



Faculty of Computer Science and Information Technology

Plant Monitoring System with Email Alert using Arduino and Raspberry Pi

Lau Ming Xian

Bachelor of Computer Science with Honors (Software Engineering)

2019

UNIVERSITI MALAYSIA SARAWAK

THESIS STATUS ENDORSEMENT FORM

TITLE PLANT MONITORING SYSTEM WITH EMAIL ALERT USING
ARDUINO AND RASPBERRY PI

ACADEMIC SESSION: 2018/19

IAU MING XIAN

(CAPITAL LETTERS)

hereby agree that this Thesis* shall be kept at the Centre for Academic Information Services, Universiti Malaysia Sarawak, subject to the following terms and conditions:

1. The Thesis is solely owned by Universiti Malaysia Sarawak
2. The Centre for Academic Information Services is given full rights to produce copies for educational purposes only
3. The Centre for Academic Information Services is given full rights to do digitization in order to develop local content database
4. The Centre for Academic Information Services is given full rights to produce copies of this Thesis as part of its exchange item program between Higher Learning Institutions [or for the purpose of interlibrary loan between HLI]
5. ** Please tick (✓)

CONFIDENTIAL

(Contains classified information bounded by the OFFICIAL SECRETS ACT 1972)

RESTRICTED

(Contains restricted information as dictated by the body or organization where the research was conducted)

UNRESTRICTED

Validated by

(AUTHOR'S SIGNATURE)

(SUPERVISOR'S SIGNATURE)

Permanent Address

24, JALAN MURNI 3, TAMAN
MURNI, 83000 BATU PAHAT,
JOHOR

Date: 14-5-2019

Date: _____

Note * Thesis refers to PhD, Master, and Bachelor Degree

** For Confidential or Restricted materials, please attach relevant documents from relevant organizations / authorities

Plant Monitoring System with Email Alert using Arduino and Raspberry Pi

LAU MING XIAN

This project is submitted in partial fulfillment of the requirements for the degree of Bachelor of Computer Science with Honors

Faculty of Computer Science and Information Technology
UNIVERSITI MALAYSIA SARAWAK 2019

DECLARATION

I hereby declare that the project entitled “Plant Monitoring System with Email Alert using Arduino and Raspberry Pi” submitted by me to Faculty of Computer Science and Information Technology, University Malaysia Sarawak (UNIMAS) is a record of an original work done by me under guidance of Madam Nurfaeza binti Jali.

(LAU MING XIAN)

ACKNOWLEDGEMENT

Firstly, I would like to express my sincere thanks to my Final Year Project (FYP) supervisor, Mdm Nurfaeza Jali for her advices throughout the FYP 1 semester. I am extremely thankful and grateful to her for sharing expertise and valuable guidance.

In addition, I would like to express my gratitude to all my friends and faculty member for their help and supports. The support and feedback given have been useful throughout the process of Final Year Project.

TABLE OF CONTENTS

ACKNOWLEDGEMENT	ii
TABLE OF CONTENTS.....	iii
LIST OF TABLES	vii
LIST OF FIGURES	viii
ABSTRACT.....	x
ABSTRAK.....	xi
CHAPTER ONE: INTRODUCTION.....	1
1.1 Introduction.....	1
1.2 Problem Statement	2
1.3 Objectives.....	2
1.4 Scope	3
1.5 Brief Methodology	3
1.6 Significance of Project	5
1.7 Project Schedule.....	6
1.8 Expected Outcome	8
1.9 Project Outline.....	9
1.10 Conclusion.....	9
CHAPTER TWO: LITERATURE REVIEW.....	10
2.1 Introduction	10
2.2 Background	10
2.3 Review of the existing system.....	10
2.3.1 Plantui6.....	11
2.3.2 Aerogarden Harvest Wi-Fi Classic.....	13
2.3.3 Click & Grow Smart Garden 3	15
2.3.4 Edyn Smart Garden System.....	16
2.4 Comparison of Function and Features Between Existing Systems.....	19
2.5 Summary of the systems reviewed.....	20
2.6 Review of Software used.....	21
2.6.1 Arduino IDE	21
2.6.2 Fritzing.....	22
2.7 Review of Hardware Used	23

