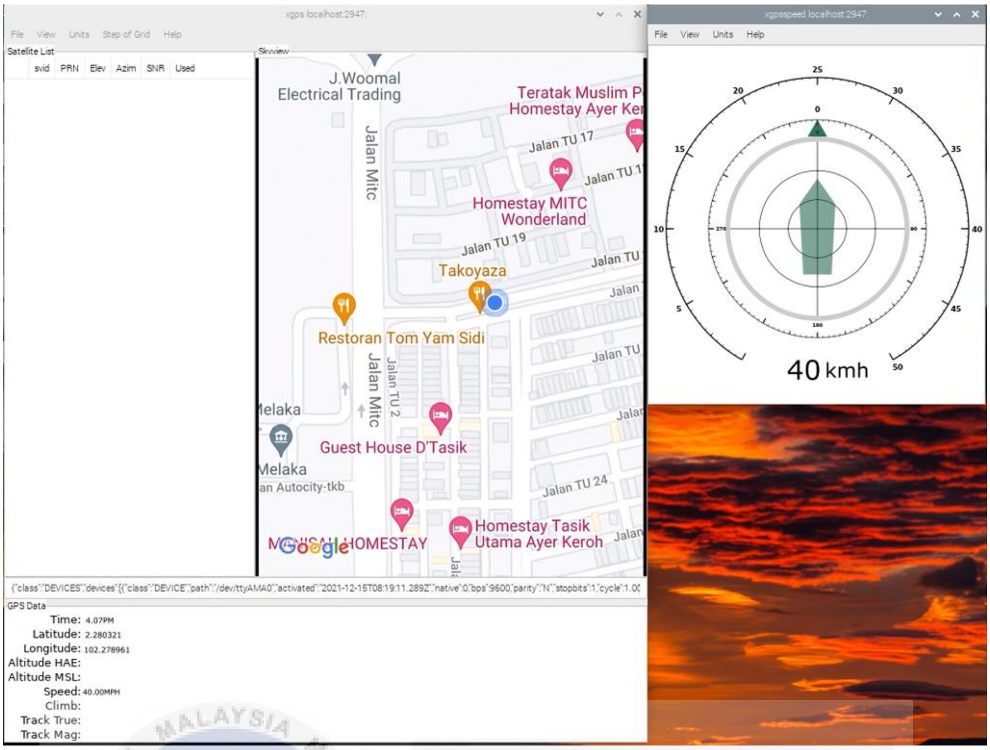
Figure 3.16 Implementation of component flowchart

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Table 3.2 Testing table of item

No.	Item	functionality
1	IMU MPU-6050	Good
2	NEO-6M GPS module	Good
3	Web Camera	Good

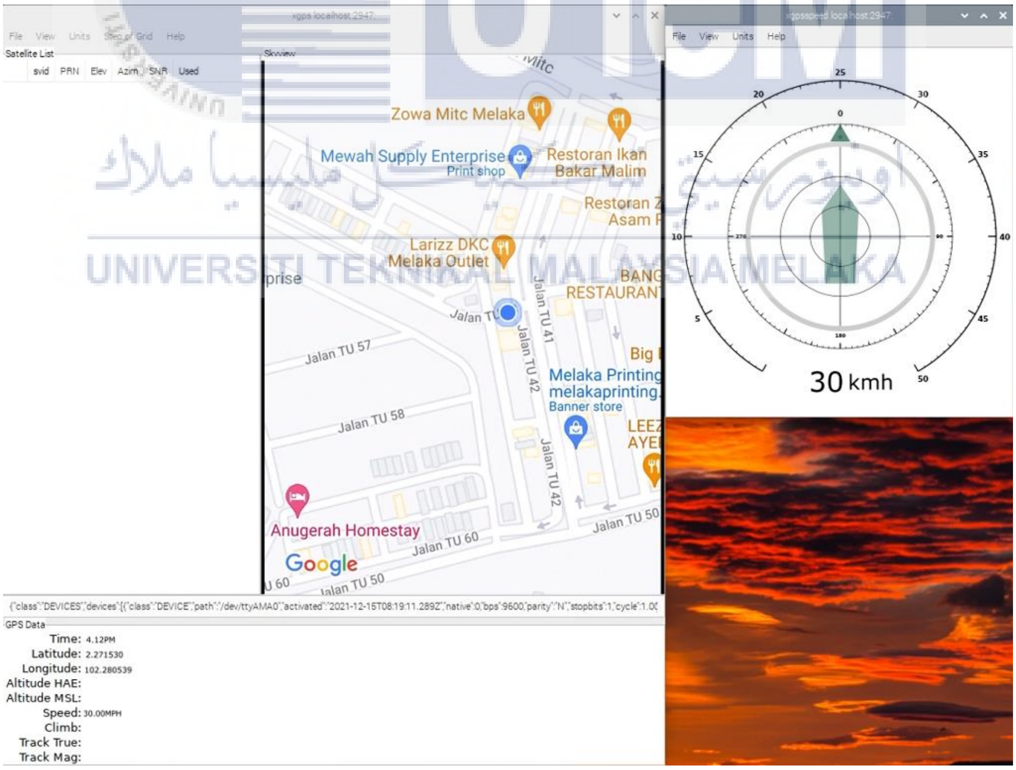
Next, this test is conducted on the gps and imu sensor. The test is conducted by testing the sensor in different destination. From TTU (Taman Tasek Utama))to FTKEE, FTKEE to Pertonas and Pertonas to Mydin. Also, the data are collected by comparing the measurement from the GPS and IMU 6050 show in Figure 3.17 and Figure 3.18 .



```
{"class":"DEVICES","devices":[{"class":"DEVICE","path":"/dev/ttyAMA0","activated":"2021-12-15T08:19:11.289Z","native":0,"bps":9600,"parity":"N","stopbits":1,"cycle":1.0(
```

GPS Data
Time: 4.07PM
Latitude: 2.280321
Longitude: 102.278961
Altitude HAE:
Altitude MSL:
Speed: 40.00MPH
Climb:
Track True:
Track Mag:

Figure 3.17 Interface data Home to FTKEE



```
{"class":"DEVICES","devices":[{"class":"DEVICE","path":"/dev/ttyAMA0","activated":"2021-12-15T08:19:11.289Z","native":0,"bps":9600,"parity":"N","stopbits":1,"cycle":1.0(
```

GPS Data
Time: 4.12PM
Latitude: 2.271530
Longitude: 102.280539
Altitude HAE:
Altitude MSL:
Speed: 30.00MPH
Climb:
Track True:
Track Mag:

Figure 3.18 Interface data FTKEE to Petronas

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.4 Summary

To ensure that the objectives are met, every flow and progress must be done and followed correctly throughout this chapter. Aside from that, the system operation, mechanical design, and circuit design are represented by describing how the sorting system works in a flowchart and diagram. This chapter also describes and justifies why the system's hardware and software were chosen and implemented.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter presents the results and analysis on the development of V-Box system. The result obtain is from actual testing on different sample of speed from IMU 6050 and coordiante sensor, it is tested in threee different destination. It shows the results when all hardware components are connected, completed circuit design and V-box design, testing the V-Box System and analysis upon completion of driving.

4.1 Hardware component

In this subtopic, it show complete wiring V-Box system in Figure 4.1 and Figure 4.2. LCD 3.5 inch connect to pinout raspberrry pi 4 1 into 26 and for GPS Neo 6M connect into raspberry pi 4 pinout 2,6 and 10 also for IMU 6050 connect to pinout 3,4,5 and 34. For web camera just connect at usb port at rapsberry pi 4.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 4.1 Wiring inside V-Box system

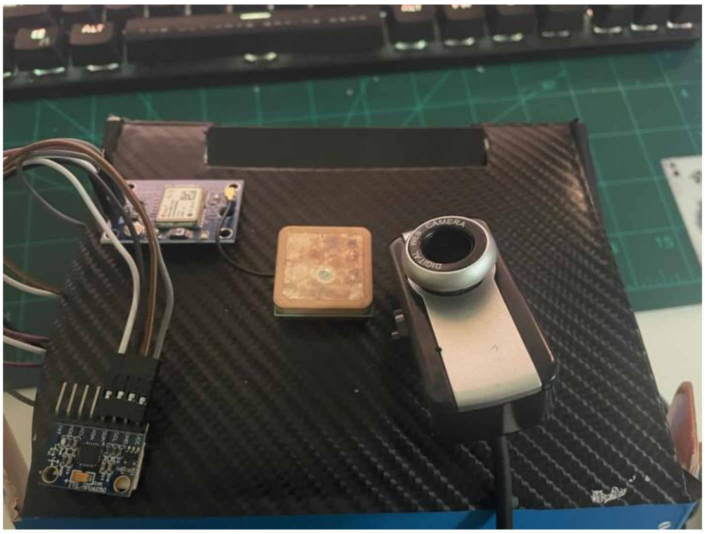


Figure 4.2 Wiring outside V-Box system

4.2 V-Box circuit design

The V-box system circuit design use fritzing software to develop wiring on raspberry pi and all component that use on V-box system show in Figure 4.3.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

