Remote Watering System for Home Garden

by

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Technology (Hons)
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CERTIFICATION OF APPROVAL

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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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SITI AISYAH ZAINAL ABIDIN

ABSTRACT

This project is conducted to develop a part of a home automation system which is a remote watering system that enables the user to monitor their home garden during their absence. Home automation system nowadays has become an alternative for the user to take care of their home. Previously, people always rely on other people to take care of their home. Those who want to leave their home for vacation or outstation has to ask other people's help, for example, their neighbor to water their garden. Today, with the assistance of the home automation system, it allows the user to monitor their home remotely, even if they are away from their home. In this project, a remote watering system which is a system that enable user to monitor and control the watering system via a web server has been developed. This system consists of two parts, the watering system and the web server interface. The watering system consist of Arduino microcontroller, soil humidity sensor and a water pump. The sensors will read the current soil humidity and update it on the web server. The second part of the system which is the web server interface enables the user to see their garden's current soil humidity reading and allow them to turn on and turn off the button to control the watering system. The system also allow user to activate automation mode if she does not want to control it manually. For this project, an incremental model is adopted for the project development and testing is done to test the functionality of the system. After several testing done, it can be concluded that the system has successfully fulfilled its functionality as proposed in this project.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.1 Project Background

In Malaysia, gardening has widely been practiced by Malaysian especially those who lives in rural area. They do gardening for many reasons including planting their own food, income generation, decorating their house and even for self-satisfaction or as a hobby. Although gardening activity in urban area is not widely practiced as compared to rural area, the introduction of edible garden, urban farming and community garden in the urban area has encouraged the community to have their own garden. Plus, with modern issues such as food security, environmental sustainability and health, it has driven the spread of urban farming or urban gardening among Malaysian (Nair, 2014).

Malaysia Government has once launched a campaign "Bumi Hijau" in 2006 as an initiative to encourage Malaysian to plant their own food and at the same time promoting people to take care of the environment (Putrajaya, n.d). In line with this campaign, there are now seven community garden in Putrajaya as reported by Putrajaya Corp Landscape and Park Department. Not only that, recently it was reported that Universiti Putra Malaysia (UPM) has launched Urban Agriculture as an effort to encourage modern farming among city dwellers in the limited space in their home as a guaranteed source food for the nation by 2020 (Noh, 2015).

However, gardening is not an activity that people can simply do in a short period of time. It requires some skill, knowledge and commitment for people to do gardening. For example, some of the plants need to be watered daily and this create a problem for people who are busy with their work especially those who live in urban area. The senior deputy director of Putrajaya Corp Landscape and Park Department, Noriah Mat said that the participation by the community member in urban gardening project getting decreased

to a mere 5% over the years although many have shown their interest. Although some of the project were successful, some were in doubt about the sustainability of urban farming and some of them were still finding time when to do the urban farming as most of them have a day job (Yeen, 2014).

Living in the modern world these days has shown that technology can be used to improve human's daily activity. A lot of innovations were introduced to help to improve human's life in all aspects such as communication, health, home and many more. Home automation system, for example, has been used to improve human's life.

Thus, the idea of this project is to embed the technology in gardening activity to help them to monitor their garden and at the same time improve their gardening process which is watering the plant. This paper propose a remote watering system that enable the user to monitor current soil humidity of their garden and control the watering system via a web server.

1.2 Problem Statement

Gardening is an activity that needs supervision from the human. Some people enjoy gardening as their hobby. However, it becomes a problem for people to monitor their garden during their absence. They have to seek help from their neighbor or relative to take care of their garden when they are away from home (for example: going for vacation) and this is a very tedious process. Furthermore, working people does not have time to monitor their garden daily. These people usually treat gardening as a weekend hobby in which they will focus on gardening during their free time on their weekend.

Therefore, the idea of this project is to develop a system for people to monitor and water their home garden through a web server that can be accessed through the Internet.

1.3 Objectives

The main objective of this project is to develop a remote watering system as a part of home automation system which is a web based garden watering system that helps the user to monitor and water their plant through the web server. The objectives of developing the web server can be divided into three parts which are:

1. To allow user to check the current soil humidity level of their garden.

2. To allow user to turn on and off the watering system to water their garden.
3. Set the watering system into automate mode

1.4 Scope of Project

The system is basically designed for people who has a garden but having some constraint in watering it. The aim here is to develop a system that enable the user to monitor their garden based on its current soil humidity and enable them to control watering system remotely through the web server.

For this project, a prototype of the system has been developed which will be focusing on the ability of the watering system to be accessed via a web server and it is designed for indoor garden. This system has been developed using a simple microcontroller which is Arduino and Input-Output (IO) components which are the soil humidity sensor and water pump. There are various type of soil moisture sensor available, however for prototyping purpose, a resistive sensor is used as it readily available in the market. Other than that, the prototype has been developed using an Ethernet connection instead of Wifi because of the Wifi limitation in the development area.

1.5 Relevancy of the project

This project is a part of the home automation system. Since it is a part of a home automation system, it is assumed that each house has either Wifi connection or Ethernet connection. Furthermore, since it is developed for small scale use which is home use, using a simple microcontroller like Arduino, soil humidity sensor and water pump are relevant in this context.

In term of time scope, the student was given 8 months to complete the project which consist of Final Year Project 1 (FYP1) and Final Year Project 2(FYP2). Based on the time scope, the time needed to complete this project will be fit into the timeline. FYP1 will cover processes of planning, analysis and design and FYP2 will cover the implementation and testing.

CHAPTER 2
LITERATURE REVIEW

2.1 Home Automation System

In most of advanced countries, a home automation system has been widely adopted to increase the efficiency of their home. However, in a developing country like Malaysia, the market for home automation system are still at a growing phase. According to the research entitled Home Automation Trends in Asia, Malaysia and India will take about 2 to 3 years to contribute to the emergence of home automation market (ResearchandMarket, n.d).

Automation can be defined as an automatically controlled operation of equipment, process or system by using mechanical or electrical devices that take place the role of human (Merriam-Webster, n.d). With the help of technology, automation is commonly used in a manufacturing industry, transportation, telecommunication and many more. Home automation is one of the examples of an automation system. Home automation can be referred as the usage of electrical devices such as computer to control basic of home functions and features automatically and also remotely (WhatIs.com, n.d). There are a lot of options for people to have home automation systems out there. These includes the home automation system that user need to purchase (commercial home automation) and also Do It Yourself (DIY) home automation that user can configure by themselves using their knowledge and follows the tutorial available on the internet.

There are a lot of application areas in the home automation system. Based on the research done, home automation system can be divided into six application areas which are security, lighting, energy, climate control, irrigation and entertainment (Takayama, Pantofaru, Robson, Soto, & Barry, 2012).

Home security system refers to the system used to take care of the security of the house such as detecting an intruder. Lighting, on the other hand, involves a system to control the light. According to Takayama et al., (2012) lighting is a very common application in home automation. Another application area like energy was used to monitor the energy consumption of the house to avoid energy waste. Other than that, automation system like a climate control and irrigation system enable the home component to be controlled as a response to the environmental factor. For example, in climate control system, an opened window will be automatically closed if they detect water falling on it and irrigation system allows the water sprinkler to be automated to water the garden.

There are a lot of reasons on why people go for the home automation system. Robinson (2012) stated that convenience, security and energy efficiency are among of the reason for the home automation system. This is further supported by Jay McLellan of Home Automation Inc who said that home automation actually makes the home energy is more efficient, comfortable, convenient and safer(Scheer & Moss, 2013). With the home automation system, the process of home monitoring becomes easier even the owners are not in their home. For example, people who are leaving their house can monitor and control their home remotely. If they forgot to switch off the switch, they can simply control it remotely via their smartphone.

The trend of the home automation system has evolved recently following the evolution of digital technology. If home automation is static before, now with the help of Internet, it is possible for human to control physical world remotely and make the home automation system is a part of the Internet of Things. The concept of Internet of Things refers to the objects (including human and animal) with the ability to transfer data over a network without the need of human to human or human to computer interaction (Wigmore, 2014).

Recent trend has revealed various kind of home automation system. Android-based, remote-controlled, web-based and a lot of other names applied has indicated that home automation is no longer a static system in which users has to control it through a main controller at home. Instead, it gives the user an ability to control the system remotely, even they are not in their home.

2.2 Irrigation in Gardening

Water is one of the important factors in gardening. Plant, like other living things, need a certain amount of water to stay healthy and alive. According to Wiecko (2006), the most important factor to determine the plant's need for water is evapotranspiration, a combination of evaporation which means the loss of water from the surface and transpiration which means water loss from the plant.

There are several factors that affect the transpiration rate of the plant such as environmental factor and the plant itself. Environmental factors included factor like humidity, temperature, soil and wind while plant factor included the type of the plant itself.