2.7.1 ESP8266 Wifi Module.....	23
2.7.2 Raspberry Pi 3 Model B	24
2.8 Conclusion.....	25
CHAPTER THREE: REQUIREMENT ANALYSIS AND DESIGN.....	26
3.1 Introduction	26
3.2 Development Methodology.....	26
3.2.1 Agile Software Development Lifecycle	26
3.3 Requirement Analysis	28
3.3.1 Hardware Requirements	28
3.3.2 Software Requirements.....	29
3.3.3 User Requirement	30
3.3.4 System Interface Requirement.....	31
3.4 Design.....	31
3.4.1 System Architecture	31
3.4.1.1 Architecture of ESP8266 part	32
3.4.1.2 Architecture of Raspberry Pi Part	33
3.4.1.3 Combined Architecture	35
3.4.2 System Schematics	36
3.4.2.1 ESP8266 Schematics	36
3.4.2.2 Raspberry Pi Schematics.....	39
3.4.3 System Interface	40
3.4.3.1 Interface for Main Page	40
3.4.4 Use Case Diagram	43
3.4.4.1 Use case view.....	43
3.4.4.2 Gardener use case (1).....	44
3.4.4.3 Gardener use case (2).....	45
3.4.4.4 ESP8266 use case (1).....	46
3.4.4.5 ESP8266 use case (2).....	47
3.4.4.6 Raspberry Pi use case (1).....	48
3.4.4.7 Raspberry Pi use case (2).....	49
3.4.4.8 Raspberry Pi use case (3).....	50
3.4.4.9 Raspberry Pi use case (4).....	51

3.4.4.10 Raspberry Pi use case (5).....	52
3.4.5 Sequence Diagram.....	53
3.4.6 Activity Diagram.....	54
3.4.6.1 Activity diagram of system part.....	54
3.4.6.2 Activity diagram of user part.....	55
3.4.7 State transition diagram.....	56
3.5 Summary.....	57
CHAPTER FOUR: IMPLEMENTATION AND TESTING.....	58
4.1 Introduction.....	58
4.2 System Requirements.....	58
4.2.1 Functional Requirements.....	58
4.3 Hardware Configuration.....	59
4.3.1 Raspberry Pi.....	59
4.3.1.1 MicroSD 16GB Memory Card.....	59
4.3.1.2 Raspberry Pi Touch Display.....	60
4.3.2 ESP8266.....	62
4.3.2.1 DHT11 Temperature Sensor.....	62
4.3.2.2 Buzzer Module.....	63
4.3.2.3 Soil Moisture Sensor.....	64
4.3.2.4 Final configuration.....	65
4.4 Software Configuration.....	65
4.4.1 Install LAMP on Raspberry Pi.....	65
4.4.2 Install Raspbian OS on Raspberry Pi.....	66
4.4.3 Installing Libraries and Module in ESP8266.....	67
4.4.3.1 ESP8266 Board Module.....	67
4.4.3.2 Blynk and ESP8266 Libraries.....	68
4.4.4 Blynk Mobile Application.....	69
4.5 Modules Design.....	71
4.5.1 Raspberry Pi Modules.....	71
4.5.1.1 Data Visualization function.....	71
4.5.1.2 History log function.....	73
4.5.1.2 Mail function.....	74

4.5.2 ESP8266 Modules	76
4.5.2.1 Blynk function	76
4.5.2.2 Post data function.....	78
4.5.2.3 Alert function	79
4.6 Testing.....	79
4.6.1 Introduction	79
4.6.2 Unit Testing	80
4.6.2.1 Raspberry Pi Module	80
4.6.2.2 ESP8266 Module	82
4.6.3 Hardware Testing	85
4.6.4 Usability Testing.....	86
4.7 Conclusion.....	87
CHAPTER FIVE: CONCLUSION AND FUTURE WORKS.....	88
5.1 Introduction	88
5.2 Achievements	88
5.3 Contributions.....	89
5.4 Limitations	89
5.5 Future works.....	89
5.5.1 Advisor features.....	90
5.5.2 Automated watering features.....	90
5.5.3 Multiple plants support.....	90
5.6 Conclusion.....	90
REFERENCES	91
APPENDICES	92