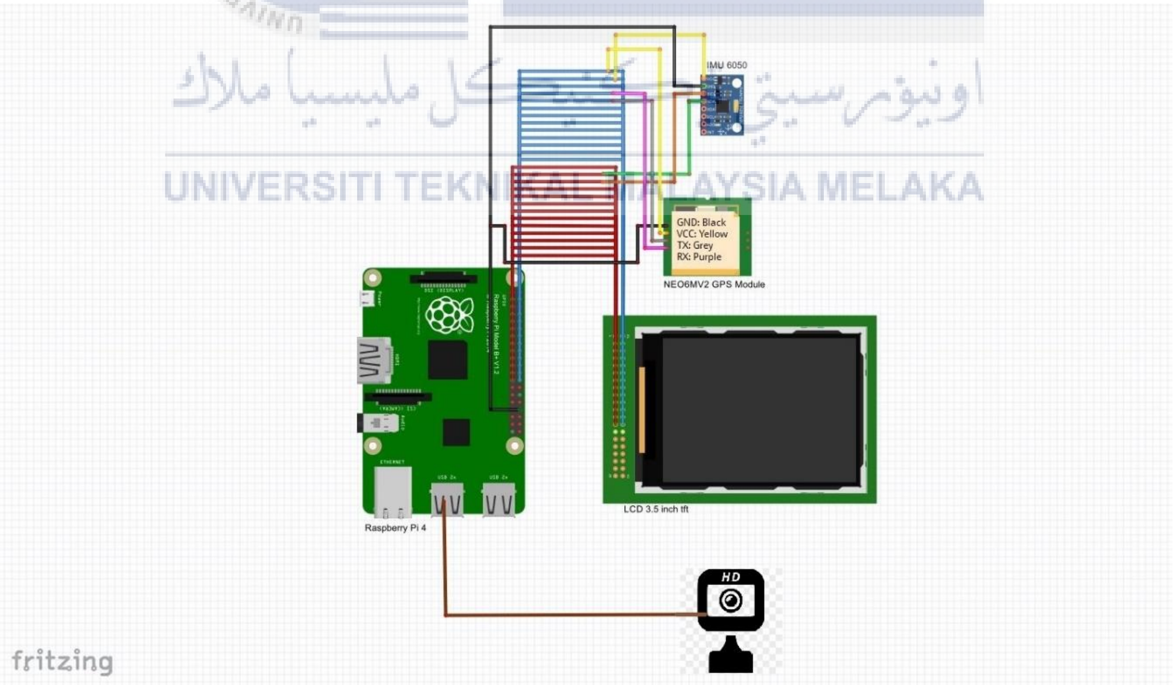
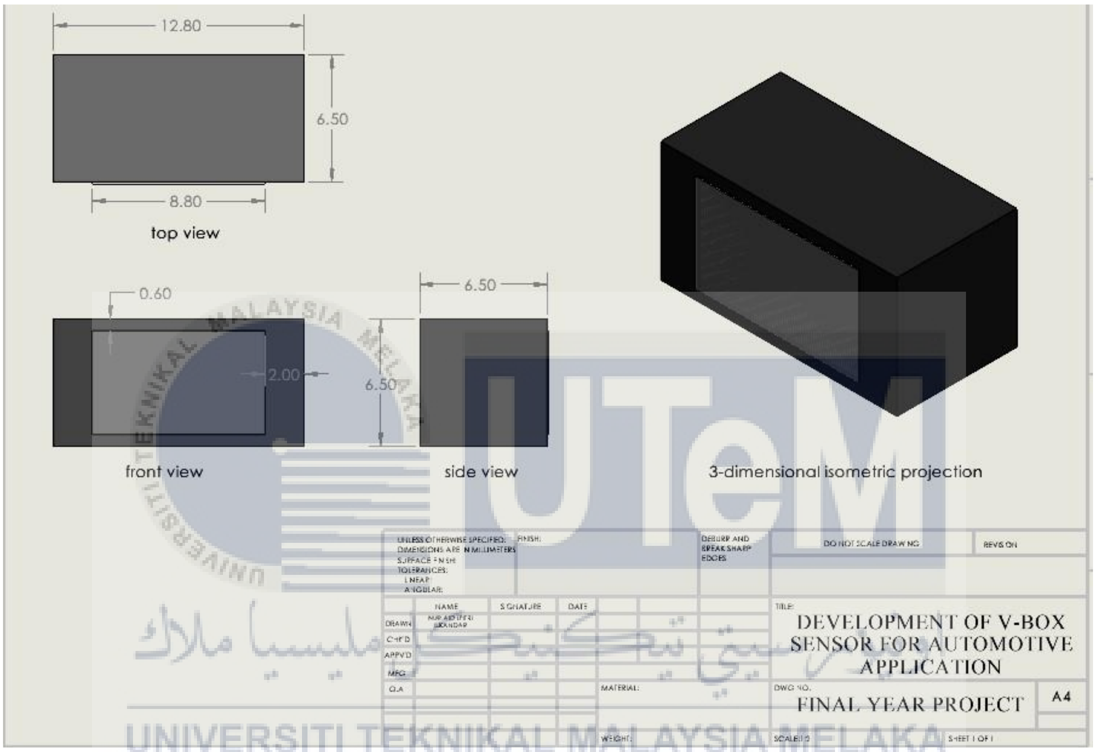


Figure 4.3 Circuit diagram of V-Box system

4.3 Mechanical design

The mechanical design will be shown in this section. This design was created using Solid Work software and illustrated in four different side views which is front, top, side, and isometric. Figure 4.4 show the model view.



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 4.4 Model view

Based on Figure 4.4, it illustrated the water surface robot in isometric view. From the design, the box consist of all the electronic component. The GPS sensor and IMU 6050 attach to top body part.

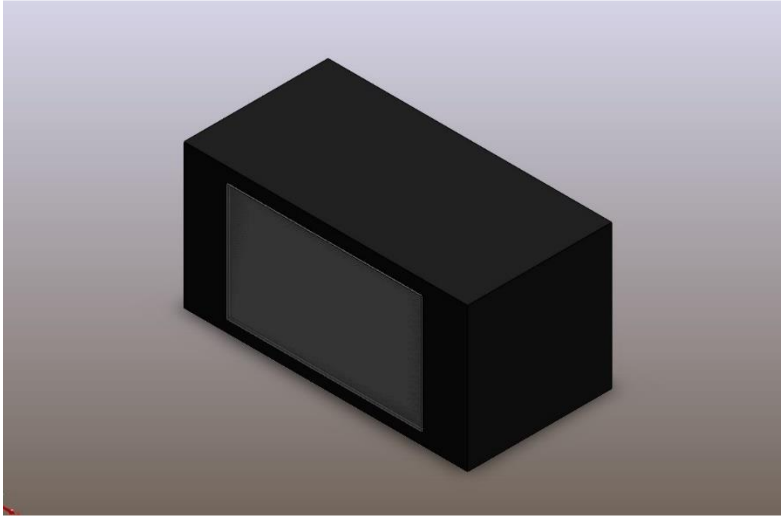


Figure 4.5 Isometric view

4.4 Testing the V-Box System

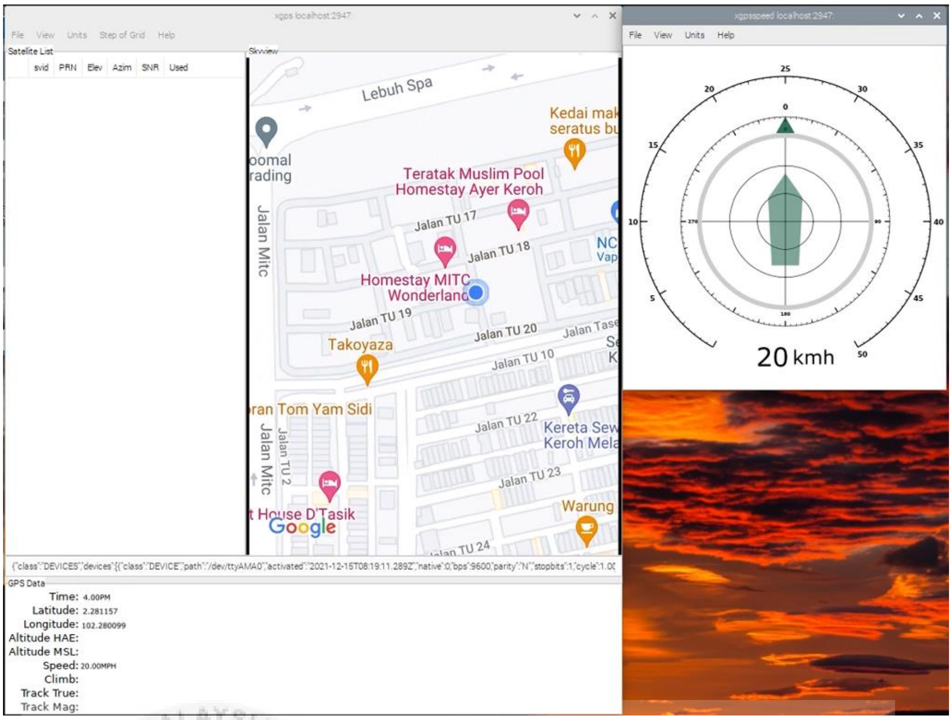
Once the V-Box System development had finished, the performance of the V-Box System to perform its speed, location and record video footage while driving was investigated and experimented shown in Figure 4.5 and Figure 4.6. The experiment was conducted in different speed to look at whether the V-Box system was capable to detect location, speed and record video in straight path and to make some turning also to test the coding complementary filter work. Then, the ability of the V-Box System to perform the pattern of location and speed shown in Figure 4.7.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 4.6 Testing V-box System

