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The Design IOT Smart Garden with Soil Temperature and Moisture Monitoring

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Abstract

The need for every human being in this world is oxygen. Plants play an important role in maintaining the carbon dioxide and oxygen content in the air. Numbers of plants are destroyed every day for the urbanization process. The number of plantings carried out is also reduced. Apart from these things more plants die due to lack of care. The main objective of this project is to protect plants by continuously monitoring the parameters that lead to the improvement of plants and human life. Automated systems are preferred over manual systems. Android software is used to create a mobile application that is used to monitor garden parameters and automate the watering process. The ESP8266 is used to connect various sensors that collect soil parameters and transmit information to the MQTT protocol via Adafruit.

Keywords:
Adafruit IO, Internet of Things, Smart Garden, Temperature Monitoring, Plant

1. Background

Plants play an important role in maintaining the carbon dioxide and oxygen content in the air. Numbers of crops are destroyed every day for the urbanization process. The number of plantings carried out has also decreased. Apart from these things more plants die due to lack of care. The main aim of the project is to safeguard plants by continuously monitoring parameters leading to improved plant and human life. Automatic systems are preferred over manual systems. Android software was used to create a mobile application used to monitor garden parameters and automate the watering process. The ESP8266 is used to connect various sensors that collect soil parameters and send the information to the MQTT protocol via Adafruit.

The rapid development of science has created various technologies that help people's lives, including the Internet of Things (IoT). IoT is an integrated system that allows people to control their devices remotely via the internet and smartphones. IoT technology is widely applied in various areas of human life, such as plant care and so-called smart gardens. The smart garden system is for monitoring and control, monitoring is for monitoring the values of the sensors used in the system, and control is for controlling the electronic objects installed in the system. The parameter values of each sensor installed in the smart garden system need to be controlled so that they are always at the value or state desired by the user. The smart garden system uses ESP8266 as a microcontroller and multi sensors (soil moisture sensor for soil moisture, DHT11 humidity temperature sensor and raindrop sensor). Results of Plant Management Observations Related to Adafruit IO.

1.1. Formulation of the problem

By referring to the background of the problem above, the researcher will discuss "How to design a tool that can manage and monitor the status of Ornamental Plants and display it on a real-time interface".

1.2. Scope of problem

To avoid extensive discussion, the researchers conducted research only on planted ornamental plants (not when sowing), the temperature range used in this research was 29 C, detailed discussion of each component was not discussed and the tool will only work when connected. Internet.

1.3. Objective

The aim of this research is to design and build a tool that is able to adjust plant conditions to facilitate plant care by monitoring soil temperature and moisture.

2. Literature review

Researchers will present reviews or studies related to several similar previous studies on the Smart Garden theme. Some of the research that will be reviewed in this proposal includes research from students of the Faculty of Computer Science, Bina Darma University in 2021, by M. Reza Fahrisi and Fathoni entitled Design of a

Microcontroller-Based Smart Garden System Using the SDLC Method. There is also research from Universitas PGRI Madiun in 2019, by Krisna Affandi entitled Designing a Smart Garden Based on the Internet of Things (IoT) Using Telegram Bots, and several other studies. The author will also describe supporting theories and empirical studies related to the design of IoT Smart Gardens with Monitoring Soil Temperature and Moisture. Starting from the meaning of Smart Garden as well as several things related to Smart Garden such as methods commonly used in plant care. There are also several basic theories regarding the microcontroller device that will be used, namely the ESP8266 microcontroller, as well as the application or programming software used to create Android software, namely Adafruit, to the IoT or Internet of Things concept which is the basis of the Smart Garden system that will be created.