LIST OF TABLES

Table 2.1: Comparison of Function and Features Between Existing System.....	19
Table 3.1: The planned development cycle for development.....	28
Table 3.2: List of hardware description	29
Table 3.3: List of software description	30
Table 3.4: List of connected pins between Buzzer and ESP8266.....	36
Table 3.5: List of connected pins between Soil Moisture Sensor and ESP8266	37
Table 3.6: List of connected pins between ESP8266 and DHT11	38
Table 3.7 Description of gardener use case (1).....	44
Table 3.8 Description of gardener use case (2).....	45
Table 3.9 Description of ESP8266 use case (1).....	46
Table 3.10 Description of ESP8266 use case (2).....	47
Table 3.11 Description of Raspberry Pi use case (1).....	48
Table 3.12 Description of Raspberry Pi use case (2).....	49
Table 3.13 Description of Raspberry Pi use case (3).....	50
Table 3.14 Description of Raspberry Pi use case (4).....	51
Table 3.15 Description of Raspberry Pi use case (5).....	52
Table 4.1 Unit Testing on Data Visualization Function	80
Table 4.2 Unit Testing on History Log Function.....	81
Table 4.3 Unit Testing on Mail Function.....	82
Table 4.4 Unit Testing on Blynk Function	83
Table 4.5 Unit Testing on Post Data Function.....	84
Table 4.6 Unit Testing on Alert Function.....	84
Table 4.7 Hardware Testing on Raspberry Pi and ESP8266	85
Table 4.8 Section A of Questionnaire Result.....	86
Table 5.1 Project Objectives and Achievements	88

LIST OF FIGURES

Figure 1.1: Agile Software Development Lifecycle Diagram	4
Figure 1.2: Sketch of hardware design	5
Figure 1.3 Project Schedule Gantt Chart	7
Figure 2.1: Plantui6 (Plantui, 2015).....	11
Figure 2.2: Components of the Plantui6 (Plantui, 2015)	12
Figure 2.3 Aerogarden Harvest Wi-Fi Classic (Aerogarden, 2017)	13
Figure 2.4 Graphical user interface of the Aerogarden App (Aerogarden, 2017)	14
Figure 2.5 Click & Grow Smart Garden 3 (Click & Grow, 2016)	15
Figure 2.6 Edyn Smart Garden System (KickStarter, 2016)	17
Figure 2.7: Graphical User Interface of Edyn App (KickStarter, 2016).....	18
Figure 2.8: Arduino IDE (Arduino, 2011)	21
Figure 2.9: Fritzing Breadboard View (Fritzing, 2009).....	22
Figure 2.10 ESP8266 Wi-Fi Board.....	23
Figure 2.11 Raspberry Pi 3 Model B	24
Figure 3.1: The architecture of the ESP8266 part.....	32
Figure 3.2: The architecture of Raspberry Pi part.....	33
Figure 3.3: Combined Architecture	35
Figure 3.4: Schematic of ESP8266 with Buzzer.....	36
Figure 3.5: Schematic of ESP8266 with Soil Moisture Sensor	37
Figure 3.6: Schematic of ESP8266 with DHT11 Temperature and Humidity Sensor	38
Figure 3.7 Schematic of Raspberry Pi 3 Model B	39
Figure 3.8: Proposed Design of the main page of the system.....	40
Figure 3.9: Temperature option page.....	41
Figure 3.10: Humidity option page.....	42
Figure 3.11: Use case diagram of Plant Monitoring System	43
Figure 3.12: Use case diagram (1) of gardener.....	44
Figure 3.13: Use case diagram (2) of gardener.....	45
Figure 3.14: Use case diagram of ESP8266 (1).....	46
Figure 3.15: Use case diagram of ESP8266 (2).....	47
Figure 3.16: Use case diagram (1) of Raspberry Pi.....	48