Figure 4.7 Position Web camera

UNIVERSITI TEKNIKAL MALAYSIA MELAKA



{"class":"DEVICES","devices":[{"class":"DEVICE","path":"/dev/ttyAMA0","activated":"2021-12-15T08:19:11.289Z","native":0,"bps":9600,"parity":"N","stopbits":1,"cycle":1.0(

GPS Data
Time: 4.00PM
Latitude: 2.281157
Longitude: 102.280099
Altitude HAE:
Altitude MSL:
Speed: 20.00MPH
Climb:
Track True:
Track Mag:

Figure 4.8 Interface location and speed in Raspberry Pi 4

4.5 Analysis after completion of driving

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Analysis is done by reviewing all the data recorded in the V-Box. In analysis, V-Box get data is the location such longitude, latitude, google map, stering behavior and speed with diffrence destination in Figure 4.9.

a) Recorded video TTU to FTKEE

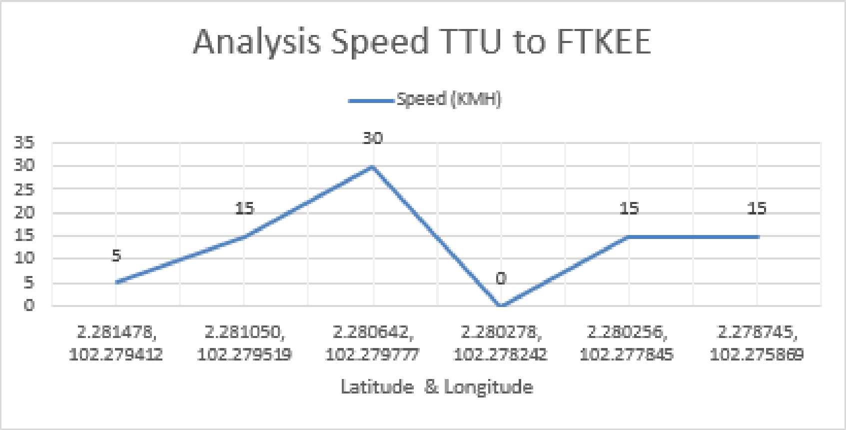
b) Recorded video FTKEE to Petronas

c) Recorded video Petronas to Mydin

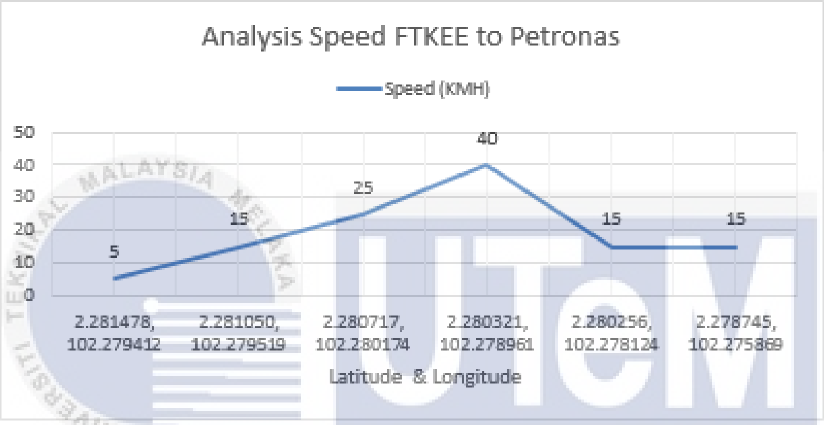
Figure 4.9 Recorded analysis review

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

There also has graph analysis of speed show in Figure 4.10. The test is conducted on the speed value. The test is conducted by testing the sensor in different destination and pick random six locations to make speed analysis.

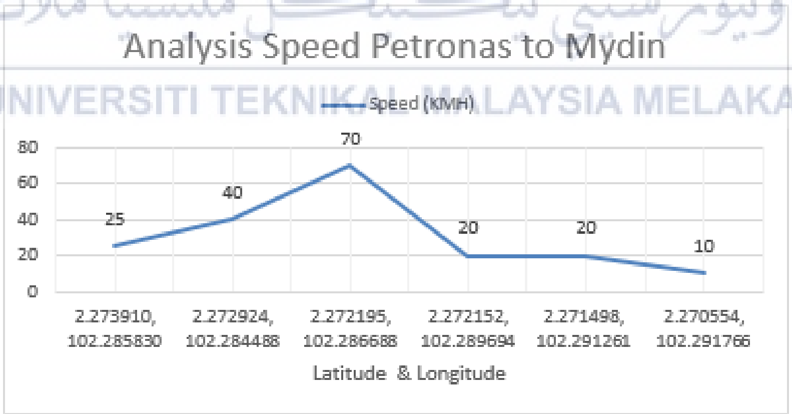


a) Speed value TTU to FTKEE



b) Speed value FTKEE to Petronas

اونيۏرسيتي تيکنيکل مليسيا ملاک
UNIVERSITI TEKNIKAL MALAYSIA MELAKA



c) Speed value Petronas to Mydin

Figure 4.10 Graph of speed analysis

4.6 Summary

The results and analysis were highlighted in order to attain the objectives of this project. The V-Box sensor design is carried out with the whole component embedded within it such as GPS and MPU6050 this project is complete. The V-Box sensor ensures the equipment and actuation vecinal system and environment safety. The GPS is implemented and the vechicle will be located and IMU 6050 to detect speed of vechicle. The webcam used to record video footage while driving for analysis with data from sensor fusion sensor.

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The structural design, mechanical elements, and controls of the V-Box sensor all play an essential role in its performance. Aside from that, the technology employed for the V-box sensor effects the vehicle's movement. Furthermore, in order to achieve the goal of monitoring data from the IMU sensor and the GPS, the components utilised have an influence on the performance of the data from the vehicle. So, it is challenging to complete this project. The objective of this Development Of V-Box Sensor For Automotive Application has been successfully achieved. The first objective is to design a V-Box system using Raspberry Pi which has been achieved successfully. The second objective is to monitor and record data from the IMU sensor and the GPS via the V-Box. The second objective was also achieved as mentioned in the result. It can monitor data and record data from the sensors data given by V-Box system. The third objective is to analyze car motion from V-Box's data. As mentioned in the result, the test conducted for GPS and IMU 6050 sensor perfectly without any bug or error, so the third objective was also achieved.

5.2 Recommendations

For future improvements, the V-Box system could be use HyperText Markup Language (html) to make analysis in real time with web camera for V-box system. Secondly, 7 inch screen tft preferable 3.5 inch screen tft for get video web camera record in real time and has simple wiring connect to raspberry pi 4. Lastly, Using wifi camera that can transfer video between the digital camera and the raspberry pi without any wires.

5.3 Project potential

For the long term goal, this project can be developed for Autonomous Vehicles (AVs) in Malaysia. This system can be developed in various designed system and might pursuit of autonomous cars has inspired collaboration between carmakers and tech innovators. Google's self-driving vehicle initiative, is reaching Level 4 autonomy, with autonomous cars currently transporting people around for several years. There a five levels of vehicle autonomy as defined by the Society of Automotive Engineers (SAE). They range from 0 (human control) to 5 (full autonomous) but to develop for this type of autonomous cars, Malaysia really needs good engineers who are specialized in various backgrounds and they need to work together. Other than that, our country is not ready for this type of a technology and thus, will not be able to develop this type of a system. As mentioned before, this development has a big potential in helping the Malaysia transportation performing effectively.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

REFERENCES

Becker, J. C. and Simon, A. (2000) 'Sensor and navigation data fusion for an autonomous vehicle', *IEEE Intelligent Vehicles Symposium, Proceedings*, (Mi), pp. 156–161. doi: 10.1109/ivs.2000.898335.

Chu, T. *et al.* (2012) 'Monocular camera/IMU/GNSS integration for ground vehicle navigation in challenging GNSS environments', *Sensors*, 12(3). doi: 10.3390/s120303162.

Fayyad, J. *et al.* (2020) 'Deep learning sensor fusion for autonomous vehicle perception and localization: A review', *Sensors (Switzerland)*, pp. 1–34. doi: 10.3390/s20154220.

Gonzalez, R. and Dabove, P. (2019) 'Performance assessment of an ultra low-cost inertial measurement unit for ground vehicle navigation', *Sensors (Switzerland)*, 19(18). doi: 10.3390/s19183865.

Herman, S. and Ismail, K. (2017) 'Single Camera Object Detection for Self-Driving Vehicle : A Review', 1(3), pp. 198–207.

Hlaing, N. N. S., Naing, M. and Naing, S. S. (2019) 'GPS and GSM Based Vehicle Tracking System', *International Journal of Trend in Scientific Research and Development*, Volume-3(Issue-4), pp. 271–275. doi: 10.31142/ijtsrd23718.

