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FUZZY LOGIC FOR HERB AND VEGETABLE SMALL- SCALE AGRICULTURE

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A project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology with Honours



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this project report entitled "FUZZY LOGIC FOR HERB AND VEGETABLE SMALL-SCALE AGRICULTURE" 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 MUHAMMAD ZUHAILY BIN ZAINALARIFFIN Student Name • 10/JAN/2022 Date • 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 with Honours.

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DEDICATION

Special dedication to my beloved parent, ZAINALARIFFIN BIN MOHD HUSSIN & ZAITY ZALIZA BINTI ZAINAL To supportive supervisor TS MOHAMED AZMI BIN SAID My family members & my friends.



ABSTRACT

All things if it involves in a large scale, it might require special observation to obtain the desrired results. Then, if took a look in agricultural sector, even in small scale, they always want have a big return for their crops. But if the larger the crop, the greater the cost and manpower need to spend. Because now are in era of technology, this paper propose the implement of fuzzy logic concept for small agricultur. The farmer might optimize the crops and record growing data of their crop with less interaction at farm. By this paper, the simulation of fuzzy logic will use as to get the simulation result of the crop and the prototype system will be produce based on simulation input that are being used. In the end, the result will show the simulation output and two plant that one of it use tradisional farming and other one use fuzzy logic system.



ABSTRAK

Semua perkara jika melibatkan dalam skala besar, mungkin memerlukan pemerhatian khas untuk mendapatkan hasil yang diharapkan. Kemudian, jika dilihat pada sektor pertanian, jika dalam skala kecil, mereka selalu menginginkan hasil yang besar untuk tanaman mereka. Tetapi jika semakin besar tanaman, semakin besar kos dan tenaga kerja yang perlu dikeluarkan. Kerana sekarang di era teknologi, makalah ini mengusulkan pelaksanaan konsep logik kabur untuk pertanian kecil. Petani mungkin mengoptimumkan tanaman dan mencatat data tanaman mereka yang semakin bertambah dengan kurang interaksi di ladang. Dengan makalah ini, simulasi logika kabur akan digunakan untuk mendapatkan hasil simulasi tanaman dan sistem prototaip akan dihasilkan berdasarkan input simulasi yang sedang digunakan. Pada akhirnya, hasilnya akan menunjukkan keluaran simulasi dan dua kilang yang salah satunya menggunakan pertanian tradisional dan satu lagi menggunakan sistem logik kabur.



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TABLE OF CONTENTS

		PAGI
DEC	CLARATION	
APP	ROVAL	
DED	DICATIONS	
ABS	TRACT	i
ABS	TRAK	ii
ACK	KNOWLEDGEMENTS	iii
ТАВ	BLE OF CONTENTS	i
LIST	r of tables	iii
LIST	r of figures	iv
LIST	r of symbols	vi
LIST	T OF ABBREVIATIONS	vii
LIST	Γ OF APPENDICES	viii
СНА	PTER 1 all INTRODUCTION	1
1.1	Background	1
1.2 1.3	Problem Statement TI TEKNIKAL MALAYSIA MELAKA Project Objective	1
1.4	Scope of Project	3
CHA	APTER 2 LITERATURE REVIEW	5
2.1	Research. Ideology and Concept from Previous Project	5 5
	2.2.1 Automatic Plant Watering System	5
	2.2.2 Plant Monitoring System with IoT	7
2.3	Summary	8 11
СНА	APTER 3 METHODOLOGY	12
3.1	Introduction	12
3.2	Project Flowchart	12
3.3	3.3.1 Stage 1 : Development of Project Structure and System	14 15
	3.3.2 Stage 2 : Determination of Project Method	16
	3.3.3 Stage 3 : Develop the prototype hardware	23
	3.3.3.1 ESP32	23
	3.3.3.2 LDR Sensor	24

	3.3.3.3 Ultrasonic Sensor	24
	3.3.3.4 Soil Moisture Sensor	25
	3.3.3.5 PH Sensor	25
	3.3.3.6 Submerge DC Motor Pump	25
	3.3.3.7 LED light	26
3.4	Summary	26
CHA	PTER 4 RESULTS AND DISCUSSIONS	27
4.1	Introduction	27
4.2	Development of Fuzzy Logic System	27
	4.2.1 Section 1	28
	4.2.2 Development of Fuzzy Logic System	31
	4.2.3 Section 3	33
	4.2.4 Result for Fuzzy Logic System	34
	4.2.5 Result of The Plant	36
	4.2.6 Overall Results.	41
CHA	PTER 5 CONCLUSION AND RECOMMENDATIONS	43
5.1	Conclusion	43
5.2	Future Works Error! Bookmark r	ot defined.
5.3	Future Works	43
5.4	Future Works Error! Bookmark r	ot defined.
5.5	Future Works Error! Bookmark r	ot defined.
REFF	ERENCES	45
APPE	ENDICES	47
	اويوم سيبي بيغ يتعظم ميسيا مارد	
	UNIVERSITI TEKNIKAL MALAYSIA MELAKA	

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1	21 Crop in Mashland Plain cropping pattern	9
Table 4.0	Input result for the system	29
Table 4.1	Experimental result rule for the system	32



LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1	The design of Automatic Watering.	6
Figure 2.2	Block diagram.	7
Figure 2.3	Fuzzy interface system editor.	10
Figure 3.1	TL estimation genaral flow.	13
Figure 3.2	Project architecture flowchart.	14
Figure 3.3	Project fuction block diagram.	15
Figure 3.4	MATLAB software for fuzzy logic system.	16
Figure 3.5	MATLAB software FIS interface.	17
Figure 3.6	All the input are be rename with all the sensor that uses.	18
Figure 3.7	Setup all the membership function for all the input based on collecting data.	18
Figure 3.8	Create rule for the system as much as posible .	19
Figure 3.9	Setup the plant result for the system.	20
Figure 3.10	Result data rule Viewer and Surface Viewer.	20
Figure 3.11	Software flow chart.	22
Figure 3.12	Cooding on Arduino IDE.	23
Figure 3.13	pH colour chart.	25
Figure 4.1	Setting in section (input)	28
Figure 4.2	Soil moisture on membership fuction.	29
Figure 4.3	Light intensity on membership fuction.	30
Figure 4.4	pH level on membership function.	31