Figure 3.17: Use case diagram (2) of Raspberry Pi	49
Figure 3.18: Use case diagram (3) of Raspberry Pi	50
Figure 3.19: Use case diagram (4) of Raspberry Pi	51
Figure 3.20: Use case diagram (5) of Raspberry Pi	52
Figure 3.21: Sequence Diagram of Plant Monitoring System	53
Figure 3.22: Activity diagram of system part	54
Figure 3.23: Activity diagram of user part.....	55
Figure 3.24: State transition diagram of Plant Monitoring System	56
Figure 4.1: Installation of Micro SD Card	60
Figure 4.2: Side view of the raspberry pi attached with adapter board	61
Figure 4.3: Top view of Raspberry Pi Touch Display board.....	62
Figure 4.4: DHT11 sensor connects with the ESP8266 board.....	63
Figure 4.5: The buzzer module connects with the ESP8266 board	64
Figure 4.6: Raspbian OS	66
Figure 4.7: Boards Manager in Arduino IDE	67
Figure 4.8: Select ESP8266 Board.....	68
Figure 4.9: Include Library in Sketch	69
Figure 4.10: Register Page and Dashboard of the Blynk Mobile Application	70
Figure 4.11: Interface Design of Data Visualization	71
Figure 4.12: Snippet code of the render option of chart	72
Figure 4.13: Snippet code of construction of table	73
Figure 4.14: Interface Design of History log	74
Figure 4.15: Server settings to send the mail	74
Figure 4.16: Sender and Recipient setting	75
Figure 4.17: Screenshot of the email notification	75
Figure 4.18: Widget Setting.....	76
Figure 4.19: Declared variables in Sensor.ino code	77
Figure 4.20: Result of ipconfig -a command	77
Figure 4.21: Snippet code of write data to the Blynk mobile application	78
Figure 4.22: Snippet code of post data function	78
Figure 4.23: Snippet code of alert function	79

ABSTRACT

Most of the people stop gardening is because of the insufficient knowledge about taking care of the plant. The proposed system for this project aims to ease the process of grows plant using sensor to capture environment data. The environment data including temperature, air humidity, light, and soil moisture. In this project, a DHT11 basic temperature humidity sensor will be used to receive temperature and air humidity data. Next, an analog capacitive soil moisture sensor will be used to measure the soil moisture level. These data will be sent to Raspberry Pi and these data will be visualized and the result will be displayed to the user through the web-based system interface. Based on the data captured, an email alert will be sent to the user as a reminder to water the plant.

ABSTRAK

Kebanyakan orang berhenti penanaman kerana pengetahuan yang tidak mencukupi tentang penanaman. Projek ini bertujuan untuk memudahkan proses penanaman tumbuhan dengan menggunakan sensor untuk mendapat maklumat persekitaran tumbuhan. Maklumat persekitaran termasuk suhu, kelembapan udara, cahaya, dan kelembapan tanah. Dalam projek ini, sensor “DHT11” akan digunakan untuk menerima data kelembapan udara dan suhu. Seterusnya, sensor “Gravity” akan digunakan untuk menerima tahap kelembapan tanah. Maklumat ini akan dihantar kepada Raspberry Pi dan maklumat ini akan divisualisasikan dan pengguna boleh memantau statistic persekitaran tumbuhan. Berdasarkan maklumat yang diterima, e-mel akan dihantar kepada pengguna sebagai peringatan untuk menyiram tumbuhan.

CHAPTER ONE: INTRODUCTION

1.1 Introduction

A new trend in the Internet technologies and Wireless Sensor Networks (WSN) is being realized with the increase in users of the Internet and changes on the internetworking technologies enable networking on everything around people. (Kelly, Suryadevara, & Subhas, 2013). “Internet of things (IoT)” is about machine talking to each other and these communications will be extended to “things” (Sundmaeker, Guillemin, Friess, & Woelffle , 2010). A machine attached with sensors can collect the data and perform certain tasks automatically to solve the daily life problems. These data collected by the sensor can be saved for the future decision making.