Kim, T. and Park, T. H. (2020) 'Extended kalman filter (Ekf) design for vehicle position tracking using reliability function of radar and lidar', *Sensors (Switzerland)*, 20(15), pp. 1–18. doi: 10.3390/s20154126.

Kocic, J., Jovicic, N. and Drndarevic, V. (2018) 'Sensors and Sensor Fusion in Autonomous Vehicles', *2018 26th Telecommunications Forum, TELFOR 2018 - Proceedings*, pp. 18–21. doi: 10.1109/TELFOR.2018.8612054.

Marco, V. R. *et al.* (2021) 'A novel IMU extrinsic calibration method for mass production land vehicles', *Sensors (Switzerland)*, 21(1). doi: 10.3390/s21010007.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Mazhar, M. K. *et al.* (2020) ‘A novel roll and pitch estimation approach for a ground vehicle stability improvement using a low cost IMU’, *Sensors (Switzerland)*, 20(2). doi: 10.3390/s20020340.

Sofwan, A. (2018) ‘Filtering for Data Acquisition on Wireless Sensor Network’, pp. 180–184.

Thesis, B. S. and Bader, M. (no date) ‘Autonomous navigation Position tracking of a remote control vehicle using IMU Autonomes Fahren Positionsbestimmung eines’.

Vanmore, P. S. V *et al.* (2017) ‘Smart Vehicle Tracking Using Gps’, *International Research Journal of Engineering and Technology(IRJET)*, 4(3), pp. 66–69. Available at: https://irjet.net/archives/V4/i3/IRJET-V4I317.pdf.

Yang, Y. *et al.* (2020) ‘A fast weakly-coupled double-layer eskf attitude estimation algorithm and application’, *Electronics (Switzerland)*, 9(9), pp. 1–22. doi: 10.3390/electronics9091465.

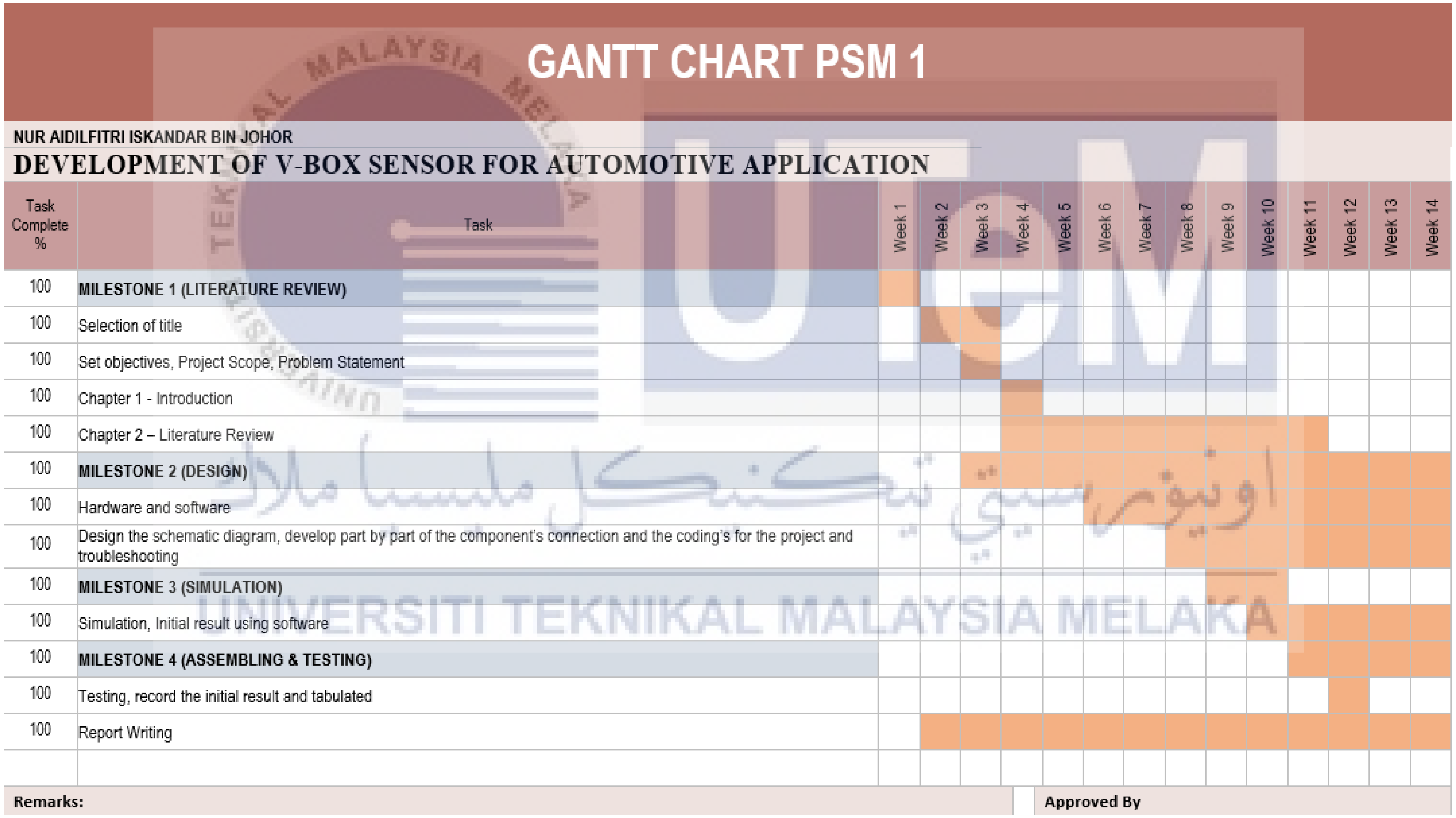
Zein, Y., Darwiche, M. and Mokhiamar, O. (2018) ‘GPS tracking system for autonomous vehicles’, *Alexandria Engineering Journal*, 57(4), pp. 3127–3137. doi: 10.1016/j.aej.2017.12.002.

Zhu, X. *et al.* (2017) ‘Research on Localization Vehicle Based on Multiple Sensors Fusion System’, *Proceedings - 2017 International Conference on Computer Network, Electronic and Automation, ICCNEA 2017*, 2017-Janua, pp. 491–494. doi: 10.1109/ICCNEA.2017.75.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPENDICES

Appendix A Gantt chart PSM 1



GANTT CHART PSM 1

NUR AIDILFITRI ISKANDAR BIN JOHOR

DEVELOPMENT OF V-BOX SENSOR FOR AUTOMOTIVE APPLICATION

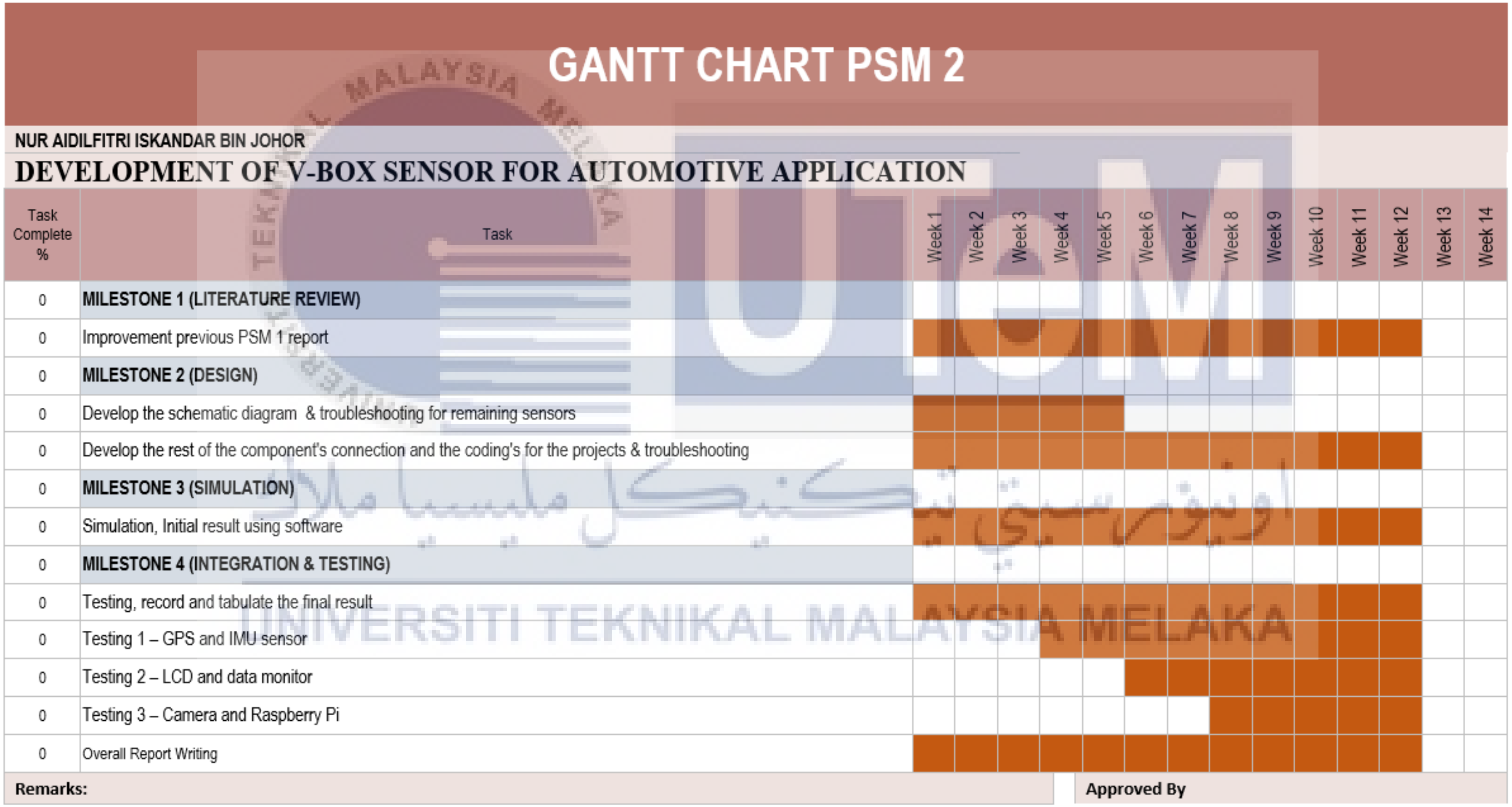
Task Complete %	Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
100	**MILESTONE 1 (LITERATURE REVIEW)**	■													
100	Selection of title		■	■											
100	Set objectives, Project Scope, Problem Statement			■											
100	Chapter 1 - Introduction				■										
100	Chapter 2 – Literature Review				■	■	■	■	■	■	■	■			
100	**MILESTONE 2 (DESIGN)**			■	■	■	■	■	■	■	■	■	■	■	■
100	Hardware and software						■	■	■	■	■	■	■	■	■
100	Design the schematic diagram, develop part by part of the component's connection and the coding's for the project and troubleshooting								■	■	■	■	■	■	■
100	**MILESTONE 3 (SIMULATION)**									■	■				
100	Simulation, Initial result using software										■	■	■	■	■
100	**MILESTONE 4 (ASSEMBLING & TESTING)**											■	■	■	■
100	Testing, record the initial result and tabulated												■		
100	Report Writing		■	■	■	■	■	■	■	■	■	■	■	■	■