Figure 4.5	Water level on membership function.	31
Figure 4.6	Rule editor in section 2.	32
Figure 4.7	Output membership function.	34
Figure 4.8	Soil moisture VS Light intensity.	35
Figure 4.9	Soil moisture VS pH level.	35
Figure 4.10	Seeds.	37
Figure 4.11	Week 1 Control system pot.	37
Figure 4.12	Week 2 Control system pot.	37
Figure 4.13	Week 2 Control system pot.	38
Figure 4.14	Week 2 Uncontrol system pot.	38
Figure 4.15	Week 3 control system pot.	38
Figure 4.16	Week 3 Uncontrol system pot.	38
Figure 4.17	Week 4 control system pot.	39
Figure 4.18 🖄	اونيوس سيني ني—.Week 4 Uncontrol system pot	39
Figure 4.19	Week 5 control system pot. MALAYSIA MELAKA	39
Figure 4.20	Week 5 uncontrol system pot.	39
Figure 4.21	Result output system in Surface view and Rule view.	41
Figure 4.22	Result high of plant in week 4.	41
Figure 4.23	Result hight of plant in week 5.	42

LIST OF SYMBOLS

- Voltage Current V -
- A _



LIST OF ABBREVIATIONS

- Iot Internet of Things
- LDR Light Dependent Resistor
- LED Light Emitting Diode
- DC Direct Current
- FIS Fuzzy Interface System



LIST OF APPENDICES

APPENDIX	TITLE	
Appendix A	Datasheet of ESP-WROOM-32	48
Appendix B	Datasheet of Soil Moisture Sensor	49
Appendix C	Experimental result rule for the system	51
Appendix D	Result plant by week for control system and un control system	60



CHAPTER 1

INTRODUCTION

1.1 Background

This chapter describes the project summary, and the main objectives of the project. This section covers the background of the project, the problem statement of why the discovery was developed, the priority of the project's requirements to resolve the problem statement with the purpose at the end of the project and the scope of the analysis to be carried out throughout the course of the projects.

1.2 Problem Statement

In the light of the world rapidly rising population, the agricultural sector is becoming increasingly significant. Rather than purchasing, more people are opting for a personal garden where they can grow flowers or vegetables. Plants are important to the ecological cycle's maintenance. This project will use Internet of Things (*IoT*) technology and Arduino to build a smart plant monitoring system. The aim of this project will be on software development for the web platforms. Sensors are used to calculate certain environmental parameters that affect plants parameters such as soil moisture, pH level, and light intensity. Relevant data from the sensors is sent to the *IoT* (Internet of Things) platform via Arduino boards. This device, which will be monitor with looking at web and it implement the result of simulation, then it will minimize manual interference and increase the plants' overall efficiency.

This system is designed by using IoT technology simulation of fuzzy logic to overcome the limitations of farmers in conducting manual continuous monitoring of crops and obtain the status from their crops. In this system, Arduino microcontroller, pH sensor, LDR sensor, ultrasonic sensor, and moisture sensor are used to detect the environmental parameters. The pH sensor is used to determine whether a water solution is acidic or alkaline. The LDR sensor detects light intensity, the ultrasonic sensors sense the water level in the water storage, and the soil moisture sensor analyses the soil volumetric water content and displays the moisture level to the user. These sensors are connected to the controller and the status on each sensor can be viewed by using the application from the smartphone.

Irrigation is an important factor in producing healthy crops. The water provided is a key element that ensures that the plants can survive under certain conditions. Most of the user used a manual system to irrigate crops but this system is not efficient. [1] Intensive agriculture is labor-intensive, as it necessitates constant monitoring of the crops, and the use of a timer for watering plants is not always realistic in real-life situations. As a result, the authors provided a paper framework that enables advanced fuzzy logic to be used in smart farming plant monitoring systems to cut employment costs. Plants will die if the water supply to the plant is insufficient or vice versa. In addition, gardeners must regularly monitor their crops to ensure that their crops are in good health.

Because people are now busy working, the proposed article intends to offer comfort to people by decreasing manual effort and improving the overall performance of any system without requiring user input [2]. They designed a smart monitoring and smart gardening system that enables IoT to perceive and regulate garden parameters without requiring their physical presence.

People do not know when to undertake proper watering activities according to the soil moisture rate and the crop's needs, according to the problem statement in the study [3].

As a result, they offered a paper on the design of an automatic watering system for plants with IoT monitoring and notification to control the amount of water required by the plants based on soil moisture.

1.3 Project Objective

The main objective to run this project is to create a framework for fuzzy logic application for small agriculture. Specifically, the objectives are as follows:

- a) Simulate Fuzzy logic system as to get prediction on FUZZY LOGIC FOR HERB AND VEGETABLE SMALL-SCALE AGRICULTURE project result.
- b) Develop experimental hardware consist of ThingSpeak cloud storage to store data, monitor and control of FUZZY LOGIC FOR HERB AND VEGETABLE SMALL-SCALE AGRICULTURE and validate the simulation result.
- c) Analyzing and propose good method for growing mini scale agriculture utilizing recent fuzzy logic control method.

1.4 Scope of Project

The scope of this project are as follows:

- a) The project utilize Fuzzy logic for small agriculture is a system for household to use new plant proses as to help improve quality plant crops.
- b) The simulation of fuzzy logic was developed using MATLAB and the input were getting from fuzzy logic in agricultural implementation paper.

- c) ESP 32 is a microcontroller build in Wi-Fi that used for the harware. Its such as control unit that used as to send result curent situation of the plant to users and can storage the result data. The tabulate data from ESP 32 will keep update to interface system as long the system run.
- d) The result from the simulation will be compare with real result as to make comparisons and make minor improvement when it needed for future planting process.
- e) The moisture sensor will detect the moisture of the soil and give signal to ESP 32 to dispense water if the soil not in moisture range level. The quality of water that use for irrigation will monitor by pH sensor frequently.