John (2006) stated that there are a state that plant are able to survive without water, which is known as dormancy, however every plant have its own limitation for them to recover when they are insufficient of water during this period of time. The inability for the plant to recover from the moisture loss is known as permanent wilting point (John, 2006). Therefore, water is important for the plant to survive.

According to Wiecko (2006), there are many factors that affect the transpiration and evaporation process of the plant including humidity, temperature and wind. Low humidity cause the both process of evaporation and transpiration high, however for the temperature, it has a different effect on the process. The high temperature will cause the evaporation rate to be high but for transpiration process, it works differently. Wiecko (2006) further stated that usually the leave transpire more as the temperature rise, however if the temperature is too high, the stomata closure can be triggered to save water. Therefore, unless the temperature is extremely high, the rate of transpiration increases as the temperature increase.

In irrigation system, there are a lot of methods that can be used. Drip irrigation, sprinkler system, soaker hose and hand-held hosing are among of irrigation methods been used. Drip irrigation is highly efficient irrigation system and economical method to save water. According to Wilson and Bauer (2014), drip irrigation exceeds about 90 % efficiency as compared to another method like sprinkler which only have 50% up to 70% efficient. Drip irrigations deliver water directly to the soil, minimizing water loss through

evaporation. OrganicGardening (n.d-a) stated that the main benefit of drip irrigation is that it helps to save both time and effort, especially for busy gardeners. Other method is by using a water sprinkler, a water hose that rotates and spray water droplets over a wide area. Bradley and Negus (2001) stated that sprinkler is useful for watering a newly laid lawn however it might be wasteful for a serious watering because of the water evaporated instead of penetrating the ground.

A soaker hose is another efficient method of watering the garden. It is quite similar to the drip, however unlike the drip that has emitter at a specific interval, soaker hose made up of a tiny pore along it(OrganicGardening, n.d-b). Other method is a hand-held hosing which is quite a traditional way of watering the garden. Hand-held hosing allows the gardener to specifically target the watering volume and watering frequency to meet the need of the garden however if not properly handled, it will lead to the waste of water (Government, 2012).

2.3 Smart Irrigation

As mentioned earlier, the irrigation system is another application of automation system. Some home automation includes smart irrigation system as a part of their system especially for a home that has lawn or garden. Regardless of it uses, smart irrigation system becomes important nowadays to ensure the optimize use of water especially in the field of agriculture in which water resources are scarce (Angelopoulos, Nikoletseas, & Theofanopoulos, 2011).

Smart irrigation system can be defined as an irrigation system that helps in water saving by monitoring and using information about site condition (such as soil moisture, rain, wind and more) and applying those factor to apply the right amount of water (Dukes, n.d). The Environmental Protection Agency reported that the using of “smart” irrigation system controller to replace the traditional clock timer can help to save of average 8800 gallons of water annually (CROTTA, 2014).

Angelopoulus et al. explained that typical irrigation system often uses a timer to automate the irrigation time and the system rarely adapts toward the weather changes or humidity changes (Angelopoulos et al., 2011). However, this traditional irrigation system cause a problem as the plant will be watered in a regular time interval regardless of the

weather and the soil condition. Abbas et al. stated that such system are poorly adaptable to the different water need of the plant which may result of the plant getting excessive water during the cold weather or leaving it under irrigated during the hot weather (Abbas et al., 2014).

Correspond to the advancement of technology, a lot of smart irrigation system has been proposed either for agriculture sector or a small scale use such as home. For this project, few irrigation system that using a different kind of approach has been reviewed to study their similarities and differences. Although the system was mainly designed for the agriculture field, the concept are still the same and the approach can still be used for a smaller scale project such as home garden.

Table 1. Comparison of smart irrigation system (King, 2014; Kumar, Arshad, Mathavan, Kamal, & Vadamala, 2014; M.Usha Rani & S.Kamalesh, 2014)

Based on the comparison above, it can be seen that all of the system use soil humidity as a parameter in the irrigation system with two of them has proposed their own self-made moisture sensor as an alternative to develop a cost-effective irrigation system. This is a good approach especially for large scale use like agriculture industry in which a lot of sensor is required to monitor large area. In term of interfacing with the user, web server seems to be the best option since the user can access it remotely. As compared to

	Smart Irrigation System	**Smart Irrigation Using Low-Cost Moisture Sensors and XBee-based Communication**	**Web Based Service to Monitor Automatic Irrigation System for the Agriculture Field Using Sensors**
Hardware	-Arduino Microcontroller -LCD -Self-made Moisture Sensor	-PIC 16F876A Microcontroller -Self-made Moisture Sensor -XBee Module	-Arduino Microcontroller -Grove moisture sensor -Water Flow Sensor
Communication Protocol	-	XBee Wireless Technology	Zigbee and GSM
Interface	Physical Button and LCD	VB Interface	Web server and mobile phone
Operating mode	Automated and manual	Automated	Automated

Liquid Crystal Display (LCD) and Visual Basic(VB) interface that run on the PC, the user have to be near to the system to control it.

CHAPTER 3
METHODOLOGY

Generally, research methodology can be referred to all techniques or methods used to collect information and data in conducting a research. In the software engineering field, methodology refers to the framework used to structure, plan and control the development process of information system(CMS, 2005). Over the year, a variety of frameworks has evolved with each of it has addressed different strength and weaknesses. Some of the example of software development methodologies are waterfall model, incremental, prototyping and many more.

3.1 Software Process Model

A software process can be referred as a collection of activities, actions and task that are performed when developing a product (Pressman, 2010). Sometimes, software development processes are also referred as software life cycle because it describes the life of a software product from the beginning until the implementation, delivery, use and maintenance (Pfleeger & Atlee, 2006).

One of the earliest models to be introduced was a waterfall model, a model that suggests a sequential approach to software development (Pressman, 2010). In waterfall model, each step must be completed before proceed with another step. Waterfall model is a suitable approach in software development in which the software requirement is well-understood (Pressman, 2010). However, some of the disadvantages of this model are the difficulty for this model to cope with changes and late fault detection in the development process (Peterson, Wohlin, & Baca, 2009).

Previously, customer are willing to wait for the software system cycle time. However, in today's dynamic business environment, customer demands the software to be delivered in a shorter time. Therefore, another software development process model, an incremental process model is introduced to cope with the changes. An incremental often is viewed as a modified version of waterfall model (Tsui & Karam, 2011). An incremental development refers to the development process in which the requirement is

break down into subsystems by its functionality (Pfleeger & Atlee, 2006). The development is started with the first subsystem and it has been incremented by integrating with the next subsystem in the next software cycle. There is a difference between incremental development and iterative development. Pfleeger and Atlee (2006) further explained that in incremental development, the development will start with a small piece of the system and it will be incremented by adding other functionality in each release while iterative development delivers the full system at the beginning and the functionality will be improved in each new release.

3.1.1 Incremental Model

For this project, an incremental model is adopted for the development of the system. Incremental model use the same generic process of software development activities which are gathering requirement, design, code and testing. Pressman (2010) stated that when incremental model is adopted, the first increment is often the core product. According to Tsui and Karam (2011), the core product is the product that contains most of the functionalities. The first increment may be delivered to the user as release 1 and additional functionality and features then will be developed becoming release 2, 3 and so on.

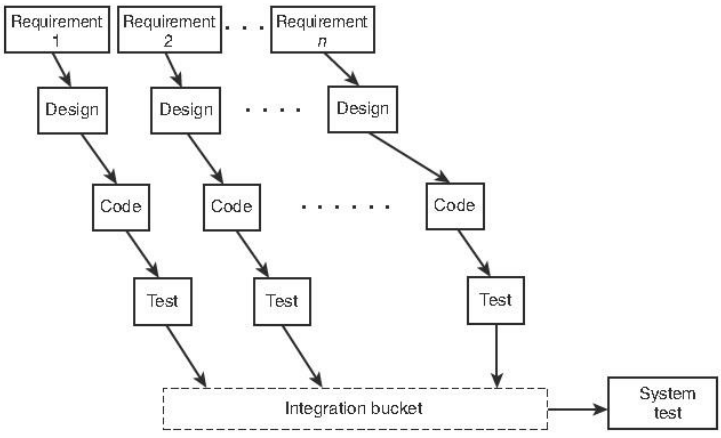

Figure 1. Incremental Model (Tsui & Karam, 2011).

For this project, the system is broken down into several functionalities and it is put into increment. Below is the increment of the project.

Table 2. Increment for the project

Increment	**Functionality**
Increment 1	Setting up Arduino input and output devices which are soil humidity sensor and water drip
Increment 2	Setting up an internet connection
Increment 3	Setting up the web server

For this project, the irrigation system is the core product, thus it has been the first to be developed. Second increment is connecting the Arduino with the Internet connection. Lastly, web server is created for the user to control the watering system.