Remarks:

Approved By

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Appendix B Gantt chart PSM 2



GANTT CHART PSM 2

NUR AIDILFITRI ISKANDAR BIN JOHOR

DEVELOPMENT OF V-BOX SENSOR FOR AUTOMOTIVE APPLICATION

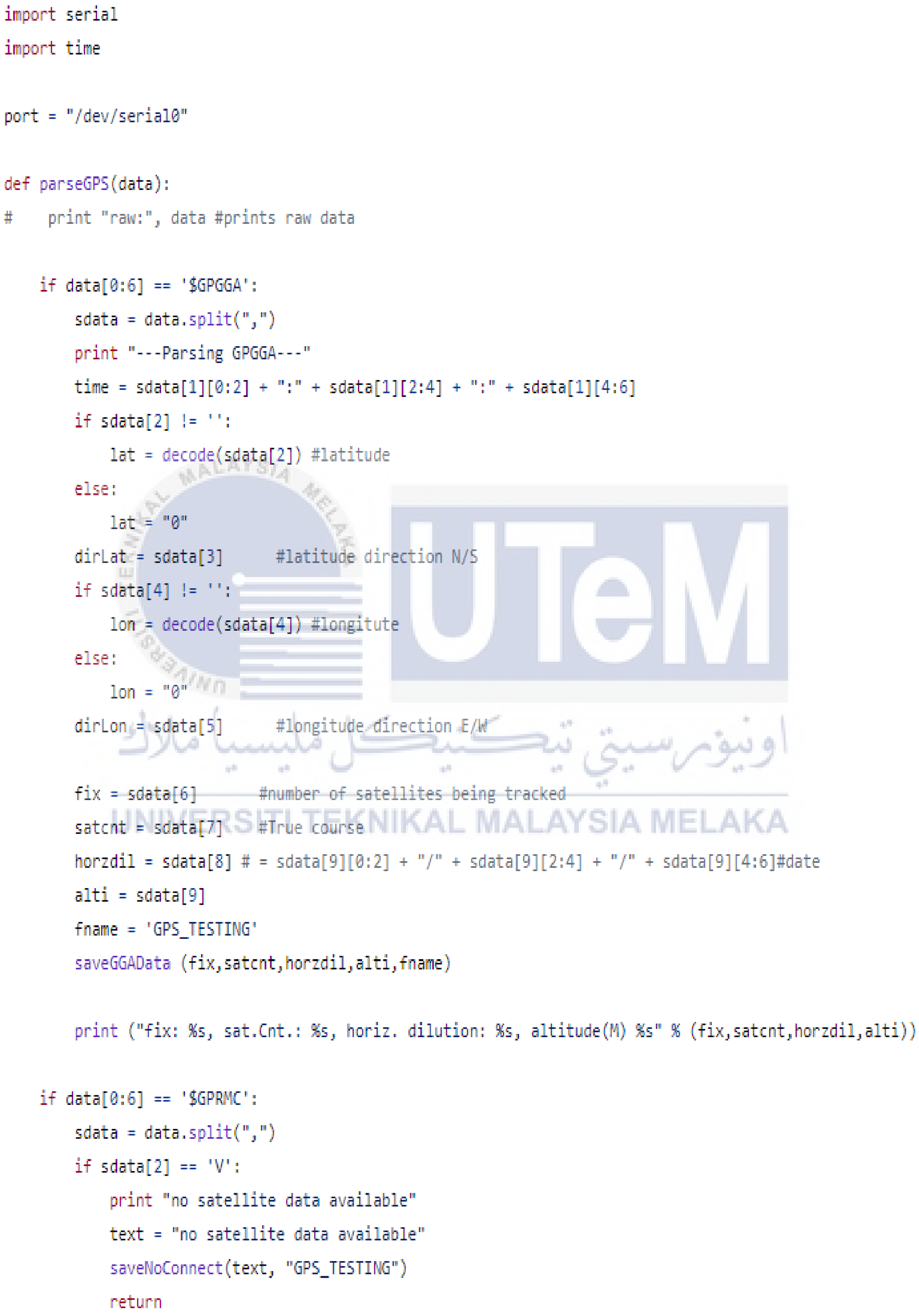
Task Complete %	Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
0	**MILESTONE 1 (LITERATURE REVIEW)**														
0	Improvement previous PSM 1 report	■	■	■	■	■	■	■	■	■	■	■	■		
0	**MILESTONE 2 (DESIGN)**														
0	Develop the schematic diagram & troubleshooting for remaining sensors	■	■	■	■	■									
0	Develop the rest of the component's connection and the coding's for the projects & troubleshooting	■	■	■	■	■	■	■	■	■	■	■	■		
0	**MILESTONE 3 (SIMULATION)**														
0	Simulation, Initial result using software	■	■	■	■	■	■	■	■	■	■	■	■		
0	**MILESTONE 4 (INTEGRATION & TESTING)**														
0	Testing, record and tabulate the final result	■	■	■	■	■	■	■	■	■	■	■	■		
0	Testing 1 – GPS and IMU sensor				■	■	■	■	■	■	■	■	■		
0	Testing 2 – LCD and data monitor						■	■	■	■	■	■	■		
0	Testing 3 – Camera and Raspberry Pi								■	■	■	■	■		
0	Overall Report Writing	■	■	■	■	■	■	■	■	■	■	■	■		

Remarks:

Approved By

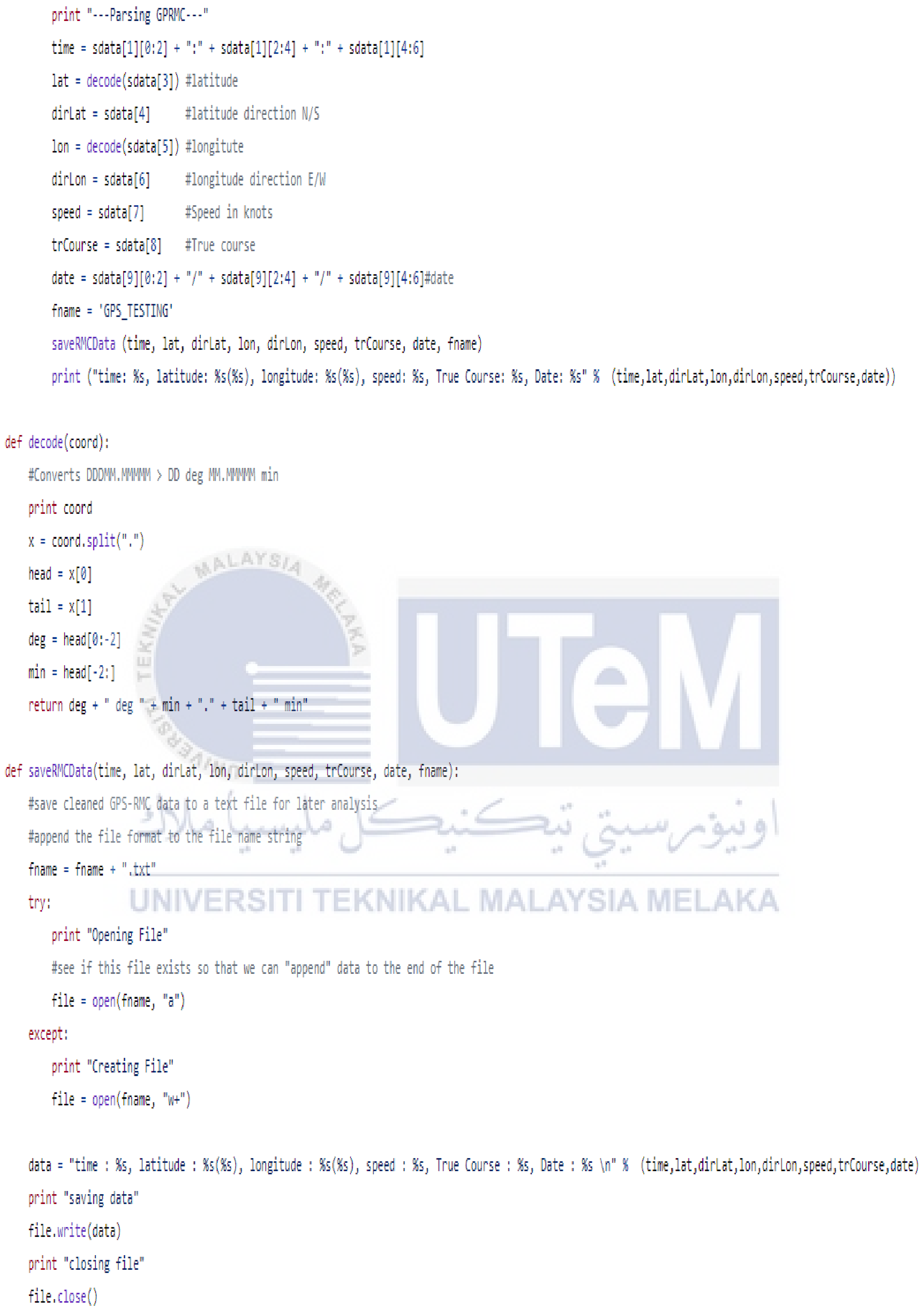
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Appendix C Coding GPS sensor



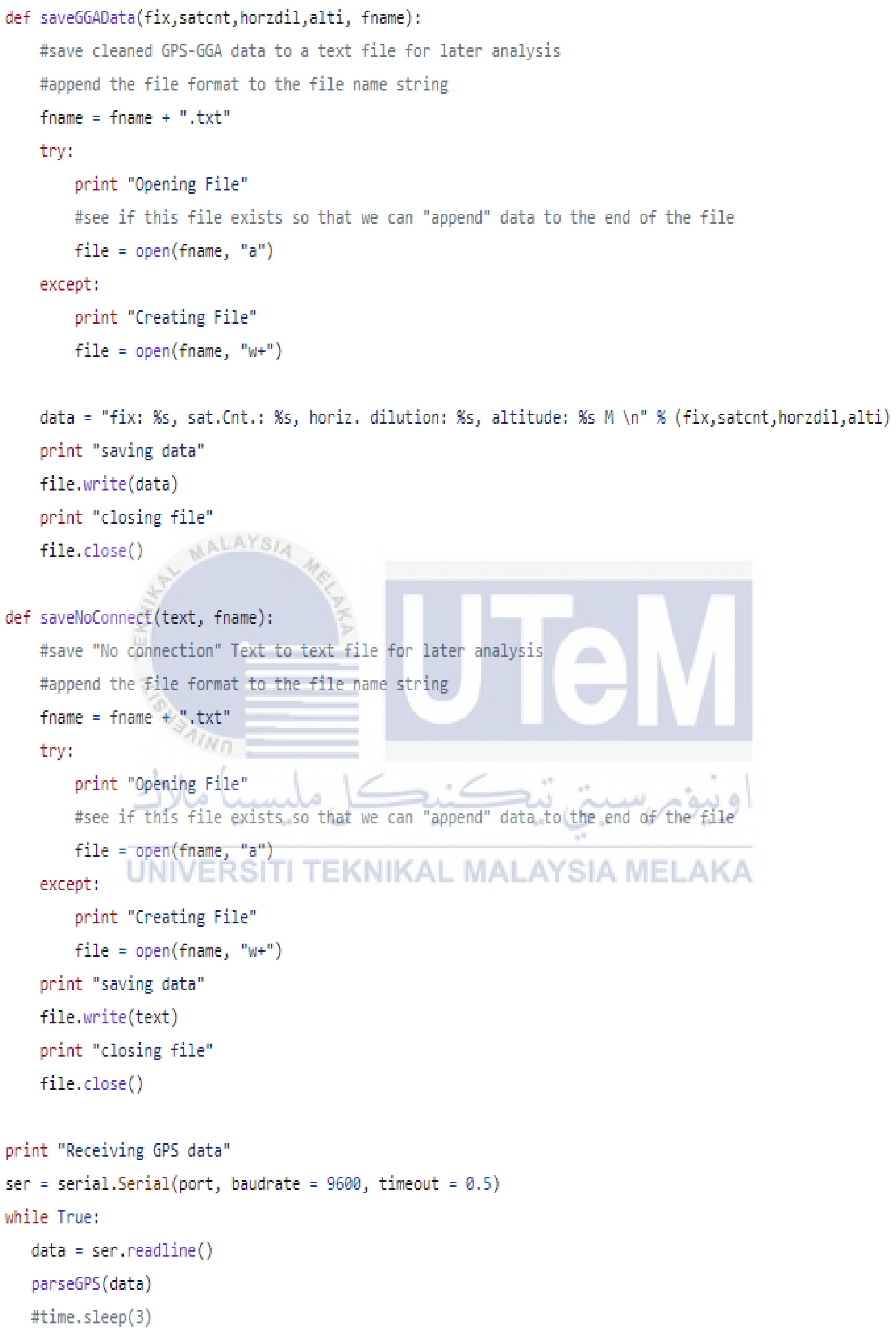
```
import serial
import time

port = "/dev/serial0"

def parseGPS(data):
#    print "raw:", data #prints raw data

    if data[0:6] == '$GPGGA':
        sdata = data.split(",")
        print "---Parsing GPGGA---"
        time = sdata[1][0:2] + ":" + sdata[1][2:4] + ":" + sdata[1][4:6]
        if sdata[2] != '':
            lat = decode(sdata[2]) #latitude
        else:
            lat = "0"
        dirLat = sdata[3]      #latitude direction N/S
        if sdata[4] != '':
            lon = decode(sdata[4]) #longitute
        else:
            lon = "0"
        dirLon = sdata[5]      #longitude direction E/W

        fix = sdata[6]       #number of satellites being tracked
        satcnt = sdata[7]    #True course
        horzdil = sdata[8] # = sdata[9][0:2] + "/" + sdata[9][2:4] + "/" + sdata[9][4:6]#date
        alti = sdata[9]
        fname = 'GPS_TESTING'
        saveGGAData (fix,satcnt,horzdil,alti,fname)

        print ("fix: %s, sat.Cnt.: %s, horiz. dilution: %s, altitude(M) %s" % (fix,satcnt,horzdil,alti))

    if data[0:6] == '$GPRMC':
        sdata = data.split(",")
        if sdata[2] == 'V':
            print "no satellite data available"
            text = "no satellite data available"
            saveNoConnect(text, "GPS_TESTING")
            return
```

UNIVERSITI TEKNIKAL MALAYSIA MELAKA



```
        print "---Parsing GPRMC---"
        time = sdata[1][0:2] + ":" + sdata[1][2:4] + ":" + sdata[1][4:6]
        lat = decode(sdata[3]) #latitude
        dirLat = sdata[4]      #latitude direction N/S
        lon = decode(sdata[5]) #longitute
        dirLon = sdata[6]      #longitude direction E/W
        speed = sdata[7]       #Speed in knots
        trCourse = sdata[8]    #True course
        date = sdata[9][0:2] + "/" + sdata[9][2:4] + "/" + sdata[9][4:6]#date
        fname = 'GPS_TESTING'
        saveRMCData (time, lat, dirLat, lon, dirLon, speed, trCourse, date, fname)
        print ("time: %s, latitude: %s(%s), longitude: %s(%s), speed: %s, True Course: %s, Date: %s" %  (time,lat,dirLat,lon,dirLon,speed,trCourse,date))

def decode(coord):
    #Converts DDDMM.MMMMM > DD deg MM.MMMMM min
    print coord
    x = coord.split(".")
    head = x[0]
    tail = x[1]
    deg = head[0:-2]
    min = head[-2:]
    return deg + " deg " + min + "." + tail + " min"

def saveRMCData(time, lat, dirLat, lon, dirLon, speed, trCourse, date, fname):
    #save cleaned GPS-RMC data to a text file for later analysis
    #append the file format to the file name string
    fname = fname + ".txt"
    try:
        print "Opening File"
        #see if this file exists so that we can "append" data to the end of the file
        file = open(fname, "a")
    except:
        print "Creating File"
        file = open(fname, "w+")

    data = "time : %s, latitude : %s(%s), longitude : %s(%s), speed : %s, True Course : %s, Date : %s \n" %  (time,lat,dirLat,lon,dirLon,speed,trCourse,date)
    print "saving data"
    file.write(data)
    print "closing file"
    file.close()
```