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The term "literature review" refers to an examination of previous debates, journals, and research papers on Smart Plant Monitoring System. This chapter will be utilised as a reference in the future to aid with the experience of problems during project execution to ensure that this project is successful.

2.2 Research, Ideology and Concept from Previous Project

2.2.1 Automatic Plant Watering System

The paper suggests a design for an automated plant watering system for small gardens in the house, based on the journal Automatic Plant Watering System for Small Garden [5]. Basically, during at home there are space at front and back yards that can be a place to small gardening. But not at all the space have suitable to use as gardening. Then, daily activities lead many people had not enough time to water their plants. All the plant if not get enough water, they can wither and damaged.

So, the researcher uses the smart way as to manage the solution for get better crops production. The researchers improve by make an efficiency of watering system even in advance weather conditions. Because they are various plant need different amount of water, an intelligent system needed to apply with using sensor and actuators.

They suggest a system for watering plants in the journal Automatic Watering System for Plants with IoT Monitoring and Notification [2.] According to the findings of the researchers, the plants receive adequate water for their growth. The plant also needs suitable water volume because it will make a direct impact for the plant. The researcher said the watering can be manually and automatically device. So, they propose watering system that can control by situation of soil moisture. The researcher uses Microcontroller WeMo's D1 as the processor to integrates the sensors that are be used as to control the sensors and make connection Wi-fi as to connect the watering device to the internet. The researcher makes collection data from interview with open questions, and obtained date based on observation that related through water requirement for the plant that want to plant.



Figure 2.1 : The design of Automatic Watering System (by Jacquline M.S Waworundeng, Novian Chandra Suseno, Robertg Ricky Y Manaha)

2.2.2 Plant Monitoring System with IoT

By this paper of *IoT* Based Plant Monitoring System [6], propose a system that used *IoT* based as to monitor the plants. The researcher used benefit of The Internet of Things (*IoT*) as a platform to improve the accuracy, economic benefits, efficiency and reduce intervention of human. The researcher uses Arduino Uno as microcontroller as to control the sensor that being used. This project used ESP 8266 Wi-fi module as to connect the microcontroller with the connection of Wi-fi. It also used to transmit all the data from the sensor to server as to the monitoring platform. The serve that the researcher use is ThingSpeak.



Figure 2.2 : Block Diagram (by Prof. Likhesh Kolhe, Prof. Prachi Kamble, Mr. Sudhanshu Bhagat, Mr.Sohail Shaikh, Mr. Ronak Sahu, Miss.Swati Chavan, Miss.

Prajakta Zodge)

Next, the paper is about a Plant monitoring and smart gardening system using *IoT* [3], propose an automatic plant monitoring and smart gardening by using Raspberry Pi platform. This researcher makes a system that can be more easily be monitor and control. This system also provides a camera as to monitor the garden through the smart device. The researcher using a low cost of Raspberry Pi as to make the system cheaper as usual. The system also provides of monitoring for temperature of the plant, moisture of the soil, humidity of surround of the plant, light intensity, and pH of the soil. This system provides monitoring view in data based using numerical value, charts, and graphs.

2.2.3 Advance Technology of Fuzzy Logic in Agriculture

They are currently working on implementing an advanced technology based on a fuzzy logic system. Based on the article Design of a Laser Leveling Machine Control System The researcher offers a machine control system that includes a transmitter, receiver, and controller based on Fuzzy Control Theory [4]. The goal is to use a finicky logic system to produce the best output result.By apply the systems, they might decrease cost of labor and get excellent result in the end of their projects.

The researcher next suggests a finicky system based on the journal Agricultural Optimal Cropping Pattern Determination Based on Fuzzy System [7], which provides a framework for integrating database management system with fuzzy logic to improve the decision-making process. Cropping patterns are created by the researcher. This is because it one of the crucial causes that reduces degrades the quality of the products.

Table 2.1 : 21 crops in Mashhad plain cropping pattern (by E. Neamatollahi, J.

Number	Crops	Number	Crops
1	1 Wheat		Rain-fed lentil
2	Rain-fed Wheat	13	Red beans
3	Barley	14	Sunflower
4	Rain-fed Barley	15	Tomato
5	Canola	16	Maize
6	Sugar beet	17	Alfalfa
7	Cotton	18	Qasil (Barley and Millet forage)
8	Corn 19 Vegetables		Vegetables
9	Onion	n 20 Cucumber	
10	Potato	21	Melon
11	Rain-fed Pea		

Vafabakhshi, M.R. Jahansuz & F. Sharifzadeh)

From the table, the researcher determines all the crops that were planted. Then, the researcher determining an optimal pattern of each crop as to get data of characteristics plant that needs. Next, the researcher create scenarios were to define the things that each crop that needed. From that, in the end of the simulation output, the researcher can reach their objective that is minimizing the use of chemical fertilizing and pesticides for the crops. Furthermore, the researcher can be maximum of production of crops products.

This paper by [1] propose paper about Towards Smart Agriculture Monitoring Using Fuzzy Systems. According to the study, traditional farming is time-consuming and requires constant monitoring of all crops. This type of work can be taxing for farmers. As a result of the difficulty, the researcher creates a smart farming system that includes a fuzzy logic system to make it easier to produce high-quality crops. First for all, the researcher makes a collection data of the crops as to identify all that need for each of it. Then the researcher tabulates the situation in fuzzy logic system in the software as to get the result and make decision after that. Then after getting the best result for the crops, the researcher creates the device that give same input to the plant, so that the result of growing plant will approaching same to simulation result. This project was use Arduino Uno, Node MCU, Arduino NANO for the micro controller as to control the sensor and actuator that being used.