3.1.2 Gantt Chart

For FYP1, the phase has covered phase one and phase two which are planning and analysis and design. The development process and testing has been completed during the FYP2.

Table 3: Gantt Chart for the project

	FYP1															BREAK		FYP2														
	January			February				March				April				May		June				July				August				September	
Task	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	BREAK	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Selection of project topic	*																															
Planning	*																															
Identify problem																																
Define objective																																
Literature review																																
Submit logbook				*		*		*		*		*		*		*			*		*		*		*		*		*			
Analysis and Design								*																								
Comparative study																																
Data gathering																																
Methodology																																
Data analysis																																
System design																																
Interim report												*																				
Proposal defence													*																			
Implementation													*																			
Development of Increment 1																																
Code																																
Test																																
Release 1																		*														
Development of Increment 2																																
Code																																
Test																																
Release 2																					*											
Development of Increment 3																																
Code																																
Test																																
Release 3																								*								
Pre-Sedex																											*					
Technical report submission																											*					
Dissertation submission (soft bound)																												*				
Oral Presentation																																
Hard bound submission																															*	

*Milestone Task

3.2 Data Gathering

Several techniques have been used to gather the data for the project. They are observation and interview.

3.2.1 Observation

For this project, observation has been made on gardening activity with the objective of gathering information on gardening activity were carried out in Malaysia. Several houses with the garden and also public places (such as park) has been visited to look on the watering methods been used to water the garden.

Based on the observation, several watering method is observed used in gardening. For lawn, water sprinkler is used for irrigation. However, for home garden, most of them still using manual way of watering garden by using pipe host and watering can.

3.2.2 Interview

Other than observation, interview also has been conducted to gather data on gardening activity. The reason of conducting an interview is because gardening is not a hobby that most people have in common. Thus, by interviewing specific kind of group which is people with gardening as their hobby, it could help to solicit further details on the need for home garden watering system. Therefore, two persons from different background were being interviewed accordingly.

For the interview, two respondent of different background which is a housewife and career woman were interviewed. However, both share the similarities of having garden at home. Several basic questions about gardening and how it affects their living were asked in the interview. Below are the summaries of the interview.

Table 4. Interview result comparison

Details	**Respondent 1**	**Respondent 2**
Age	38	37
Gender	Female	Female
Occupation	Housewife	Businesswoman

Type of garden own	Small in-ground garden with some container garden	Container garden
Question 1: **Do you like gardening and why?**	Yes. Because the plant is beautiful, unique and has its own character. Plant actually gives benefit to us as it actually has a contact with other living things such as bird and insect.	Not really. But I did have a container garden just to fill in my backyard space.
Question 2: **Is gardening an easy activity?**	Not really difficult if you have your interest. But you have to really spend your time for maintenance like watering plant at least once a day and putting fertilizer twice a week. Psychologically, nature-lover has to have contact and touch with the plant so that they become healthy.	Difficult if you do not have skill.
Question 3: **If you are leaving your house for days, how did you maintain your garden?**	Depend on the weather. If it is raining, then just depending on the rain water. However, if it is dry and hot, usually ask other people (relatives) to look after the garden.	Ask neighbors to water my plant if I went for outstation.
Question 4: **If there is a system to monitor your garden through your smart phone, how would you feel?**	If there is a technology to monitor the garden through smartphone and it can help to water the plant, of course it would be really helpful	Would be really helpful for a busy people like me.

	even if you are not leaving for vacation. You just monitor from the office or house.	

Based on the interview, two different views were obtained from people who love gardening and another one who do not really like gardening but have garden at home. For the second question, it can be seen that there is about similar opinion on gardening activity especially on the ease of it. Both of them think that gardening need a commitment especially for maintaining the garden. However, one of them thinks that it is not a big problem if people have interest on it.

The third question asked about how they maintain their garden during their absence. From the interview, it can be concluded that they are still dependent on the weather and other people to take care of their garden. However, when they were asked about their opinion of having technology to assist them in gardening, both agree that it would be helpful to have such kind of devices.

3.3 Tools

For this project, there are several components needed consist of hardware and software to build the system.

3.3.1 Hardware

1. Arduino Uno

   Arduino Uno is a microcontroller board based on the ATmega328 that contain anything that support a microcontroller. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

Figure 2: Arduino Board

There are many type of Arduino such as Arduino Uno, Arduino Mega, Arduino Yun and many others. Arduino Uno is most commonly used for the entry level. Thus, it has been chosen for the prototyping purpose.

2. Soil Moisture Sensor

A soil moisture sensor is a sensor that used to read the amount of moisture present in the soil. The sensor used in this project is a resistive sensor which works on the concept more water will conduct electricity easily. This sensor has two probes are used to pass current through the soil, and then it reads that resistance to get the moisture level. More water makes the soil conduct electricity more easily (less resistance), while dry soil conducts electricity poorly (more resistance) (DFRobot,n.d).

Figure 3: Soil Moisture Sensor

3. Immersible Pump and Water Tube

   This immersible pump is water pump that is intended to use under the water to pump out the water. This pump is used to pump out water from the water container.

Figure 4: Immersible Pump and Water Tube

4. Arduino Ethernet Shield

   Arduino Ethernet Shield is a component that can be attached to the Arduino to enable the Arduino to connect to the internet via Ethernet using the RJ45 cable.

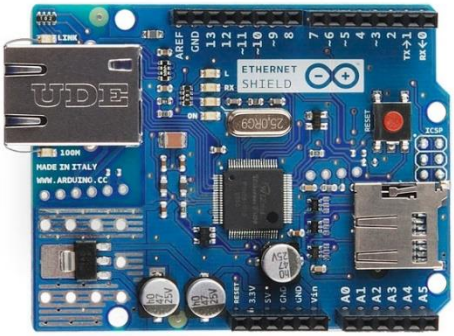

Figure 5: Arduino Ethernet Shield

5. Relay

   This 2 channel module relay is used to control devices with high voltage (which is the water pump) and act as switch to turn on or turn off the water pump.

Figure 6: Relay

6. 6v Battery

   Power supply to power up the water pump

7. 12V Power Supply

   Power supply to power up the Arduino

3.3.2 Software

1. Arduino Software

   Arduino Software is an open-source Integrated Development Environment (IDE) that enable user to write a code and to upload it into Arduino. It runs on multiple platform which are Window, Linux and Mac OS X. Arduino supported HTML language to be coded inside Arduino. The importance of having this supportive functionality is because HTML is needed to code the web server as the interface to control the watering system.

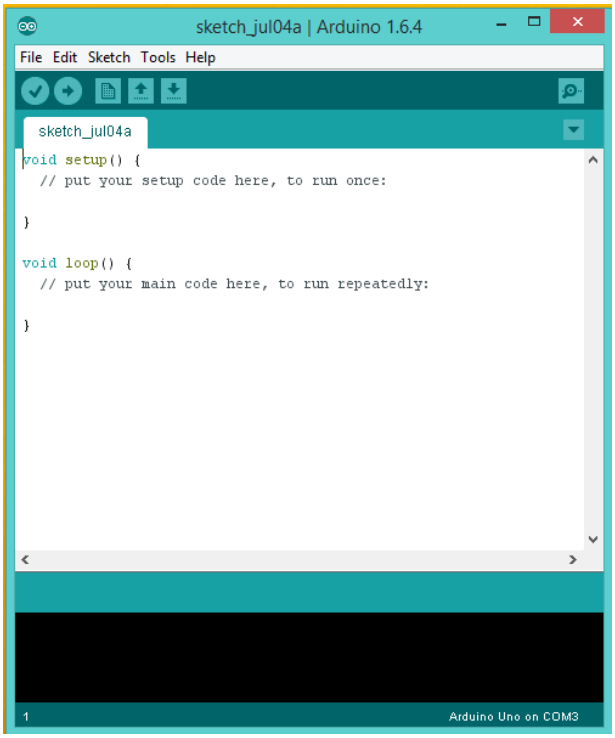

Figure 7: Arduino IDE

CHAPTER 4
RESULT AND DISCUSSION

4.1 System Design

Based on the data gathering done, several factors were figured out to be considered before come out with a proposed system. They are:

1. Size and type of the garden

   Based on the observation, there are several types of home garden in Malaysia such as container garden and in-ground garden. Container garden is the garden where people grow plant in the container whereas in-ground garden is the garden in which people gardening directly on the ground. In-ground garden could be the garden that grows vegetable or landscape garden. However, there are also vegetable that is grown in the container such as hydroponic. For this project, the system is designed for container garden.