2.1. Previous Research

No.	Author	Research Title	Research result	Difference
1	M. Reza Fahrisi, Fathoni	DESIGNSYSTEM SMARTGARDEN BASED MICROCONTROLLER	The Smart Garden system can sprinkle water to the ground if	There are no IoT features yet so no can
		USESDLC METHOD[6]	Soil moisture reaches dry levels. (2021, Faculty of Computer Science, Bina Darma University)	carry out remote monitoring
2	Krisna Affandi	DESIGN AND BUILDING OF A SMART GARDEN BASED ON THE INTERNET OF THINGS (IoT) WITH TELEGRAM BOT[3]	The Smart Garden system can sprinkle water using the Telegram BOT as a medium for entering command input (2019, PGRI Madiun University)	The sensors used are the Rcyago PMS710 sensor as a soil moisture sensor and the Si7021 sensor as a replacement for temperature and air humidity sensors. Research also uses Telegram BOT as a medium for enter command input
3	Reginald Mahendra, Ahmad Muhammad Thantawi	DESIGN AND BUILDING OF A SMART WATERING SYSTEM FOR PLANT USING RASBERRY PI[4]	Indoor Smart Garden System Based on Arduino UNO ATMega 328 microcontroller (2020, Persada Indonesia University YAI)	Research Using Raspberry Pi and Command input is done via and based Website
4	F. Faridah	SOIL MOISTURE CONTROL APPLICATION IN SMART GARDEN USING SOIL MOISTURE SENSOR[8]	The smart garden system is based on the Arduino Microcontroller Atmega 328 which has DHT 22 components, humidity RTC, LCD, relay board module, keypad, and pump for supports the work of the system.	Research using Arduino microcontroller ATMEGA 328 and DHT 22, RTC Humidity. Research has not implemented an IoT-based Android Application System
5	Deni Kurnia,	DESIGN	GardeningSmart	Study
	Adolf LoveSuprian to	SMART GARDENING PROTOTYPESYSTEM (GSS)FOR PLANT CARE WEB-BASED ORCHID[5]	System(GSS) is a prototype care system plant Whichthe control is designed via the Web (2016, PolytechnicEngineering Indorama)	Use Raspberries Pi And input Order carried outthrough And Website based

2.2. Supporting theory

1) Decorative plants
Ornamental plants are a classification of garden plants based on function. Therefore, in general, vegetable, medicinal or fruit plants can become ornamental plants, or vice versa. Ornamental plants, whether in the form of herbs, vines, shrubs, shrubs or trees, including those used by people as components of gardens, kitchen gardens, room decoration, religious and national ceremonial facilities, cosmetics/ Including all plants that you consciously use as components of clothing You. , or as a component of the composition, flowers. According to Zulkarnain (2009), all ornamental plants are planted for their beauty. Therefore, the classification of leaf plants according to this definition is actually not limited to flowering plants, but also plantation and forest plants whose forms have aesthetic value and are cultivated with the aim of beautifying or beautifying the plants. Environment
2) Smart Garden
Smart Garden is a plantation or garden concept using technological intelligence, information on plant conditions and soil moisture levels controlled by a system of tools
3) ESP8266
The ESP8266 is basically an e-Lua based firmware. The ESP8266 is equipped with a micro USB port which functions for programming and power supply. Apart from that, the ESP8266 is also equipped with push buttons, namely the reset and flash buttons. ESP8266 uses the Lua programming language which is a package from ESP8266. The Lua language has the same logic and programming structure as C, only the syntax is different. If you use the Lua language, you can use the Lua loader or Lua uploder tools. Apart from the ESP8266 language, it also supports the Arduino Ide software by making several changes to the board manager on the Arduino Ide. Before using this board, it must be flashed first so that it supports the tools used. Before using this board, it must be flashed first so that it supports the tool that will be used. If you use the Arduino IDE, use the appropriate firmware, namely the firmware output from Ai-Thinker which supports AT Command. To use the tool loader, the firmware used is the ESP8266 firmware.
4) Arduino IDE Software
IDE is an abbreviation for Integrated Development Environment. IDE is a program used to create programs on the ESP8266.
Programs written using Arduino Software (IDE) are called sketches. Sketch is written in a text editor and saved in a file with the .ino extension. In the Arduino IDE software, there is a kind of black message box which functions to display status, such as error messages, compile and upload programs. At the bottom rightmost of the Arduino IDE software, shows the configured board along with the COM Ports used.
5) Soil Moisture Sensor
Soil Moisture Sensor is a soil moisture detection module that can be accessed with a microcontroller such as Arduino. This soil moisture sensor can be used in agricultural systems, plantations, and hydroponic systems using Hydroton. Soil moisture sensors can be used in automatic irrigation systems, or offline or online monitoring of plant soil moisture. Sensors on the market contain two modules in their sales package, namely a sensor for humidity detection and an electronic module as a signal amplifier.
6) Raindrop Sensors
Raindrop Sensoror rainwater sensors are used to record and determine certain quantities. Rainwater sensors are designed to use the conductivity of rainwater to connect circuits when rainwater hits them (active sensors). When rainwater hits the sensor panel, it is electrolyzed through the water because the electrolyte, a liquid that conducts electricity, contains water. The water sensor is built using a circuit board with winding paths so that the water that hits the paths merges and conducts an electric current. The purpose of the rainwater sensor is to provide input for the level of electrolysis of the water in contact with the water sensor plate. To prevent damage to the sensor due to rust or dirt, the cable must be coated with tin or another material that allows the cable to connect and conduct electricity.
7) DHT Sensor 11
The DHT sensor is a sensor that functions to measure temperature and humidity in the air and also contains an NTC (Negative Temperature Coefficient) type thermistor to measure temperature, a humidity sensor with resistive characteristics to changes in water content in the air and there is a chip that carries out several analog conversions. to digital and outputs in single-wire bi-directional format (two-way single cable).
8) DC Mini Submersible Water Pump
Mini Submersible Water Pump is a small submersible water pump motor. This mini water pump is usually used for aquariums, fish ponds, hydroponics, robotics or projects in making microcontroller-based applications. Mini Submersible Water Pump uses a Brushless DC motor and works With a DC 5V voltage, the advantage of this mini water pump is that it is quiet to use and safe when working in water.
9) Adafruit IO
Adafruit IO is one of the Mqtt server service providers for IoT, this service can be used to make the ESP8266 controlled remotely using subscribe and publish facilities. Adafruit IO controls the ESP8266