Gardening works as a means of nurturing relationships between people, communities and the landscape. The relationships are social, economic and ecological (Irvine, Johnson , & Peters, 1999). The practice of a community gardening is widespread as both collective gardens and individual allocated spaces (Holland, 2011).

However, most of the people do not have the time or resources to do gardening. It is important to develop devices that facilitate the process of growing the plants which can promote the interest of people on gardening.

This project is designed to help inexperienced gardener or those who always forget to take care of their plants by using IoT devices. Few factors need to be considered when gardening such as soil, weather, and climate. The system will display the condition of the environment of the plant by collect the data using analogue sensor and send mail to the user when the plants need water by

using Raspberry Pi which acts as a server. The user can water the plant till the optimum soil moisture according to the result to avoid over usage of water.

1.2 Problem Statement

There are research states that people use more water in gardening due to lack of knowledge about water usage (Liangxin, Fei, Guobin, & Wei, 2014). If there is too little water will prevent plant growth and the quality of the plant will be affected while if there is too much of water, it will leach fertilisers and reduce aeration (Caetano, Pitarma, & Reis, 2015). People often scared of growing plants especially for the people who have less experience in gardening as they scared the plants will die due to lack of water or watering the plant over the optimal level. Besides, the location of the plants is important as the plant overexposes to the sunlight will cause the water evaporates fast and cannot absorb by the plant. Furthermore, it is time-consuming to take care of a plant, and it will be a troublesome for those busy at work.

1.3 Objectives

1. To analyse the existing plant monitoring system and proposed solution on improving the design of graphical user interface and alert features.
2. To design and implement plant monitoring system that visualises environment data and display in numerical or graph form.
3. To test different environment data to identify the suitable value of environment data that reach optimum condition.

1.4 Scope

The plant monitoring system is intended to give the user a graphical interface showing the condition of the environment. Besides, the system also sends an email alert to the user to remind them to water the plant or inform them about the condition of the environment of the plant. The end user is focused on those people who are busy at work to remember water the plant and people who are lack of experience in gardening.

The main scope for this system is to ease the process of growing the plant. It shows the result in graphical or numerical form which gives the user a better understanding of the environment of the plant and what they should do to facilitate the growth and maintenance of plants.

1.5 Brief Methodology

This project is using Agile Software Development Lifecycle model to design the system. The agile methodology breaks project into different cycles. In each cycle, there are phases such as planning, requirement analysis, design, implementation and testing, and review. Agility capability enables software development process can deal with unpredictable situation and rapid changes (Highsmith & Highsmith, 2002). The agile methodology releases prototypes which have further improvement from the previous prototype. Diagram of Agile Software Development Lifecycle is defined in the Figure 1.1 below.

For planning phase, the problem statement of the project needed to be defined clearly. Based on the problem statement, the scope and objectives of the project are defined in this phase. For requirement analysis phase, similar project will also be reviewed in this phase to help gathering

useful information for this project. Besides, the datasheet of the component needed to be collected to define the specification of these component. For the design phase, the hardware architecture needed to be defined in this phase. The sketch of the hardware architecture is defined in the Figure 1.2 below. Each of the sensor is divided into different module to ease the process of design the interface and input output functions. Moreover, the backend system is designed in this phase for data storing and client-server communication purpose. For implementation and testing phase, the system is implemented and testing under different condition. The various function of the system will be tested with different data input. Lastly, for the review phase, any limitations or errors will be collected and make changes in the next prototype.