2. Watering method

   Watering method is another factor to be considered in developing the system. For this project several watering methods are considered which are water sprinkler, soaker hoses and water drip. Water sprinkler is suitable for the wide garden as the water sprayed by the sprinkler will cover a wide area. However, it might waste more water as other methods. Soaker host is a host with a tiny pore along it. Unlike sprinkler that spray water in the air, soaker host water the ground deeply through its tiny pore. Soaker host is suitable to water in-ground garden but not suitable to water the plant in the container. Lastly is the water drip. Water drip has almost similar function with the soaker host however instead of having tiny pore along the hose, water drip has emitter (to emit the water) at a certain interval along the tube that fit the arrangement of the plant. Since the system is designed for the container garden, thus water drip might be the most suitable watering method as compared to water sprinkler and soaker hose.

3. Sensors

   Since the system is designed to monitor the garden, some devices are needed to collect input for our system. In gardening, usually there are several factors that can be considered to water the plant such as soil humidity, temperature and weather condition. Since the system is designed for indoor garden, soil humidity might be a good input as compared to others.

4. Hardware and software

   For this project, two hardware have been considered which are Raspberry Pi and Arduino. Raspberry Pi is a mini computer that has almost the same capability of real computer and Arduino is a microcontroller, which is a part of computers. Both has the similarities of getting connected with input output devices such as sensors and this make them have almost the same capabilities. However, considering of connecting the hardware with the analog or digital sensors, Arduino would be better option for the project.

5. Networking

   Since one of the functionalities of the system is enabling the use to monitor their garden from their smartphones, networking is another factor to be considered in order to set up the web server on Arduino. For this project, internet connection is used instead of other communication method such as Bluetooth or GSM because of the nature of consumer that were into the Internet nowadays. Arduino supports both wired and wireless internet connection. For this project, Ethernet is used instead of wireless network because of Wifi limitation in the campus area.

6. Programming language

   For the watering system, the Arduino is programmed using Arduino open source software which use C/C++ language and the web server is programmed using basic HTML and CSS.

Basically, this project can be divided into two parts which are developing the watering system and the web server. For the watering system, the Arduino is connected into the water pump and also soil humidity sensor. The Arduino will read the soil humidity and update it on the web server. The web server will display the current humidity level and the user can switch on the watering system to water the plant through the web server.

4.1.1 Setting up the hardware

Generally, Arduino contains several types of pin on it, the connection to the ground, digital pin, analog pin and 5v power supply. Digital pin is used to handle digital input or output (data that is expressed as 1 or 0) while analog pin is used to handle analog input or output (data that is presented in varying quantity). In this project, both digital pin and analog pin are used. Digital pin is used to control digital output which is the water pump whereas analog pin is used to handle analog input which is soil humidity sensor.

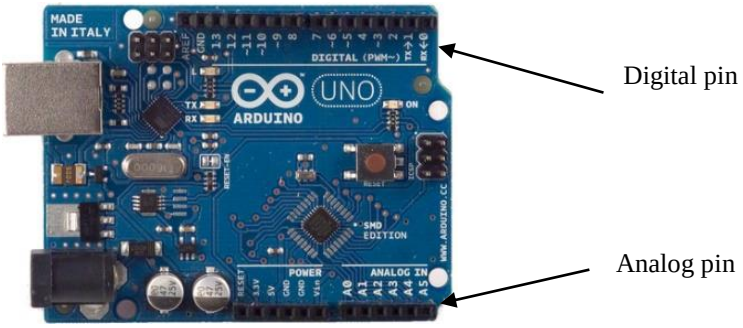

Figure 8: Digital and Analog Pin

To set up the circuit, a consultation was made with the technologist from the Electronic and Electrical (EE) Engineering Department. In order to connect the pump with the Arduino, a relay is used because the pump require a high voltage and it is likely use more power than the Arduino digital output can directly draw. If it's directly connected with the digital output of Arduino, there is a possibility that it will damage the board. Therefore, a relay is used to enable the low power component (Arduino) to control high power components (water pump).

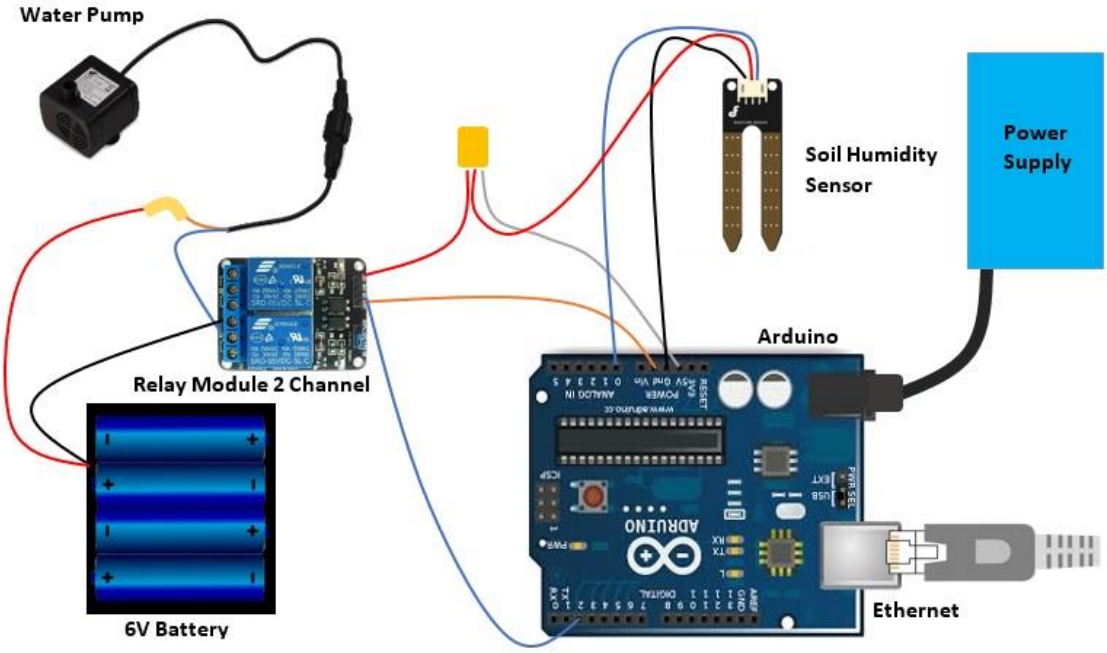

Figure 9: Connection of the components

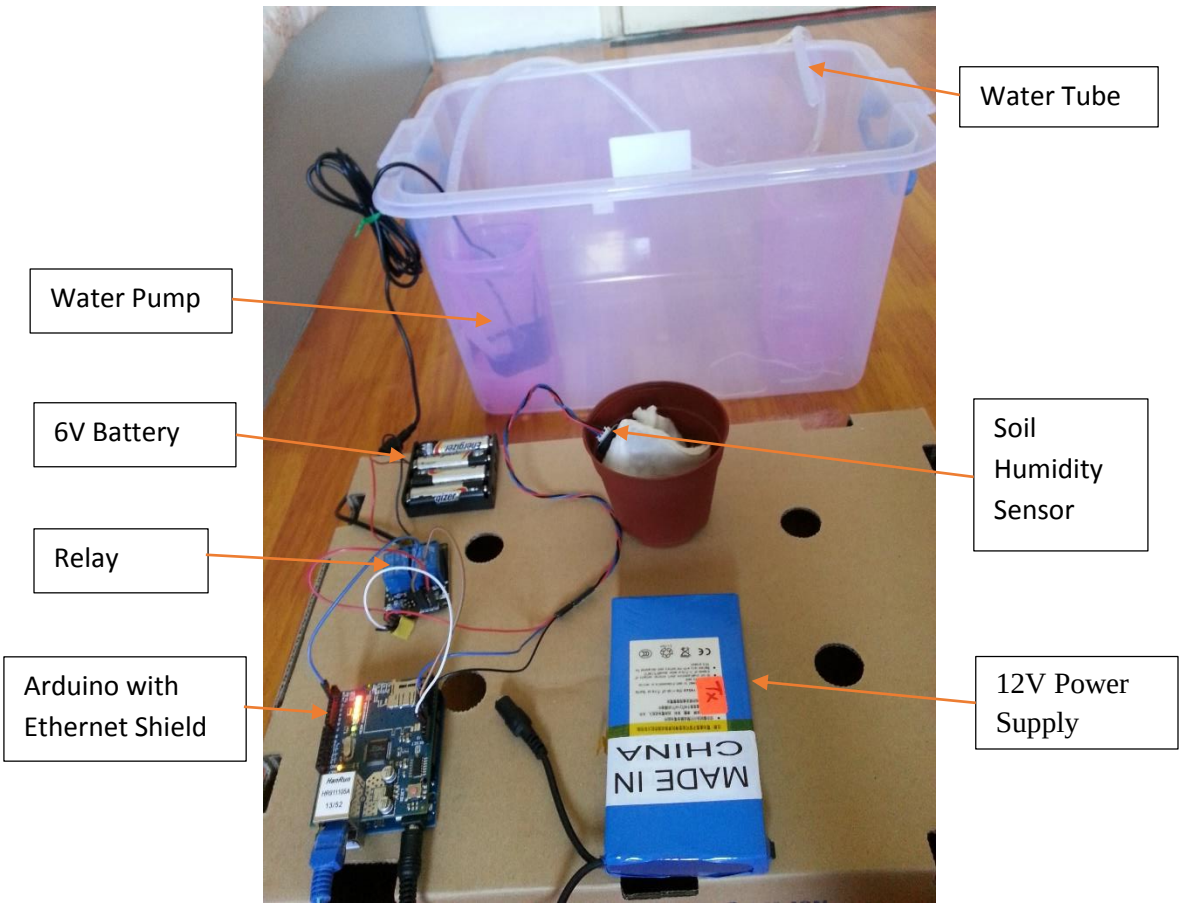

Figure 10: Real setup

4.1.2 Programming the Arduino

All the programming part for this project was done in the Arduino Software. The programming can be divided into three parts which are networking, controlling the input and output and programming the web server.