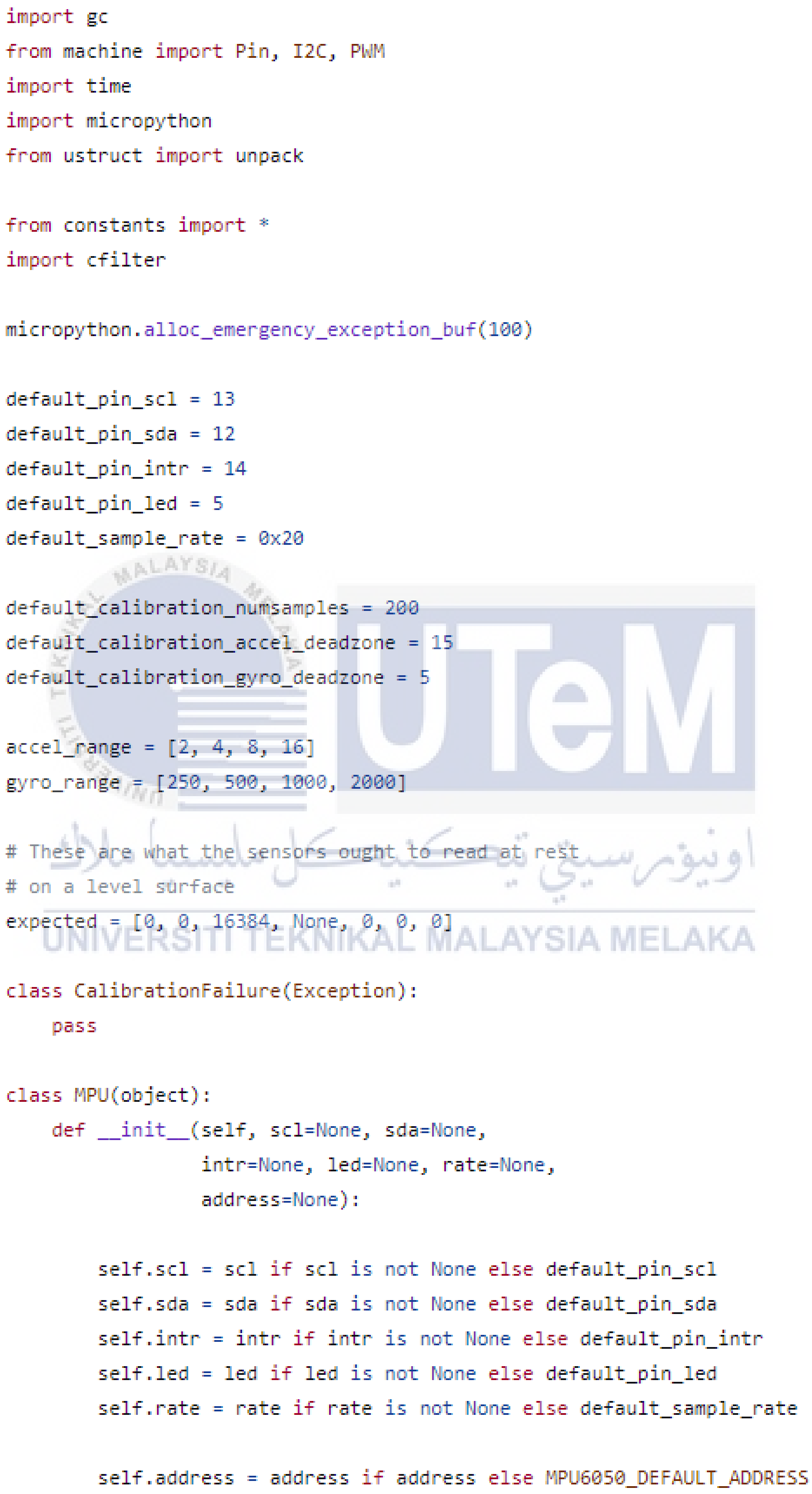
UNIVERSITI TEKNIKAL MALAYSIA MELAKA



```
def saveGGAData(fix,satcnt,horzdil,alti, fname):
    #save cleaned GPS-GGA data to a text file for later analysis
    #append the file format to the file name string
    fname = fname + ".txt"
    try:
        print "Opening File"
        #see if this file exists so that we can "append" data to the end of the file
        file = open(fname, "a")
    except:
        print "Creating File"
        file = open(fname, "w+")

    data = "fix: %s, sat.Cnt.: %s, horiz. dilution: %s, altitude: %s M \n" % (fix,satcnt,horzdil,alti)
    print "saving data"
    file.write(data)
    print "closing file"
    file.close()

def saveNoConnect(text, fname):
    #save "No connection" Text to text file for later analysis
    #append the file format to the file name string
    fname = fname + ".txt"
    try:
        print "Opening File"
        #see if this file exists so that we can "append" data to the end of the file
        file = open(fname, "a")
    except:
        print "Creating File"
        file = open(fname, "w+")
    print "saving data"
    file.write(text)
    print "closing file"
    file.close()

print "Receiving GPS data"
ser = serial.Serial(port, baudrate = 9600, timeout = 0.5)
while True:
   data = ser.readline()
   parseGPS(data)
   #time.sleep(3)
```

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Appendix D Coding IMU 6050



```
import gc
from machine import Pin, I2C, PWM
import time
import micropython
from ustruct import unpack

from constants import *
import cfilter

micropython.alloc_emergency_exception_buf(100)

default_pin_scl = 13
default_pin_sda = 12
default_pin_intr = 14
default_pin_led = 5
default_sample_rate = 0x20

default_calibration_numsamples = 200
default_calibration_accel_deadzone = 15
default_calibration_gyro_deadzone = 5

accel_range = [2, 4, 8, 16]
gyro_range = [250, 500, 1000, 2000]

# These are what the sensors ought to read at rest
# on a level surface
expected = [0, 0, 16384, None, 0, 0, 0]

class CalibrationFailure(Exception):
    pass

class MPU(object):
    def __init__(self, scl=None, sda=None,
                 intr=None, led=None, rate=None,
                 address=None):

        self.scl = scl if scl is not None else default_pin_scl
        self.sda = sda if sda is not None else default_pin_sda
        self.intr = intr if intr is not None else default_pin_intr
        self.led = led if led is not None else default_pin_led
        self.rate = rate if rate is not None else default_sample_rate

        self.address = address if address else MPU6050_DEFAULT_ADDRESS
```

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

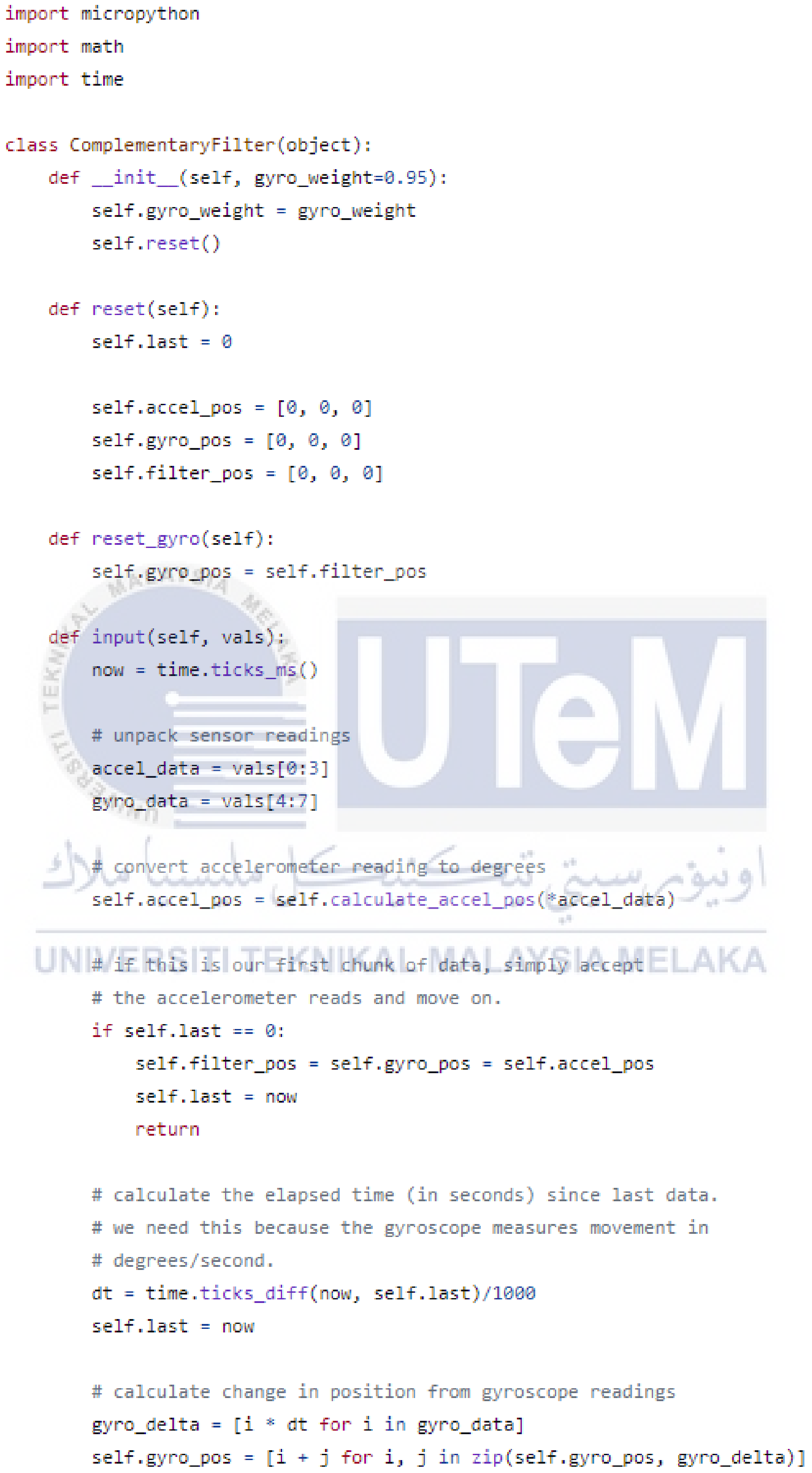
```
    self.buffer = bytearray(16)
    self.bytebuf = memoryview(self.buffer[0:1])
    self.wordbuf = memoryview(self.buffer[0:2])
    self.sensors = bytearray(14)

    self.calibration = [0] * 7

    self.filter = cfilter.ComplementaryFilter()

    self.init_pins()
    self.init_led()
    self.init_i2c()
    self.init_device()

def write_byte(self, reg, val):
    self.bytebuf[0] = val
    self.bus.writeto_mem(self.address, reg, self.bytebuf)

def read_byte(self, reg):
    self.bus.readfrom_mem_into(self.address, reg, self.bytebuf)
    return self.bytebuf[0]

def set_bitfield(self, reg, pos, length, val):
    old = self.read_byte(reg)
    shift = pos - length + 1
    mask = (2**length - 1) << shift
    new = (old & ~mask) | (val << shift)
    self.write_byte(reg, new)

def read_word(self, reg):
    self.bus.readfrom_mem_into(self.address, reg, self.wordbuf)
    return unpack('>H', self.wordbuf)[0]

def read_word2(self, reg):
    self.bus.readfrom_mem_into(self.address, reg, self.wordbuf)
    return unpack('>h', self.wordbuf)[0]

def init_i2c(self):
    print('* initializing i2c')
    self.bus = I2C(scl=self.pin_scl,
                   sda=self.pin_sda)
```