microcontroller via a control panel created in adafruit IO web to enable or disable relays. Adafruit IO connecting the ESP8266 microcontroller and relays.

10) MQTT protocol

MQTT is a protocol applied to IoT. This protocol is very supportive for WAN networks, because WANs cover a wide area. The MQTT protocol has the advantage of being able to work with minimum energy and storage media.

11) Internet of Things

According to the Coordinator and support action for global RFID-related activities and standards, the internet of things (IoT) is a global network connection infrastructure, which connects physical and virtual objects through the exploitation of data capture and communication technology. In other words, the Internet of Things is a concept where an object has the ability to transfer data over an internet network without requiring human-to-human or human-to-computer interaction. In general, the concept of the Internet of Things (IoT) includes 3 main elements that make up the architecture of the Internet of Things, namely, real physical differences that have been integrated into a sensor module, a network connection to the internet, and a server data center that functions to store data or information. received by sensors from an application. By utilizing connectivity from a continuously connected internet network, devices that use the Internet of Things (IoT) concept can work directly. So it can make it easier for humans to do work, such as monitoring health with a Smart Watch which can provide information about human health in terms of pulse rate. The extensive application suite for Internet of Things devices is often divided into consumer, commercial, industrial, and infrastructure spaces.

3. Research methods

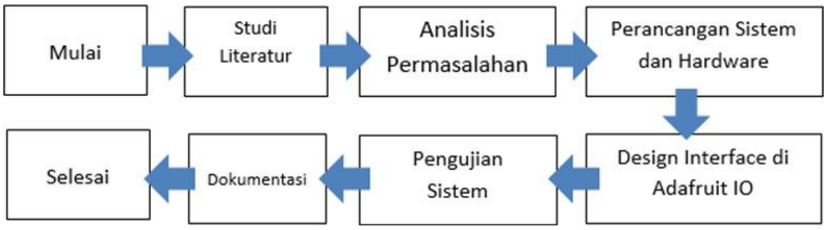

Figure 1 Research Method

The research methods used by the author are literature study, problem analysis, design and system design, system implementation, system testing, evaluation and documentation. Judging from the research method above, the author's order in conducting research is by studying literature studies from various articles, then the author finds the background of the problem, which then the author carries out system and hardware design, after which the author designs the interface in Adafruit IO so that it is easy to use and in accordance with the intended use. what the author wants to achieve, after that the author carries out system testing and then documents it in the form of photos

3.1. Study of literature

In the search for references and theories that have been obtained, they will be used as the main reference material for research work. Some of the theories used are in the form of previous research journals, articles, and the Internet. This research focuses on how the Internet of Things works for the Smart Garden system which uses the ESP8266 microcontroller as the main control. The following is some information related to this research that has been carried out by the author, including: How the ESP8266 Microcontroller works and is programmed in the Arduino IDE Software, How Smart Garden IOT works, and How it works and is programmed on Adafruit IO.