1) Networking

Arduino offers both Wifi and Ethernet connection. Since Ethernet connection is used for this project, few variables have to be set in order for the Arduino to connect to the Internet which are:

1. MAC Address

   A MAC address is particularly a global unique identifier for a device, which is in this case is the Arduino itself. It consists of 6 series of hexadecimal values.

2. IP Address

   IP address is an identifier for a computer that is connected over TCP/IP network. For this project, the IP address for the Arduino is set according to the network details obtained from the *IPConfig* command in comman prompt.

For this project, the Arduino is connected to LAN in the student accommodation in the university. The detail below has to be set in the Arduino code to establish the connection.

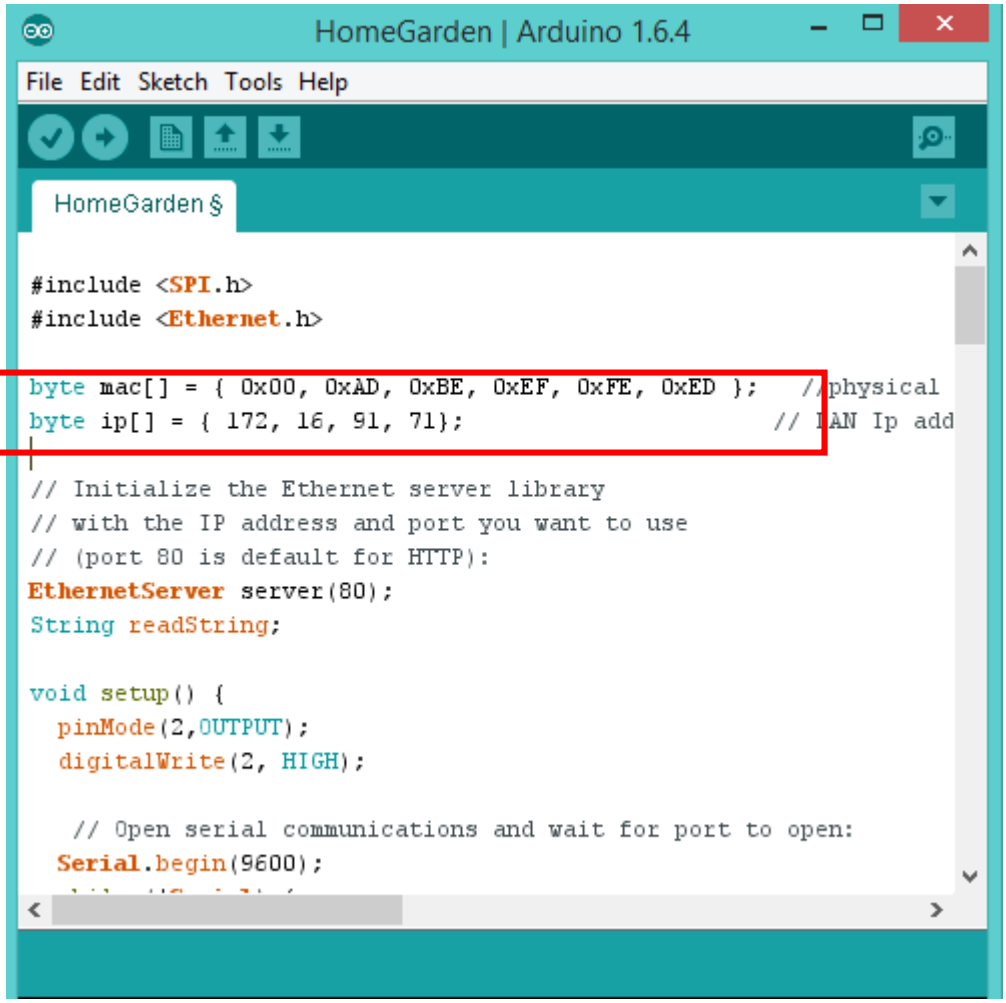

Figure 11: MAC address and IP address set on the Arduino

2) Controlling input

For the controlling the input and output part, analog pin A0 is declared as input to read the analog input from soil humidity sensor.

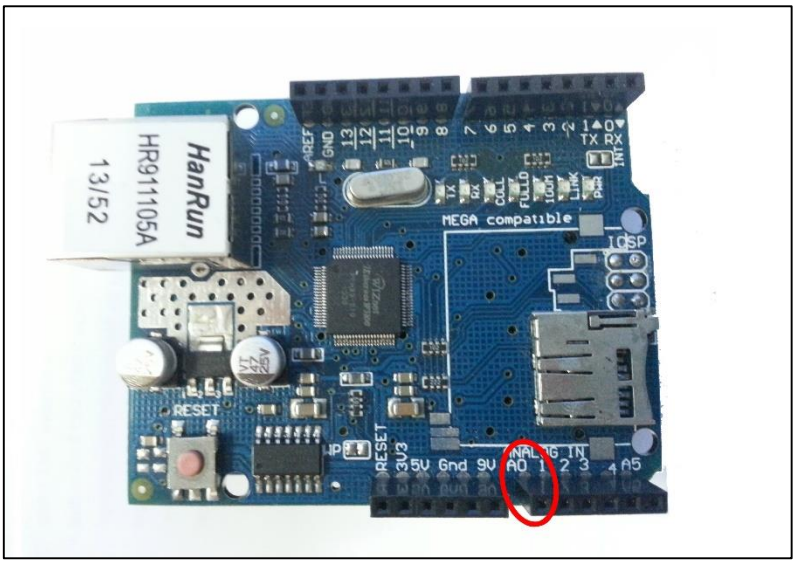

Figure 12: A0 analog pin on the Arduino

Since the analog sensor will give an analog value ranged from 0 to 950, the sensor reading has been categorized into three (based on the data sheet provided) which are:

Table 5: Scale of soil humidity sensor

Reading	Humidity Level
0-300	Low
300-700	Average
700-950	High

3) Programming the output

To control the pump, digital pin 2 is declared as output to turn on and turn off the pump.

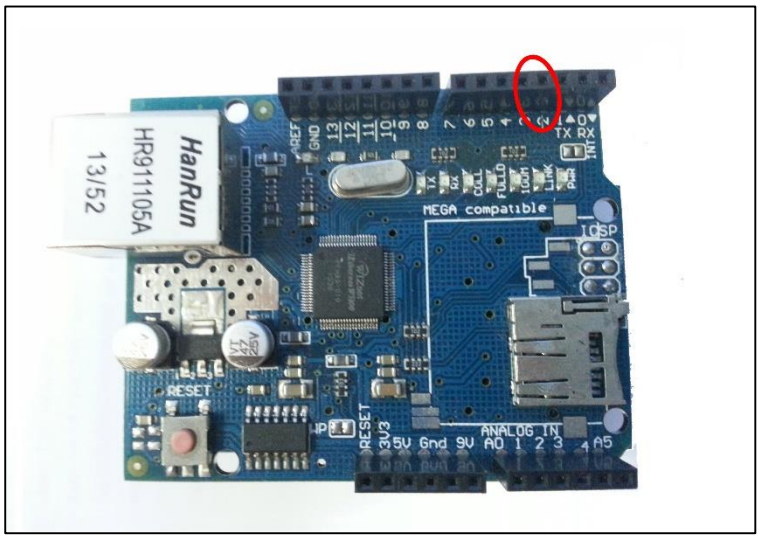

Figure 13: Digital pin 2 on the Arduino

Generally, when direct output is controlled such as LED, setting the digital pin to high allow the current to flow thus lighting up the LED and setting the digital pin to low will turn of the LED. However, in this project, water pump is an output that cannot be controlled directly. Since it needs a high voltage to turn on the pump, relay is used as a switch to turn on and off the pump. Therefore, for this project, controlling the digital pin means controlling the relay as a switch to turn on or turn off the water pump. However, relay works differently as compared to LED. In relay, setting the digital pin to low mean turning on the relay, thus allowing the water pump to on. Whereas, if digital pin is set to high means turning off the relay thus causing the water pump to off.