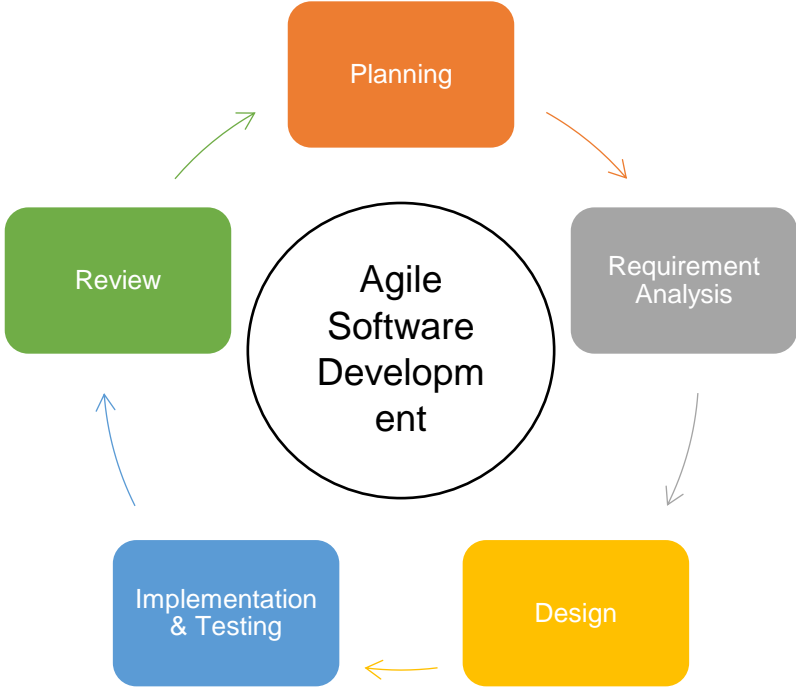


Figure 1.1: Agile Software Development Lifecycle Diagram

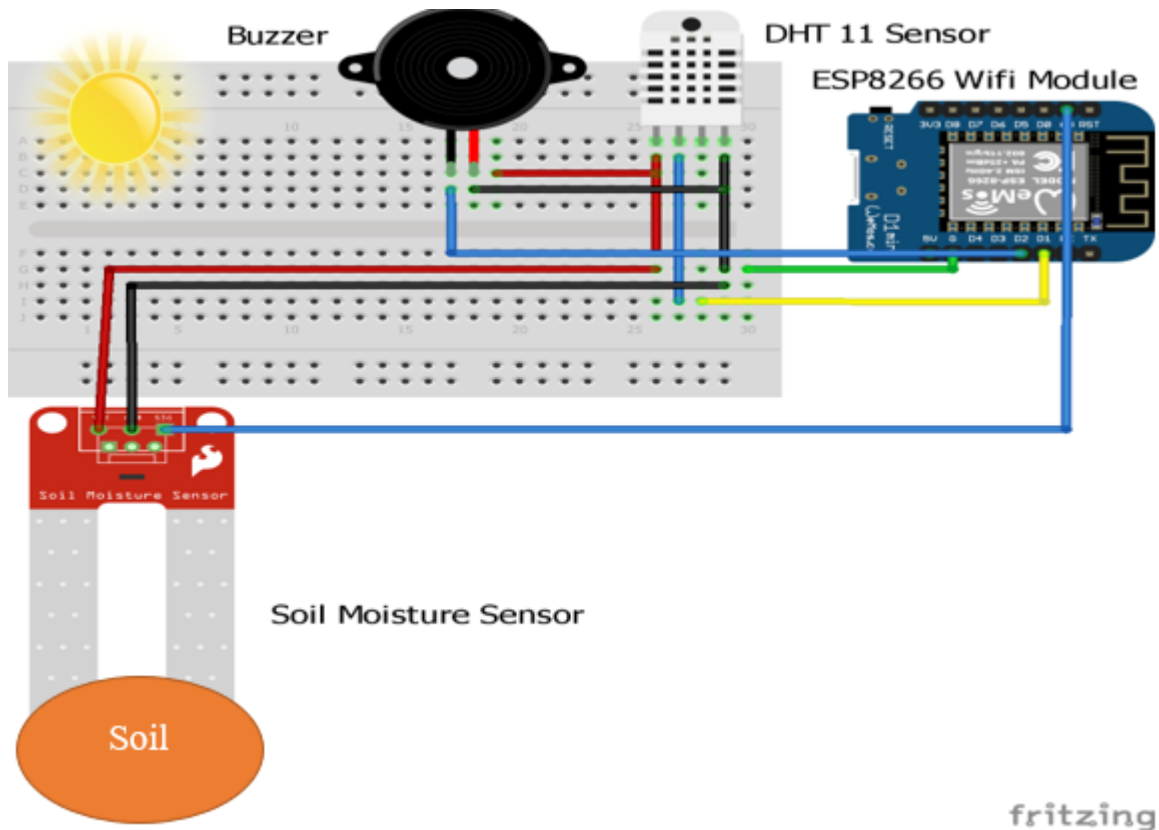


Figure 1.2: Sketch of hardware design

1.6 Significance of Project

The main aim for this system is to ease the process of growing the plant by creating a system that monitoring the environment of the plant. These data show in graphical or numerical form which gives the user a better understanding of environment of the plant and what they should do to facilitate the growth and maintenance of plants.

1.7 Project Schedule

	Task Name	Duration	Start	Finish
1	Project Proposal	13 days	Mon 24/9/18	Wed 10/10/18
2	Brief Proposal	5 days	Mon 24/9/18	Fri 28/9/18
3	Full Proposal	8 days	Mon 1/10/18	Wed 10/10/18
4	Chapter 1: Introduction	9 days	Thu 11/10/18	Tue 23/10/18
5	Introduction	2 days	Thu 11/10/18	Fri 12/10/18
6	Problem Statement	1 day	Sat 13/10/18	Sat 13/10/18
7	Objective	1 day	Sun 14/10/18	Sun 14/10/18
8	Brief Methodology	5 days	Mon 15/10/18	Fri 19/10/18
9	Scope	1 day	Sat 20/10/18	Sat 20/10/18
10	Significant of the Project	1 day	Sun 21/10/18	Sun 21/10/18
11	Project Schedule	1 day	Mon 22/10/18	Mon 22/10/18
12	Expected Outcome	1 day	Tue 23/10/18	Tue 23/10/18
13	Chapter 2: Literature Review	15 days	Mon 29/10/18	Fri 16/11/18
14	Chapter 3: Methodology	17 days	Sun 18/11/18	Mon 10/12/18
15	Submission of FYP 1 Final Report and Paper for Assessment	25 days	Mon 10/12/18	Fri 11/1/19
16	Chapter 4: Implementation and Testing	60 days	Mon 14/1/19	Fri 5/4/19
17	Chapter 5: Conclusion and Future Works	14 days	Mon 8/4/19	Thu 25/4/19