3.2. Problem Analysis

In planning the tools to be made, an appropriate system is needed to regulate the operation of the required system. From the first, users can choose between 2 modes, namely Automatic Mode and Manual Pump. In automatic mode, if the soil is dry then the soil value is < 25 then the pump will automatically turn ON and will turn off again when the soil moisture value is more than 25. In Manual mode the water pump can be controlled ON/OFF using the Pump Control Switch, while for selection In manual mode, simply position the manual pump switch to the ON position.

Air humidity is displayed in the Humidity gauge block while room temperature is displayed in the Temperature block. The Weather Indicator displays the Garden's weather by reading the rain sensor, if it lights up yellow it means it's Not Raining, while if it lights up dark blue it reads Rain.

3.4. Hardware System Design

System and hardware design for the tools to be made requires several stages that are useful for building an appropriate monitoring system, starting from block diagrams, planning design, system implementation, and hardware design. The design will also discuss the monitoring system flowchart via the Adafruit IO interface. A more detailed explanation will be discussed in the System Diagram Block sub-chapter.

3.5. System Block Diagram

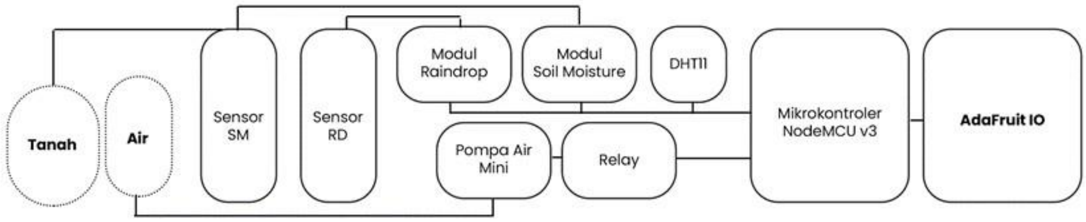

Figure 2 System Block Diagram

From the block diagram shown in the image above, you can see the flow of the current monitoring system that will be created. From the leftmost diagram, namely the SM Sensor which is plugged into the ground and the Raindrop Sensor which is placed next to the plant will send the sensor readings to their respective modules, the same as the DHT 11 sensor which will also read the ambient temperature and then all the information will be sent to the ESP8266 Board which will then be displayed to Adafruit IO which will be controlled by the user.

3.6. Hardware Design

The following will explain the hardware and design scheme for creating a Smart Garden IoT

3.7. ESP826

ESP8266 This is basically an extension of the ESP 8266 with e-Lua based firmware. The ESP8266 is equipped with a micro USB connector which is used for programming and power. The ESP8266 is also equipped with buttons, namely the reset and flash buttons. The ESP8266 uses the Lua programming language, which is a package from the ESP8266. The Lua language has the same logic and programming constructs as C, only the syntax is different. If you use Lua, you can use the Lua Loader and Lua Uploader tools.

3.8. Soil Moisture Sensor

Soil Moisture Sensor is a soil moisture detection module that can be accessed with a microcontroller such as Arduino. This soil moisture sensor can be used in agricultural systems, plantations, and hydroponic systems using Hydroton.

Soil moisture sensors can be used in automatic irrigation systems, or offline or online monitoring of plant soil moisture.

3.9. Raindrop Sensors

Raindrop sensors or rainwater sensors are used to detect and determine certain amplitudes. The rainwater sensor is made using the conductivity of rainwater, so that when rainwater hits it, the circuit is connected (the sensor works). When rainwater hits the sensor substrate, water electrolysis occurs because the electrolyte, which is a conductive liquid, contains water. This water sensor consists of a circuit board with a winding path, the water that hits the path merges and conducts electricity. The rainwater sensor is used to provide input values for the level of water electrolysis at which the water hits the water sensor board.