4) Programming the web server

Arduino has the capability to serve the HTML webpage. The HTML part can be coded inside the Arduino itself. By inserting the correct IP Address of Arduino on the web browser, the web page served on the Arduino can be viewed from the web browser. In this project, the interface is coded by using basic HTML and CSS to customize the page.

For this project, there are two components that the web server needs to have. The first one is the soil humidity reading and the second one is the button to control the water

pump. There are three buttons on the web server which are PUMP ON, PUMP OFF and AUTOMATE. When the button is clicked, it will display the current status of the watering system and the mode of the watering system either manual or automate. Basically, if the PUMP ON or PUMP OFF is clicked, it indicate the system is in the manual mode. Other requirement of this web server is that it has to be refreshed within 15 second to show the current reading of the sensor.

Table 6. Description of the button

Button	Description
PUMP ON	To turn on the water pump
PUMP OFF	To turn off the water pump
AUTOMATE	To set the watering system to automatically turn on the watering system if the soil humidity reading is low

For the AUTOMATE mode, the system will turn on the pump automatically if the soil humidity reading is below than the threshold set in the system. For this project, it is assumed that the threshold is 500. Therefore, any reading that fall below that will considered as low and the Arduino will automatically turn on the water pump.

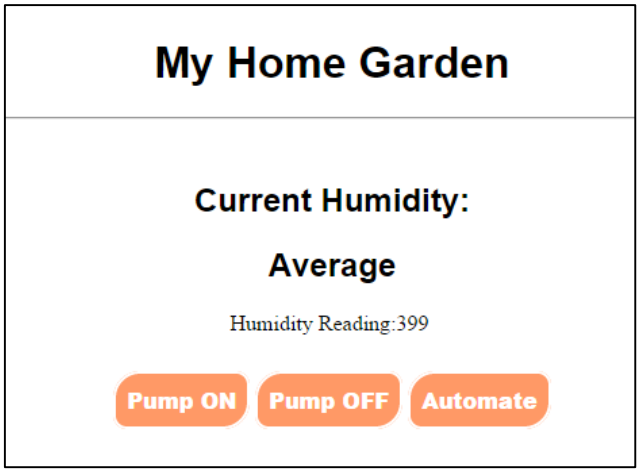

Figure 14 : Interface for the web server

4.2 Testing

After setting up the hardware and the coding part, functionality testing is done to test the functionality of the system. There are three part of testing of this system which are:

1. To monitor the current humidity level of the soil on the web server
2. To test the On and Off button on the web server
3. To test the automate button on the web server

4.2.1 To monitor the current humidity level of the soil

Purpose: To monitor the humidity level of the soil on the web server

Procedure:

1) The soil humidity sensor is inserted into the soil

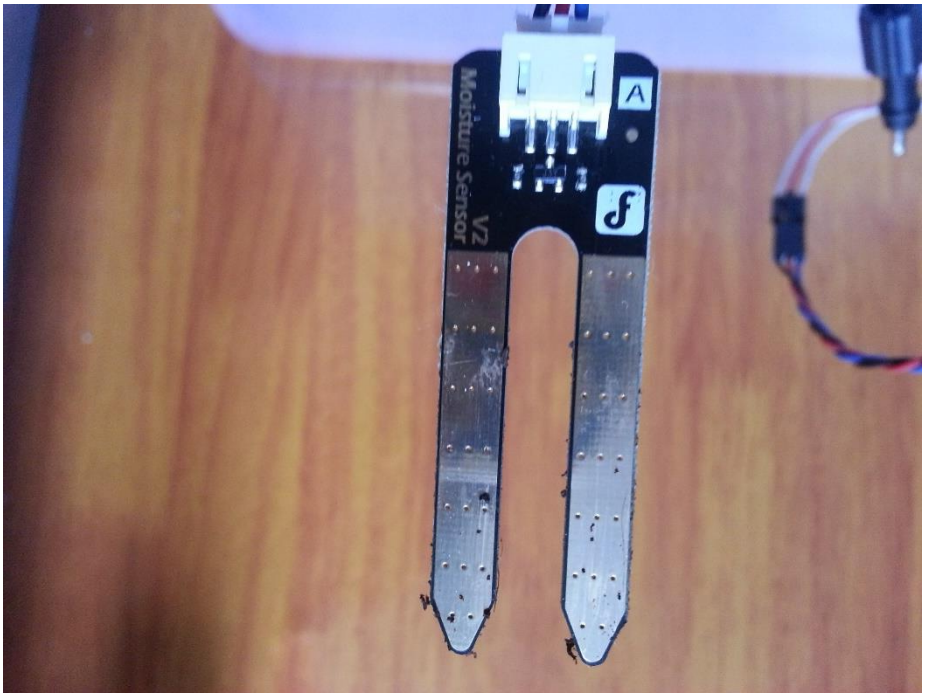

Figure 15 : Soil Moisture Sensor

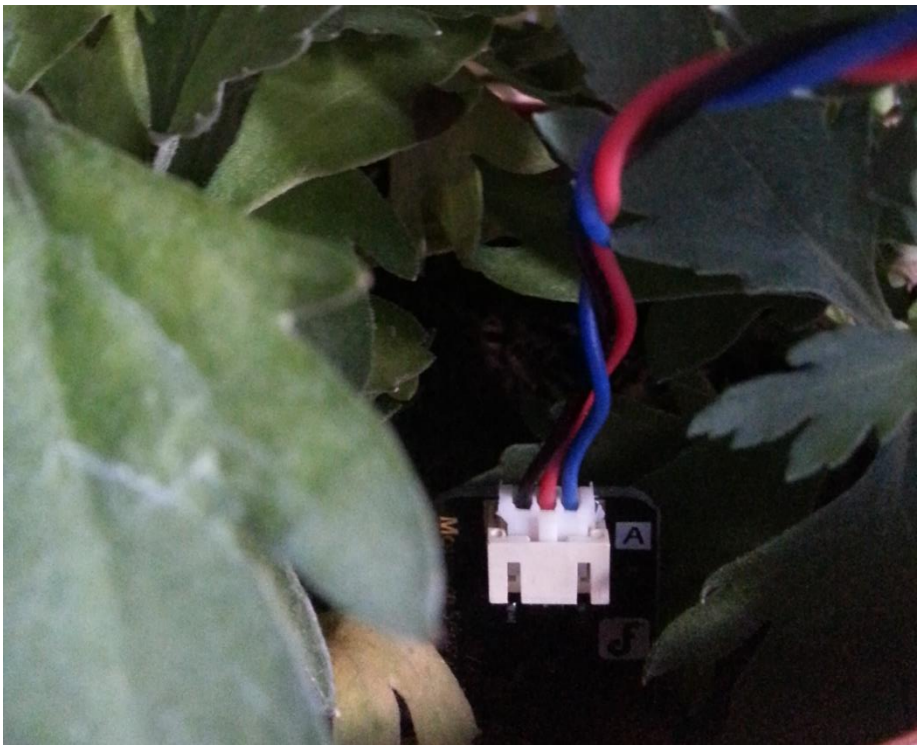

Figure 16 : Soil Moisture Sensor inserted into the soil

2) The system is connected to the power supply and Ethernet connection
3) Web browser is opened up and the IP address of the Arduino is browsed
4) The homepage of the system is displayed
5) The plant is watered before the observation started
6) The current reading of soil humidity is displayed and retrieved at every 15s
7) The soil humidity reading is recorded at every 15s for 10 retrieval
8) The experiment is repeated on the next day without watering

Result:

From the observation, the result for both condition is recorded and graphed.