Figure 2.3 : Fuzzy inference system editor (by Noramalina Abdullah, Noor Aerina

Binti Durani, Mohamad Farid Bin Shari, King Soon Siong, Vicky Kong Wei Hau,

Wong Ngei Siong, and IR. Khairul Azman Ahmad)

2.3 Summary

As conclusion for result, the researcher gets the excellent result as to reduce the need human intervention in farming and get a quality crops production. The Internet of Things has made agriculture crop monitoring simple and efficient, increasing crop productivity and, as a result, farmer profits. Fuzzy logic system and sensors of various types are used to collect information about crop conditions and environmental changes, which is then transmitted via network to farmers and devices that initiate corrective actions. Farmers are always connected and aware of agricultural field conditions and from anywhere in the world.



CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter will explain about method and process that use in this prototype project and simulation as to achieve the objective of the project. By this chapter also will include the detail flow of the project from process of the fuzzy logic system that generate using the MATLAB software, specify all input and output membership functions and get the output result. Then, as the hardware process part, this paper will implement the simulation of fuzzy logic. After that, create coding by using Arduino IDE software as to program it into the ESP86This chapter also covers every stage of the project's development, from the beginning to the end.

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3.2 Project Flowchart UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The flowchart depicted the project's development as it progressed from predevelopment to post-development. The per-development stage entails information gathering and research, as well as an understanding of all programming languages, design work, and the generation of fuzzy logic. Following the per-development process, the first step of development is completed, which is the implementation. This approach will also include the creation of coding for an IoT monitoring system. The final phase of the finalising development output result of simulation into the hardware is then done on the post development stage.



Figure 3.1: TL estimation general process flow

3.3 Project Architecture

This project architecture will be showing the procedure of this project development. The main purpose is to make sure this project is planned and act accordingly to the plan. Most of the information will be showing in flowchart as it can be easily to refer from time to time.



Figure 3.2 : Project architecture flowchart.

3.3.1 Stage 1 : Development of Project Structure and System

This is the first stage for start of the project. The project structure is made from research that already done. All the data and information that are tabulate in the literature review as to identify the problem and solve the problem statement. Below shows the project function block diagram.



As for the project system, this was the place that we generate all the input as same as the hardware part. This project system needs to generate all the idea as to solve problem statement. As to design project system, it will used MATLAB software Fuzzy Interface System (FIS). FIS is such a friendly interface that can be used to design the project system and it can generate such a great result output same as manual output result with we can insert many memberships function in every input.



3.3.2 Stage 2 : Determination of Project Method

In general, this step is the step where you pick what method you'll utilise. This stage will also describe the software that was used and why it was chosen for this project. The MATLAB programme, along with the packages fuzzy interface system (FIS), Arduino Integrated Development Environment (IDE), and ThingSpeak, will be used in this project.

The MATLAB software package includes a desktop environment specialised for iterative analysis and design, as well as a programming language that directly defines matrices and arrays. The Live Editor will allow users to construct scripts that combine code, output, and formatted text into an executable notebook. This software also provides toolboxes that professionally developed, rigorously tested, and fully documented. This software also makes the user see the different algorithms working in the user data and generate program to automate user works. MATLAB software will help users to scale analyses to run on clusters, GPUs and clouds with only minor code change. To create the output of fuzzy logic by open the FIS Editor on the MATLAB. Figure below show the simple step using the FIS Editor in MATLAB software.



Figure 3.5 MATLAB software FIS interface.

Generate the input for the project, the light intensity, water level, pH level and soil moisture on the member ship function.



Figure 3.6 : All the input are be rename with all the sensor that use.



Figure 3.7 : setup all the membership function for all the input based on collecting data.

承 Rule Editor: psm fuzzy Latest 1

File Edit View Options

1. If (Soil_moisture is 2. If (Soil_moisture is 3. If (Soil_moisture is 4. If (Soil_moisture is 5. If (Soil_moisture is 6. If (Soil_moisture is 7. If (Soil_moisture is 8. If (Soil_moisture is 9. If (Soil_moisture is	Dry) and (Light_intens Dry) and (Light_intens	ity is dark) and (pH_leve ity is dark) and (pH_leve	I is Alkali) and (Water I is Alkali) and (Water I is Alkali) and (Water I is Asid) and (Water I is Asid) and (Water I is Asid) and (Water I is Nuetral) and (Wate I is Nuetral) and (Wate I is Nuetral) and (Wate	level is low) then (Pla level is middle) then (I level is full) then (Plan evel is low) then (Plan evel is middle) then (P evel is full) then (Plant tr_level is low) then (Pl r_level is middle) then r_level is middle) then
10. If (Soil_moisture i	is Dry) and (Light_intens	sity is low_light) and (pl	I_level is Alkali) and (V	Vater_level is low) ther 🗸
<				>
If Soil_moisture is	and Light_intensity is	and pH_level is	and Water_level is	Then Plant_result is
Dry good wet none	dark Allow_light bright none	Alkali Asid Nuetral none	low A middle full none	Bad Good Excellent none
└── ~	∠	✓	✓	×
	not			
Connection	Weight: ALAYSIA			
(and	1 Dele	te rule Add rule	Change rule	<< >>
FIS Name psm fuzzy	y Latest 1		Hel	p Close

Figure 3.8 : Create rule for the system as much as posible.

In creating the rule condition, there are a lot parameter that need to be consider. All of them need to set up refer by source that approve for all the condition that will be. As the example, the plant will bad if soil moisture dry condition, no light intensity, acid of pH value, low water level in the water storage. As to get more accurate result, it need to create more rule as much as posible.



Figure 3.9 : Setup the plant result for the sytem.



Figure 3.10 Result data for rule Viewer and Surface Viewer.
In the end of generate, the users can see the output by click the viewer in the end of the project. Then, next step was created the coding by using the Arduino Integrated Development Environment (IDE). This platform is used to develop coding language for any Arduino board. This platform which contains a code writing text editor, a text terminal, a message area, a common function toolbar and a set of menus. Below shows the interface for Arduino Integrated Development Environment (IDE).