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

```
def init_pins(self):
    print('* initializing pins')
    self.pin_sda = Pin(self.sda)
    self.pin_scl = Pin(self.scl)
    self.pin_intr = Pin(self.intr, mode=Pin.IN)
    self.pin_led = PWM(Pin(self.led, mode=Pin.OUT))

def set_state_uncalibrated(self):
    self.pin_led.freq(1)
    self.pin_led.duty(500)

def set_state_calibrating(self):
    self.pin_led.freq(10)
    self.pin_led.duty(500)

def set_state_calibrated(self):
    self.pin_led.freq(1000)
    self.pin_led.duty(500)

def set_state_disabled(self):
    self.pin_led.duty(0)

def init_led(self):
    self.set_state_uncalibrated()

def identify(self):
    print('* identifying i2c device')
    val = self.read_byte(MPU6050_RA_WHO_AM_I)
    if val != MPU6050_ADDRESS_AD0_LOW:
        raise OSError("No mpu6050 at address {}".format(self.address))

def reset(self):
    print('* reset')
    self.write_byte(MPU6050_RA_PWR_MGMT_1, (
        (1 << MPU6050_PWR1_DEVICE_RESET_BIT)
    ))
    time.sleep_ms(100)

    self.write_byte(MPU6050_RA_SIGNAL_PATH_RESET, (
        (1 << MPU6050_PATHRESET_GYRO_RESET_BIT) |
        (1 << MPU6050_PATHRESET_ACCEL_RESET_BIT) |
        (1 << MPU6050_PATHRESET_TEMP_RESET_BIT)
    ))
    time.sleep_ms(100)
```

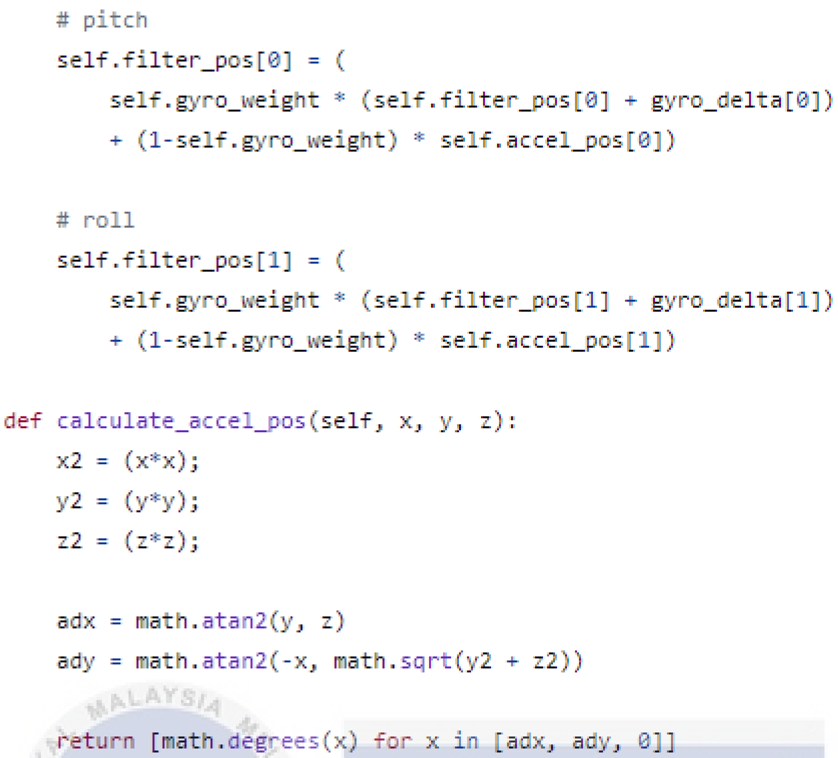
UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Appendix E Coding complementary filter



```
import micropython
import math
import time

class ComplementaryFilter(object):
    def __init__(self, gyro_weight=0.95):
        self.gyro_weight = gyro_weight
        self.reset()

    def reset(self):
        self.last = 0

        self.accel_pos = [0, 0, 0]
        self.gyro_pos = [0, 0, 0]
        self.filter_pos = [0, 0, 0]

    def reset_gyro(self):
        self.gyro_pos = self.filter_pos

    def input(self, vals):
        now = time.ticks_ms()

        # unpack sensor readings
        accel_data = vals[0:3]
        gyro_data = vals[4:7]

        # convert accelerometer reading to degrees
        self.accel_pos = self.calculate_accel_pos(*accel_data)

        # if this is our first chunk of data, simply accept
        # the accelerometer reads and move on.
        if self.last == 0:
            self.filter_pos = self.gyro_pos = self.accel_pos
            self.last = now
            return

        # calculate the elapsed time (in seconds) since last data.
        # we need this because the gyroscope measures movement in
        # degrees/second.
        dt = time.ticks_diff(now, self.last)/1000
        self.last = now

        # calculate change in position from gyroscope readings
        gyro_delta = [i * dt for i in gyro_data]
        self.gyro_pos = [i + j for i, j in zip(self.gyro_pos, gyro_delta)]
```

UTeM
اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA



```
    # pitch
    self.filter_pos[0] = (
        self.gyro_weight * (self.filter_pos[0] + gyro_delta[0])
        + (1-self.gyro_weight) * self.accel_pos[0])

    # roll
    self.filter_pos[1] = (
        self.gyro_weight * (self.filter_pos[1] + gyro_delta[1])
        + (1-self.gyro_weight) * self.accel_pos[1])

def calculate_accel_pos(self, x, y, z):
    x2 = (x*x);
    y2 = (y*y);
    z2 = (z*z);

    adx = math.atan2(y, z)
    ady = math.atan2(-x, math.sqrt(y2 + z2))

    return [math.degrees(x) for x in [adx, ady, 0]]
```

MALAYSIA MELAKA
UTeM
اونيۏرسيتي تيکنيکل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Appendix F Coding Web camera

```
import cv2
import threading

class camThread(threading.Thread):
    def __init__(self, previewName, camID):
        threading.Thread.__init__(self)
        self.previewName = previewName
        self.camID = camID
    def run(self):
        print("Starting " + self.previewName)
        camPreview(self.previewName, self.camID)

def camPreview(previewName, camID):
    cv2.namedWindow(previewName)
    cam = cv2.VideoCapture(camID)
    if cam.isOpened():
        rval, frame = cam.read()
    else:
        rval = False

    while rval:
        cv2.imshow(previewName, frame)
        rval, frame = cam.read()
        key = cv2.waitKey(20)
        if key == 27:  # exit on ESC
            break
    cv2.destroyWindow(previewName)
```

اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

```
# Create threads as follows
thread1 = camThread("Camera 1", 0)
thread2 = camThread("Camera 2", 1)
thread3 = camThread("Camera 3", 2)

thread1.start()
thread2.start()
thread3.start()
print()
print("Active threads", threading.activeCount())
```