Day 1: With Watering

Table 7. Soil humidity reading with watering

Trial	Soil Humidity Reading
1	718
2	723
3	731
4	733
5	735
6	736
7	737
8	739
9	740
10	741

Day 2: Without watering

Table 8. Soil humidity reading without watering

Trial	Soil Humidity Reading
1	766
2	759
3	755
4	752
5	749
6	746
7	744
8	742
9	741
10	740

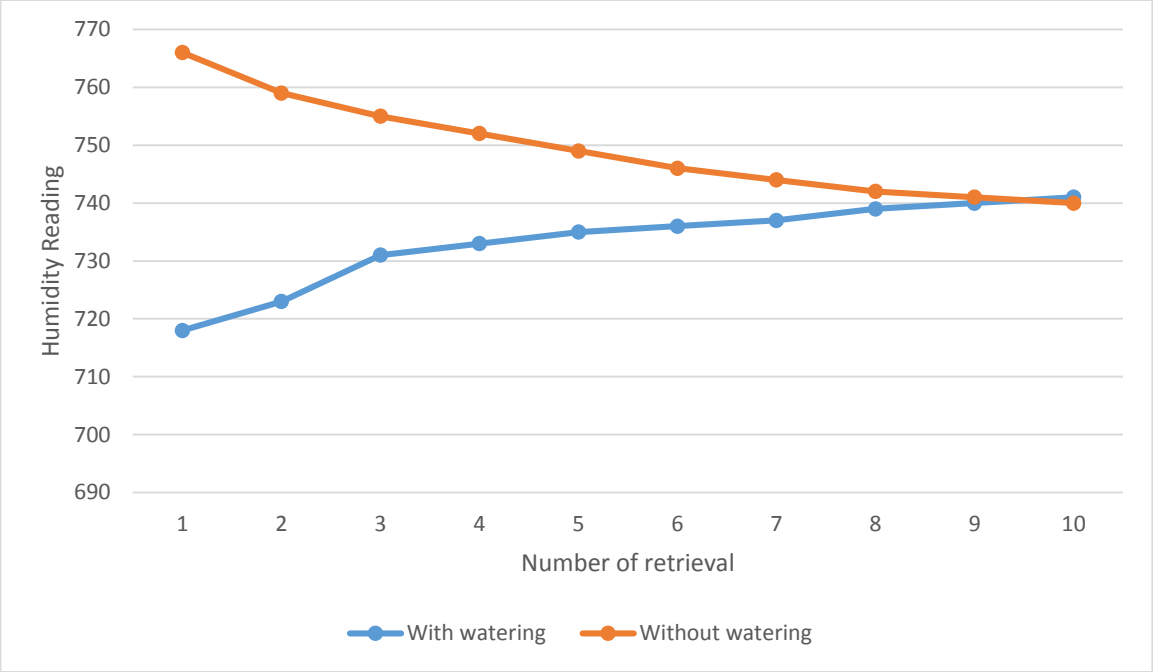

Figure 17: Graph of humidity reading

From the graph, it can be seen that the humidity reading increase when the soil is watered. This might be caused of the increase of water content in the soil. When the plant is left without watering, it can be observed that the soil humidity decreased. This might be caused by the decrease in water content due to the evaporation.

Soil moisture used in this project is a resistive sensor, which is a moisture sensor that measure humidity based on the ability of the probes to pass current through the soil. More water will conduct electricity easily (less resistance) and vice versa. However, resistive sensor is affected by the temperature of the soil. If the plant is exposed to direct sunlight and the soil get hot, it will lead to false reading of the humidity level. Since the testing is set up indoor, the light exposure is not as high as outdoor thus it might not really affect the reading of the moisture sensor.

4.2.2 Testing the button on the web server

Second testing is to test functionality of the On and Off button on the web server. Basically the system is set up and observation is made based on several condition.

Purpose: To test the On and Off button on the web server

Procedure:

1) The system is connected as shown below

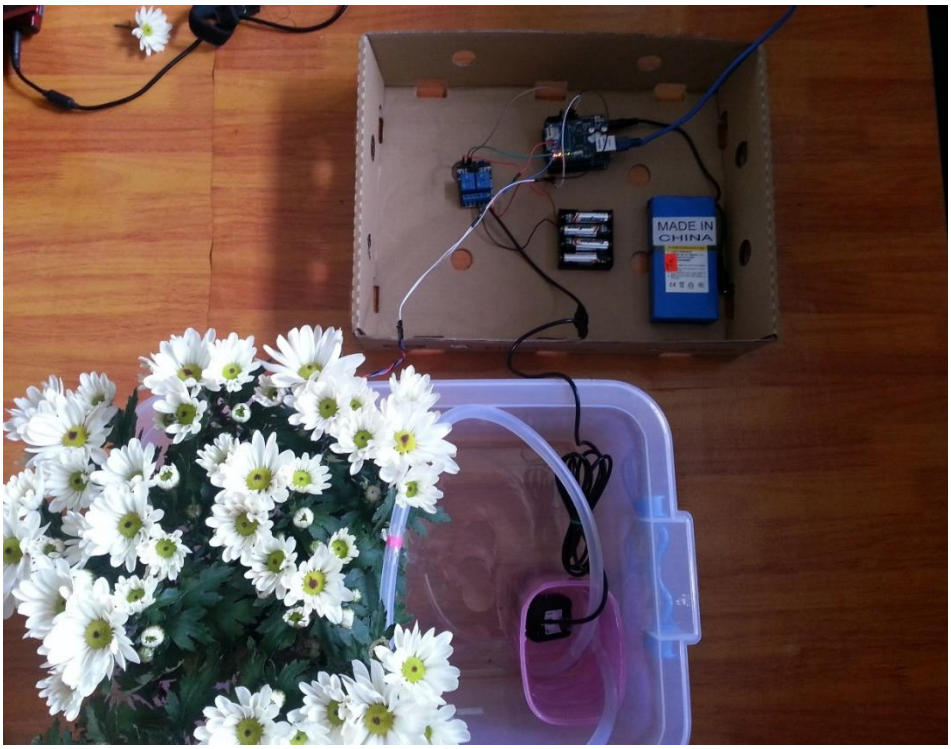

Figure 18: System setup

2) Power supply is turned on and the Arduino is connected to the Ethernet connection
3) Web browser is opened up and the ip address of the Arduino is browsed
4) The homepage of the system is displayed
5) The On button first been clicked, water pump and the web server is observed.
6) The Off button then clicked, water pump and the web server is observed.
7) The Automate button is clicked, water pump and the web server is observed.

Result:

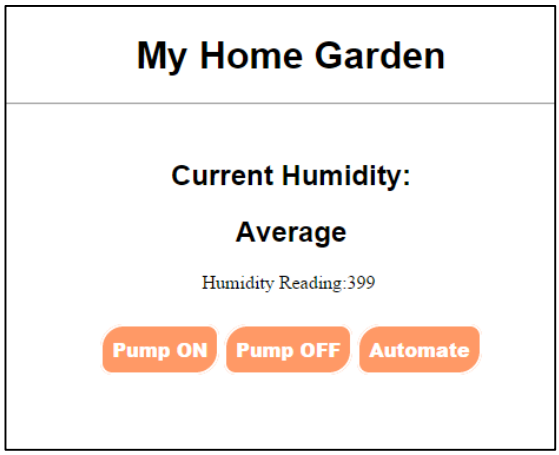

Figure 19: Interface for the web server

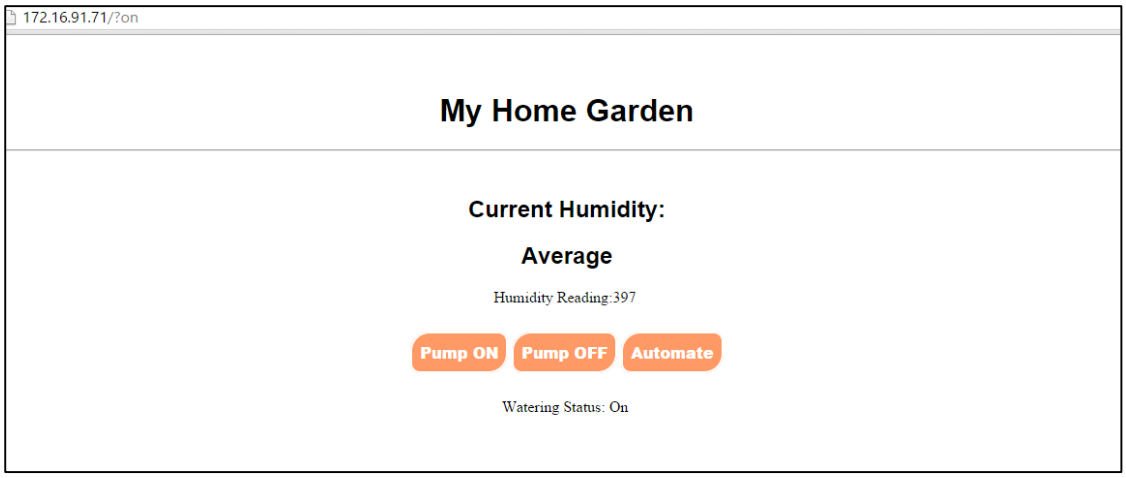

Figure 20: Interface for the web server when button On is clicked

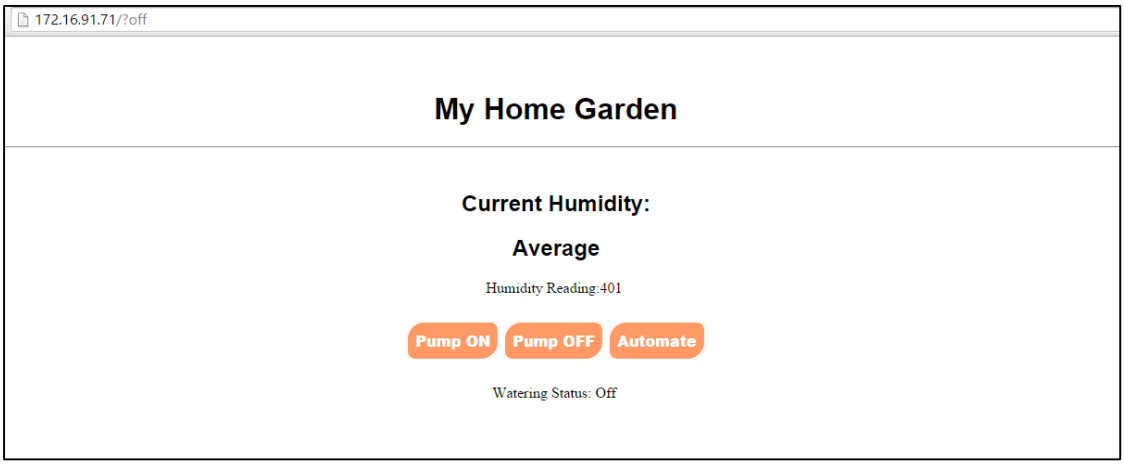

Figure 21: Interface for the web server when button Off is clicked

Table 9. ON and OFF button functionality result

Trial	Button State	Watering Status	Pump On
1	On	On	Yes
	Off	Off	No
2	On	On	Yes
	Off	Off	No
3	On	On	Yes
	Off	Off	No

Based on the observation, when PUMP ON button is pressed, the watering status will change to on the water pump is on whereas when PUMP OFF button is pressed, the watering status will change to off and the pump is off.

4.2.3 Testing the automate button on the web server

Third testing is to test functionality of the Automate button on the web server. Basically the system is set up and observation is made based on several condition which are dry soil and humid soil.

Purpose: To test the On and Off button on the web server

Procedure:

1) The system is set up like in Figure 17
2) Web browser is opened up and the ip address of the Arduino is browsed
3) The homepage of the system is displayed
4) Automate button is clicked
5) The soil moisture sensor is put in the dry soil
6) Watering status and water pump is observed
7) The soil moisture sensor then is put in the humid soil
8) Watering status and water pump is observed
9) The result is recorded as follow

Result:

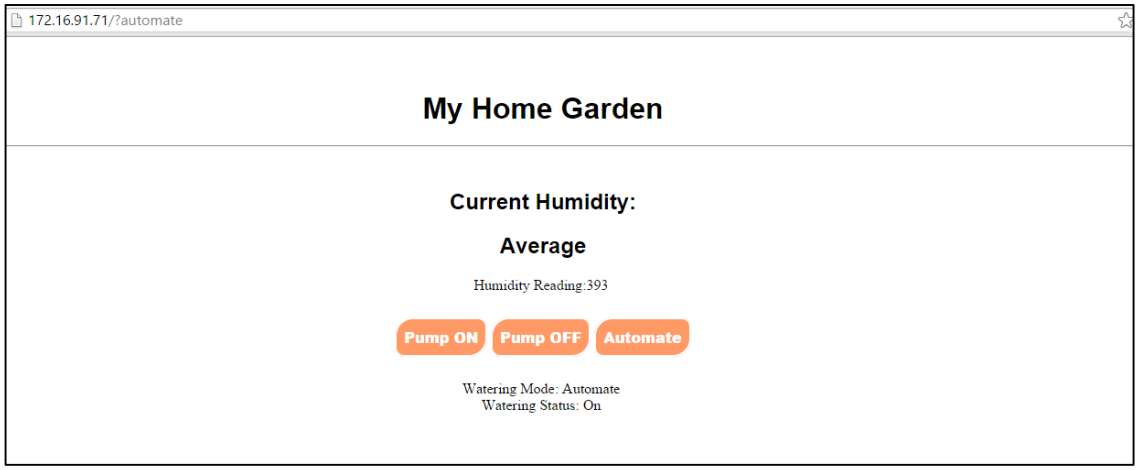

Figure 22: Interface for the web server when Automate mode is clicked

The result of the testing can be summarized as below:

Table 10. Automate button functionality result

Condition	Humidity reading	Watering Status	Pump
Dry Soil	393	On	On
Humid soil	618	Off	Off

For the testing, the soil moisture sensor is first put into a dry soil. Humidity reading is recorded and watering status and the water pump are observed. From the observation, if the reading fall below 500, the watering status changed to on and the water pump is on whereas when the humidity reading is above 500, the watering status changed to off and water pump is off. In this testing, a threshold value need to be set in order for the system to be controlled automatically. For prototyping purpose, it was assumed that ideal humidity level is 500. However, for the system to be used on the real garden, the user has to set the threshold value according to the type of the plant or the soil.

Overal, based on testing done, the system works well and fulfill its objectives. The user is able to monitor current humidity of the soil and allow them to control the button for watering system via webserver. Plus, the user can set the watering system to be on automated mode if she does not want to control it manually. However, there are few things needs to be addressed especially on the networking part.

For this project, it is set up on a Local Area Network (LAN) which means the web server can only be accessed by device that connected on the similar network. It should be enough for the purpose of demonstration purpose. However, to enable it to be accessed outside of thelocal network (as proposed in this project), the network has to be configured to enable the user to monitor and control their garden watering system remotely through the internet. To enable this, port forwarding needs to be done to enable a remote computer (for example, computer on the internet) to access a specific computer or service within a LAN. Since this system is developed in the university network, port forwarding cannot be done due to the restriction they have on the university network.

Other than that, since the system is depending on the web server, the system must be able to run 24 hours. For a real system, direct power supply should be used instead of portable battery. In this project, a portable battery of 12V is used to power up the system. 12V is considered quite high in voltage, thus it cause the Arduino to release more heat. Therefore, for safety purpose, the voltage of the power supply used should be as minimum as possible. This can be done by testing the system with power supply of different voltage. Plus, the Arduino itself should be stored in a well ventilated area to avoid excessive heat.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

After completing this project, it can be concluded that the system works perfectly as planned. It fulfills the three objectives stated in beginning of this project which are to allow user to check the current soil humidity level, allow them to turn on and off the water pump and set the system to automate mode via a web server. However, to implement it in real environment, several modifications has to be made especially on the networking and the power supply.

Overall, this remote watering system can be another part of home automation system. It gives alternatives for the home user to water their garden during their absence. The usage of web-based give a flexibility to the user either to access the server via computer or smartphone. As long as they are accessing the correct IP Address of the web server, they are able to monitor and control their garden watering system. Other than that, the system gives flexibility to the user by allowing them to set the system to automate mode if the user does not want to control it manually. However, further study needs to be carried out to learn about the different aspect of the system. For example, how long the system will long last, how to add more sensor to it and what happen if there's connection failure.

5.2 Recommendation

This system has its own potential for improvement and adaptation. Therefore, several recommendations would like to be proposed as part of future work.

1) Adding more sensor to improve the monitoring process

There are other factors that can be used to monitor the condition of the plant. For this project, a soil humidity is used as the parameter to monitor the condition of the garden. Nevertheless, the soil humidity alone might not indicate a correct condition of the plant. Therefore, it is important to have another sensor to help to improve the monitoring process.

2) Integrate the web server with weather forecast

   Having a weather forecast integrated with the web server could be another interesting functionality that the system could have especially if the system is used for the outdoor garden. Other than just providing soil humidity reading to the user, having to know the current weather updates would certainly help the user in monitoring their garden.

3) Having data log for the system

   The ability for the user to track the history of the watering system (for example: humidity reading and watering status) could be another helpful feature of the system. However, a study has to be done to find a suitable mechanism to store all the data.

4) Wireless sensor network

   Since this system is designed for a small scale use which is indoor garden, using a wired sensor would not be a problem. However, if the system is to be extended for the outdoor use or large scale area, the concept of wireless sensor network might be more suitable to be implemented. Now, with various kind of wireless technology available in the market, the usage of wireless sensor network is a good area to be discovered.

5) Water Supply

   In this project, the water supply is stored in the water container. Therefore, the user has to check the water supply to make sure it is sufficient. For further improvement, there might be a need for the system to have an alert to remind the

user that their water storage is getting low and this might need another sensor to be added to measure the water level in the water container.

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