In selecting the IoT system, it may have a lot consider that need to act such as determine the language use for inserting the coding, community support, cost, device applicable and the feature that provide when use the system. ThingSpeak one of convenience to use it. This system provides a large-scale energy data analysis, have tide prediction and many more.

Because of interface for Arduino Integrated Development Environment (IDE) use C language, the ThingSpeak also provide the C language to build the IoT system. As to minimize the problem and confusion during do the input and coding, the design software

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Figure 3.11 : Software flowchart

File Edit Sketch Tools Help



3.3.3 Stage 3 : Develop the prototype hardware

The system's hardware comprises of the following components, which are tested UNIVERSITI TEKNIKAL MALAYSIA MELAKA using the Arduino IDE (programming) and assembled on a breadboard using jumper wires to connect to a DC unit.

3.3.3.1 ESP32

ESP32 is a single 2.4 GHz Wi-Fi and Bluetooth chip that created for ultra-low power technology. This device has the best power and RF performance, showing robustness, versatility, and reliability in a wide variety of application and power scenarios. This device also designed for wearable electronic, internet of things (IoT) application. ESP32 used low duty cycle as to minimize the amount of energy that the chip expends. It also has low power

amplifier adjustable, thus it can contribute to an optimal tradeoff between communication range, data rate and power consumption.

3.3.3.2 LDR Sensor

The light sensor is a passive device which converts visible or infrared light energy into an electrical signal that can be used to obtain analogue data. Because light energy (photons) is converted into electricity, light sensors are also known as Photoelectric Devices or Photo Sensors (electrons). This sensor used to detect the intensity of the light (sunlight) falling near the plant so that if the sunlight is determined to be insufficient, the artificial light produced by the UV lamp may be compromised so that the plant can meet its nutrition requirements.

3.3.3.3 Ultrasonic Sensor

Selecting this sensor as to detect the distance or a target that use a sound wave and convert it to the reflection sound into signal by calculating the distance based on time. Ultrasonic sensors are employed in this plant monitoring system to detect water level within the water storage, and the volumetric level is shown in percentage on the applications. The equation estimates the distance of an item from the sensor when time is T and sound speed is C. The distance between an item and the sensor is equal to half of the distance travelled by the sound wave.

Distance: 1/2 T x C

Equation 3.1: Formula of Ultrasonic sensor distance

3.3.3.4 Soil Moisture Sensor

This sensor is a straightforward breakout for sensing moisture in soil and similar materials. The soil moisture sensor can be very easy to use by insert it into soil and it will read the result. If the soil moisture deficits, the sensor output value will decrease and can be shown the output result to display.

3.3.3.5 PH Sensor

The selection pH sensor as measures the acidity or alkalinity of water with a value ranging from 0 to 14. If the solution is acidic, the pH value is less than 7, and if the solution is alkaline, the pH value is more than 7. Each sort of pH sensor measures the purity of water in a different way. This sensor is utilized in this plant monitoring system to assess the quality of water that is suited for Mon Coeur Roses, which is about 5 - 6.5 for roses as example. Measuring the pH of the water might also reveal any contamination in the water.



Figure 3.13 : pH color chart.

3.3.3.6 Submerge DC Motor Pump

Submerge dc motor pump the choose for this project as it the most suitable. The propeller inside the dc motor rotates and pushes water outwards and watering the pot of the plant. It a lightweight, small-sized, low noise suitable can be use and it use low voltage to operate with power full water dispenser.

3.3.3.7 LED light

LED light was chosen because it the most effective on growing plant. This LED light was special design as to replace the natural light for plants as the plant in the dark situation. It will be turn on autocratically if the LDR sensor detect the plant in parameter of dark situation.

3.4 Summary

As a framework conclusion, it serves to explain the approach that was used in this project. This technique ensures that all of the steps are followed from the beginning to the finish of the project.

There are stages in this process that create plainly. The development of the project structure and system is the initial stage. Stage two is to decide on a project technique, and stage three is to construct prototype hardware. All three stages have already described in full how the project must be completed.

There are numerous results that must be completed in order to ensure that all development work runs properly, and that the project's goal is met. To put the plant to work, the ultimate full system is required. Finally, the outcome can be examined to both the real and simulation products.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

From all methodology above, the expected result from this method is the simulation of the fuzzy logic can be obtaining as the first phase. All the input already being insert in membership function of fuzzy interface system. As to the initial results, the output of the fuzzy logic can be observed and can be continue for further step.

4.2 Development of Fuzzy Logic System

In the MATLAB software, simulation of fuzzy logic is created. Type "fuzzy" in MATLAB command window and press enter. The Fuzzy Interface System (FIS) will load up and it have three sections. In section 1 will show input setting, all the input parameters can be edit and can be add more input for the system. In the section 2 will show the type of rule editor. It is the place for add rule and can be choose (Mamdani) or (Sugano) rule. In the section 3 will show output editor and it can edit the parameter of the output. By this project will using mamdani rule because it have advantage for well-suited to human input, more interpretable rule base and have a widesperead acceptance.

Click the input 1 or box as to start edit for the first input. Change the name input 1 to the real input with is Soil_moisture for input 1, Light_intensity for input 2, pH_level for input 3, and Water_level for input 4. Adjust the parameter in each input 1, input 2, input 3 and input 4 according to the real data.



Figure 4.1 : Setting in section (input).

For this section of FIS, all the data was made based on the data collection research paper. As for the soil moisture, journal Automatic Watering System for Plants with IoT Monitoring and Notification [2], the plant need needs suitable water volume because it will make a direct impact for the plant. Then, for the light intensity parameter also be set up based the research paper Light Intensity Effects on the Growth, Physiological and Nutritional Parameters of Tropical Perennial Legume Cover Crops [18], as mentioned that growth of the plant will greater when then plant have a good intensity of the light. Next for the pH level of the soil, all the data was getting from pH Control of Untreated Water for Irrigation [19] as the plant will affect when it does get right nutrition to grow and one of it came from water pH. Next for water level parameter are create based on own observation. By this project, for simulation in FIS foe water level was being set such the more water in the storage, the less time to be refill the water.