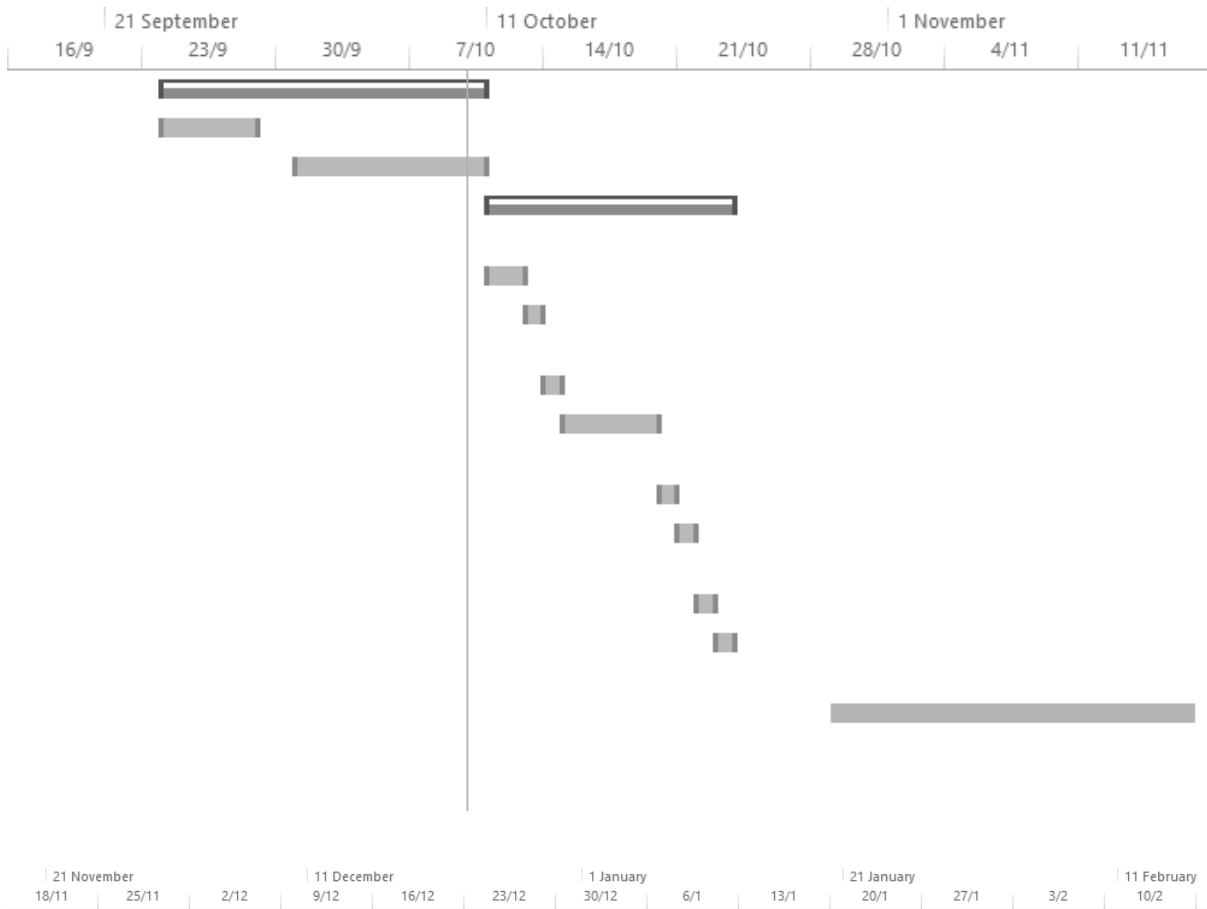




Figure 1.3 Project Schedule Gantt Chart

1.8 Expected Outcome

The system can visualise the data collected by sensors and display in a graph or numerical form.

The system can send an email alert to the user containing the data and the action need to be taken.

1.9 Project Outline

For chapter one, the introduction is lists out the problem statement, objectives and scope of the project, the methodology used, significance of project, project schedule and the expected outcome of the project.

For chapter two, it is regarding research on the existing plant monitoring system. Their limitations and functionalities will be identified and compared. It also discusses how the proposed system can overcome or improve these limitations. Besides, the software and hardware used for the project will be listed and explained in this chapter.

For chapter three, it is regarding how the current system works. The analysis of the systems to take the environment data and method to visualise the environment data are discussed in this chapter.

For chapter four, it is discussed about the tools and methods for design, implementation of the systems, and system testing.

For chapter five, it is discussed about the summary and conclusion of the project. Moreover, it also discussed about the future work or improvement that can be done for this system.

1.10 Conclusion

This chapter is regarding the introduction of the proposed system. The proposed system is about developing a system that can help the user to monitor the environment of the plant and helps the user to do decision whether the need to water the plant or not. This system able to increase the efficiency of the user in gardening.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the sensor used in this project and the existing smart garden system. The features and the design of the graphical user interface will be compared. The pros and cons of the system will be compared to determine the functionality and design of the proposed system. Besides, the tools and techniques to design the backend will be examined to choose the suitable backend framework.

2.2 Background

Gardening works as a means of nurturing relationships between people, communities and the landscape. The relationships are social, economic and ecological (Irvine, Johnson , & Peters, 1999). The practice of a community gardening is widespread as both collective gardens and individual allocated spaces (Holland, 2011).

However, most of the people do not have the time or resources to do gardening. It is essential to develop devices that facilitate the process of growing the plants which can promote the interest of people on gardening. Most of the products on the market use hydroponic growing which requires technical knowledge.

2.3 Review of the existing system

There are four existing systems will be reviewed in this system. The system consists of two hydroponic growing smart garden system which are Plantui6, and Aerogarden. Another two