 Table 4.0 : input result for the system.



	Membership Function Editor: psm fuz	zzy Latest 1 – 🗆 X
Water level	FIS Variables Soil moistufeant_result Light_intensity pH level 0 2	Membership function plots nint nints: 181 middle full 4 6 8 10 12 14 16 18 20 input variable "Water level"
	Current Variable Name Water_level Type input Range [0 20] Display Range [0 20]	Current Membership Function (click on MF to select) Name Type gaussmf Params [2.557 0]
TERNING	Selected variable "Water_level" Figure 4.5 : Water level on	membership function.
l.2.2 Developn	nent of Fuzzy Logic System	اونۇرىسىتى تىك

In section 2 will show the place for adding rule for the system. This rule use Mamdani rule as to select connection OR or AND for set the rule. In the rule editor, all possible rule was adding and use AND connection. It used 81 different rules for this project result.



Figure 4.6 : Rule editor in section 2.



Table 4.1 : Experiment result rule for the sytem.

Ŧ	#	Rule
-	1	If (Soil_moisture is Dry) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad)
	2	If (Soil_moisture is Dry) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad)
	3	If (Soil_moisture is Dry) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad)

4	If (Soil_moisture is Dry) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Bad)
5	If (Soil_moisture is Dry) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Bad)

Refer to appendix C Experimental result rule for the system.

4.2.3 Section 3

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As section 3 will show the place to edit or create output parameter. The name output 1 was change to Plant_result. In the parameter be set as three level with is Bad, Good and Excellent. In the membership for output was set in range of 0 to 30.

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4.2.4 Result for Fuzzy Logic System

As the result fuzzy logic system, it has two ways, as to see the result. In the first type of result, it co show comparision in between two input data as example soil moisture vs light intensity. The result will display by surface view the will show range by each input and the result output range. Below was the result by surface view.



Figure 4.8 : Soil moisture VS Light intensity.

Based on the result, it shows that the low light intensity will give low plant result and it goes same ways with the soil moisture. For next example of surface view is the relationship between pH level and the soil moisture.



Figure 4.9 : Soil moisture VS pH level.

4.2.5 Result of The Plant

Table 4.2 : Result plant by week for control system and uncontrol system.









Based on this project be able to achieve the objective, as mentioned in early part in chapter 1 was able to simulate the Simulate Fuzzy logic system as to get prediction on FUZZY LOGIC FOR HERB AND VEGETABLE SMALL-SCALE AGRICULTURE project result. In the simulation, for the uncontrol system, the input of the crop were set in low value. As the example, for the soil moisture and light intensity, the value were set 200 mark for the soil moisture and light intensity were set as 200 mark. Then, for control system, the value of soil moisture were set in 500 mark and the light intensity was set to 850 mark. So in the result of simulation, the output result of the plant will be different. The uncontrol system will be lower result than the control system result.

As for the real product, all the plant were located indoor of the house. The control system plant will always get light if it in dark situation. It also same goes to soil moisture. The pump will always be watering the plant until it reaches the desire condition. Unlike for uncontrol system, the plant just receives light intensity in the morning because the present of sunlight inside the house. By night, it only receives light if someone use the research area. As for irrigation for uncontrol system, the plant will only be watering in the morning.

Both of the system was be record as shown at Table 4.2 Result plant by week for control system and uncontrol system. When result collection reach on week 4, the uncontrol system show all the crop dead. In the week 3, the plant leave turn to yellow and start to withered day by day until reach to week 4. By end of week 4 just certain plant was survive. Then until on of week 5 all the uncontrol plant dead. This different with the control system, the plant grows up nicely and healthy.

For the second objective, this project able to record the data by using IoT system. All the data can be seen on Thingspeak. All the parameters can be show clearly. In others, the result of data can be storge as long as it connected with Wi-Fi.

4.2.6 Overall Results.



view and Rule view. From both view of result will show same output and can be observe.

As the result for all set of parameters, the output result can be shown by Surface

Figure 4.21 : Result output system in Surface view and Rule view.



Figure 4.22 Result high of plant in Week 4



Figure 4.23 Result hight of plant in Week 5.

Based on figure 4.22 and figure 4.23, the plant grow 1 centimer with grow a new patle in one week.

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CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this chapter will discuss about the conclusion that obtain for this project, Fuzzy Logic For Herb and Vegetable Small-Scale Agriculture, problem solving during the process and future recommendation work for this project. In this chapter are purpose to encounter problem that occur during this project be done.

5.2 Achievement

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All of the objectives for this Fuzzy Logic For Herb and Vegetable Small-Scale Agriculture has already been met before the end. This project can be implemented in a real product and monitored using an IoT system. Using FIS, this project may also simulate in simulation with a fuzzy logic system. Aside from that, the produce will undoubtedly be ready to harvest and eat safely in the end.

5.3 Final product

By in the end of this project, it has two outcomes. Firstly, a system that use simulation type and another is real system product. This because if this project just successfully with simulation, by the end still hard to see how the herb and vegetable growth.

5.4 **Problem and limitation of project**

In this project have the most problem with to transfer to the simulation output to the hardware. As to get the similarity result, all the sensors need frequently accurate to the nearest result. This because some of the sensor that used to create the device was cheaper due to limitation of budget. Others, the type of soil that used need to be suitable for plants and this factor can also affect in long term of planting process.

5.5 Recommendation

In the next phase, the rule for fuzzy logic will be added more as to get more accurate result for whole simulation system. Besides that, the used of quality sensor will more as to get the high durabily for the sensor and high accuarycy for getting the result. Others, as future can be use this system for aquaponic type of planting with fuzzy logic and can be compare the rapid growth of the plants.

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APPENDICES

Appendix A Datasheet of ESP-WROOM-32

No. 1 2	Description In Table IO_MUX, the boxes highlighted in yellow indicate the GPIO pins that are input-only. Please see the following note for further details. GPIO pins 34-39 are input-only. These pins do not feature an output driver or internal pull- up/pull-down circuitry. The pin names are: SENSOR_VP (GPIO36), SENSOR_CAPP (GPIO37), SENSOR_CAPN (GPIO38). SENSOR_VN (GPIO38), VDET 1 (GPIO34), VDET 2 (GPIO35).
2	In Table IO_MUX, the boxes highlighted in yellow indicate the GPIO pins that are input-only. Please see the following note for further details. GPIO pins 34-39 are input-only. These pins do not feature an output driver or internal pull- up/pull-down circuitry. The pin names are: SENSOR_VP (GPIO36), SENSOR_CAPP (GPIO37), SENSOR_CAPN (GPIO38), SENSOR VN (GPIO39), VDET 1 (GPIO34), VDET 2 (GPIO35)
2	GPIO pins 34-39 are input-only. These pins do not feature an output driver or internal pull- up/pull-down circuitry. The pin names are: SENSOR_VP (GPIO36), SENSOR_CAPP (GPIO37), SENSOR_CAPN (GPIO38), SENSOR VN (GPIO39), VDET 1 (GPIO30), VDET 2 (GPIO35)
2	up/pull-down circuitry. The pin names are: SENSOR_VP (GPI036), SENSOR_CAPP (GPI037), SENSOR_CAPN (GPI038), SENSOR_VN (GPI039), VDET 1 (GPI034), VDET 2 (GPI035)
	SENSOR CAPN (GPIO38) SENSOR VN (GPIO39) VDET 1 (GPIO34) VDET 2 (GPIO35)
	The pins are grouped into four power domains: VDDA (analog power supply), VDD3P3_RTC
	(RTC power supply), VDD3P3_CPU (power supply of digital IOs and CPU cores), VDD_SDIO
3	(power supply of SDIO IOs). VDD_SDIO is the output of the internal SDIO-LDO. The voltage of
.51	SDIO-LDO can be consigured at 1.8 V or be the same as that or VDD3P3_RTC. The strapping
3	voltage of the SDIO-LDO by configuring register bits. For details, please see the column "Power
X	Domain" in Table IO_MUX.
-	The functional pins in the VDD3P3_RTC domain are those with analog functions, including the
4 _	32 kHz crystal oscillator, ADC, DAC, and the capacitive touch sensor. Please see columns
20	"Analog Function 1~3" in Table IO_MUX.
5	These VDD3P3_RTC pins support the RTC function, and can work during Deep-sleep. For
	example, all RTC-GPIC can be used for waking up the chip from beep-seep. The GPIC pins support up to six digital functions, as shown in columns "Function 1 ₂ .6" In Table
· · · ·	IO_MUX. The function selection registers will be set as "N-1", where N is the function number.
JN C	Below are some definitions
	SD_* is for signals of the SDIO slave.
	HS1_* is for Port 1 signals of the SDIO host.
A DADA	HS2_' is for Port 2 signals of the SDIO host.
4 INT	U0* is for signals of the UARTO module
	U1* is for signals of the UART1 module.
	U2* is for signals of the UART2 module.
	 SPI* is for signals of the SPI01 module.
	 HSPI* is for signals of the SPI2 module.
	 VSPI* is for signals of the SPI3 module.

Appendix B Datasheet of Soil Moisture Sensor



5. Usage

5.1 With Arduino

This is a summary of the moisture sensor which can be used to detect the moisture of the soil. When the soil moisture deficits, the sensor output value will decrease. You can know whether a plant needs water or not by observing the results that the sensor outputs. The following sketch demonstrates a simple application of sensing the moisture of the soil.

Connect this module to one of analog port A0 of Grove - Base Shield with the 4 pin Grove

cable, and then insert the Sensor into the soil or place it anywhere you want.

Plug Grove - Base Shield into the Arduino/Seeeduino and connect Arduino to PC via a USB cable.



Note: This sensor isn't hardened against contamination or exposure of the control circuitry to water and may be prone to electrolytic corrosion across the probes, so it isn't well suited to being left in place or used outdoors.

Copy and paste code below to a new Arduino sketch.

int	<pre>sensorPin = A0;</pre>	// select the input pin for the potentiometer	
int	sensorValue = 0;	// variable to store the value coming from the se	ensor



```
void setup() {
    // declare the ledPin as an OUTPUT:
    Serial.begin(9600);
}
void loop() {
    // read the value from the sensor:
    sensorValue = analogRead(sensorPin);
    delay(1000);
    Serial.print("sensor = " );
    Serial.println(sensorValue);
}
```

Upload the code, please click here if you do not know how to upload.



The Result in different condition after open the serial monitor.

Sensor in air

Sensor in dry soil

Sensor in humid soil

Sensor in water

#	Rule
1	If (Soil_moisture is Dry) and (Light_intensity is dark) and
	(pH_level is Alkali) and (Water_level is low) then (Plant_result
	is Bad)
2	If (Soil_moisture is Dry) and (Light_intensity is dark) and
	(pH_level is Alkali) and (Water_level is middle) then
	(Plant_result is Bad)
3	If (Soil moisture is Dry) and (Light intensity is dark) and
5	(pH level is Alkali) and (Water level is full) then (Plant result
	is Bad)
4	If (Call assistance is Day) and (Light interaction is do 1)
4	If (Soil_moisture is Dry) and (Light_intensity is dark) and (pH level is Asid) and (Water level is low) then (Plant result
di di	(pri_lever is Asid) and (water_lever is low) then (i fant_lesure is Bad)
Ka	
i de la compañía de	
5	If (Soil_moisture is Dry) and (Light_intensity is dark) and
	(pH_level is Asid) and (Water_level is middle) then
	(Plant_result is Bad)
. 3	اونىۋەرىسىتى تىكنىكا ملىسىا ملا
6	If (Soil_moisture is Dry) and (Light_intensity is dark) and
U	(pH_level is Asid) and (Water_level is full) then (Plant_result
	is Bad)
7	If (Soil moisture is Dry) and (Light intensity is dark) and
	(pH_level is Nuetral) and (Water_level is low) then
	(Plant_result is Bad)
8	If (Soil moisture is Dry) and (Light intensity is dark) and
0	(pH level is Nuetral) and (Water level is middle) then
	(Plant_result is Bad) (1)
9	It (Soil_moisture is Dry) and (Light_intensity is dark) and (pH_loyal is Nuster) and (Water_loyal is full) they
	(pn_level is indertai) and (water_level is full) then (Plant result is Rad) (1)
	(1 fant_result is Dad) (1)

Appendix C Experimental result rule for the system

10	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)
11	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)
12	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)
13	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Bad) (1)
14	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Bad) (1)
15	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is full) then (Plant_result is Bad) (1)
16	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is low) then (Plant_result is Bad) (1)
17	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is middle) then (Plant_result is Bad) (1)
18	If (Soil_moisture is Dry) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is full) then (Plant_result is Bad) (1)
19	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)

20	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)
21	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)
22	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Bad) (1)
23	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Bad) (1)
24	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Asid) and (Water_level is full) then (Plant_result is Bad) (1)
25	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Nuetral) and (Water_level is low) then (Plant_result is Bad) (1)
26	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Nuetral) and (Water_level is middle) then (Plant_result is Bad) (1)
27	If (Soil_moisture is Dry) and (Light_intensity is bright) and (pH_level is Nuetral) and (Water_level is full) then (Plant_result is Bad) (1)
28	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)

29	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)
30	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)
31	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Bad) (1)
32	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Bad) (1)
33	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is full) then (Plant_result is Bad) (1)
34	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Nuetral) and (Water_level is low) then (Plant_result is Bad) (1)
35	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Nuetral) and (Water_level is middle) then (Plant_result is Bad) (1)
36	If (Soil_moisture is good) and (Light_intensity is dark) and (pH_level is Nuetral) and (Water_level is full) then (Plant_result is Bad) (1)
37	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)
38	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)

39	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)
40	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Bad) (1)
41	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Good) (1)
42	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is full) then (Plant_result is Good) (1)
43	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is low) then (Plant_result is Good) (1)
44	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is middle) then (Plant_result is Good) (1)
45	If (Soil_moisture is good) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is full) then (Plant_result is Good) (1)
46	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)
47	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)

48	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)
49	If oil_moisture is good) and (Light_intensity is bright) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Good) (1)
50	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Good) (1)
51	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Asid) and (Water_level is full) then (Plant_result is Good) (1)
52	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Nuetral) and (Water_level is low) then (Plant_result is Good) (1)
53	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Nuetral) and (Water_level is middle) then (Plant_result is Excellent) (1)
54	If (Soil_moisture is good) and (Light_intensity is bright) and (pH_level is Nuetral) and (Water_level is full) then (Plant_result is Excellent) (1)
55	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)
56	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)
57	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)

58	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Bad) (1)		
59	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Bad) (1)		
60	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Asid) and (Water_level is full) then (Plant_result is Bad) (1)		
61	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Nuetral) and (Water_level is low) then (Plant_result is Bad) (1)		
62	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Nuetral) and (Water_level is middle) then (Plant_result is Bad) (1)		
63	If (Soil_moisture is wet) and (Light_intensity is dark) and (pH_level is Nuetral) and (Water_level is full) then (Plant_result is Bad) (1)		
64	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)		
65	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)		
66	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)		
67	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Good) (1)		
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68	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is middle) then (Plant_result is Good) (1)		
69	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Asid) and (Water_level is full) then (Plant_result is Excellent) (1)		
70	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is low) then (Plant_result is Excellent) (1)		
71 TEKW	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is middle) then (Plant_result is Excellent) (1)		
72	If (Soil_moisture is wet) and (Light_intensity is low_light) and (pH_level is Nuetral) and (Water_level is full) then (Plant_result is Excellent) (1)		
73	If (Soil_moisture is wet) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is low) then (Plant_result is Bad) (1)		
74	If (Soil_moisture is wet) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is middle) then (Plant_result is Bad) (1)		
75	If (Soil_moisture is wet) and (Light_intensity is bright) and (pH_level is Alkali) and (Water_level is full) then (Plant_result is Bad) (1)		
76	If (Soil_moisture is wet) and (Light_intensity is bright) and (pH_level is Asid) and (Water_level is low) then (Plant_result is Good) (1)		

77	If (Soil_moisture is wet) and (Light_intensity is bright) and			
	(pH_level is Asid) and (Water_level is middle) then			
	(Plant_result is Good) (1)			
78	If (Soil_moisture is wet) and (Light_intensity is bright) and			
	(pH_level is Asid) and (Water_level is full) then (Plant_result			
	is Excellent) (1)			
70				
79	If (Soil_moisture is wet) and (Light_intensity is bright) and			
	(pH_level is Nuetral) and (Water_level is low) then			
	(Plant_result is Excellent) (1)			
80	If (Soil moisture is wet) and (Light intensity is bright) and			
00	(pH level is Nuetral) and (Water level is middle) then			
	(Plant result is Excellent) (1)			
	(I lant_result is Excellent) (1)			
	NY NO.			
81	If (Soil moisture is wet) and (Light intensity is bright) and			
<u>ж</u>	(pH level is Nuetral) and (Water level is full) then			
(Plant result is Excellent) (1)				
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Appendix D Result plant by week for control system and un control system.

No.	<u>Control System</u>	<u>Uncontrol System</u>	
1	Moisture: - Light intensity: - Level of water: - pH reading: -		
	- For both type of controlling system will go same way only for roots germination process with is the seed will be exposed to sunlight until the roots came out.		
2	<u>WEEK1</u> CONTROL SYTEM	اونيوم سيتي تيج UNCONTROL SYSTEM	
	Moisture: 400 Light intensity: 800 Level of water: 20 L pH reading: 7	Moisture: 230 Light intensity: 500 Level of water: - pH reading: 6.5	
		Figure 4.12 : Week 1 Upgentral	
	Figure 4.11 : Week 1 Control system pot.	Figure 4.12 : Week 1 Uncontrol system pot.	