3.10. DHT Sensor 11

The DHT sensor is a type of sensor that measures temperature and humidity simultaneously, it contains an NTC type thermistor (negative temperature coefficient) to measure temperature, a humidity sensor with characteristics of resistance to changes in water content and has a chip inside. which performs some analog-to-digital conversion and produces a single-cable bidirectional format.

3.11. DC Mini Submersible Water Pump

Mini submersible water pump is a type of small submersible pump motor. This mini water pump is usually used for production projects based on aquariums, fish ponds, hydroponics, robotics or microcontrollers. This mini submersible water pump uses a Brushless DC motor and works with a voltage of 5V DC. The advantage of this mini water pump is that it is quiet when used and safe when you work underwater.

3.12. Circuit Schematic

Overall Smart Garden IoT Circuit Scheme, which is designed entirely using:

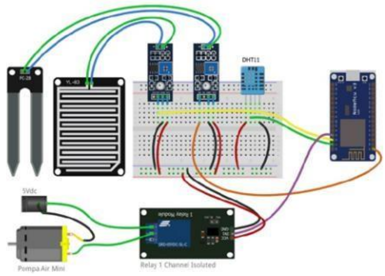

Figure 3 Overall Smart Garden IoT Circuit Scheme

1. ESP8266
2. Soil Moisture Sensor
3. DHT 11
4. Raindrop Sensor
5. Relay Module
6. Mini Waterpump
7. Relays

3.13. Adafruit IO Interface Design

In this sub-chapter we will explain the steps on how to design an interface in Adafruit IO so that it is easy to understand, and the protocol, database and software flowchart used will also be explained.

3.14. Adafruit IO

Adafruit IO is one of the MQTT server service providers for IoT that can be used to remotely control the ESP8266 using subscribe and publish functions. Adafruit IO controls the ESP8266 microcontroller to turn relays on or off via a dashboard built into the adafruit IO web. Adafruit IO connecting the ESP8266 microcontroller and relay.

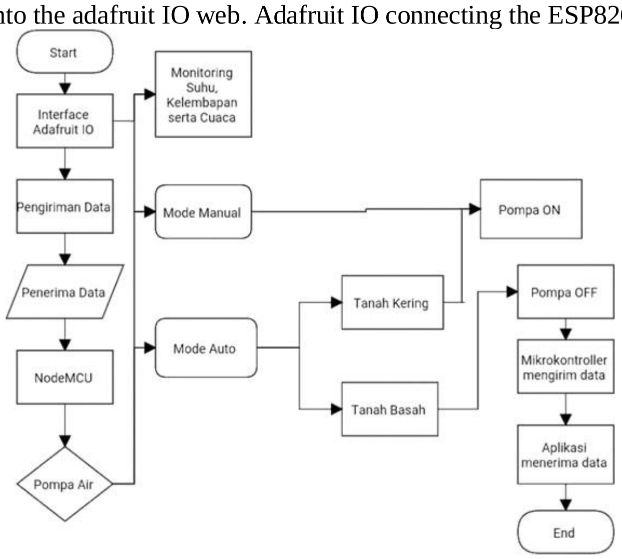

Figure 4 Software Flowchart

From the Software Flowchart above, it can be concluded that in the Adafruit IO interface there is Temperature and Humidity Monitoring as well as Weather and a mode for setting the pump, when the pump is set to Manual Mode the pump will immediately turn on, but if the pump is set to Auto Mode then the pump will detect soil moisture. if the soil conditions are dry, the pump will be ON, if the soil conditions are wet, the pump will be OFF. This information is then sent by the Microcontroller via the MQTT protocol and then continued to the Application.

3.15. Adafruit Cloud Service

Adafruit Cloud Service can be used to store and synchronize data between users in real time.

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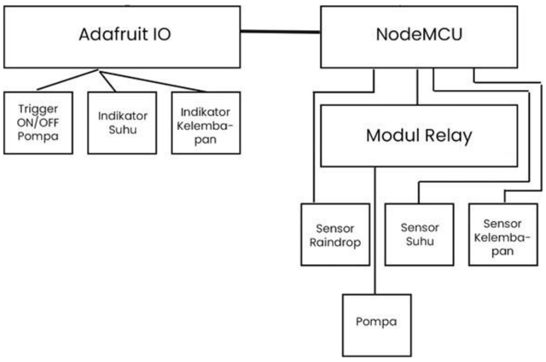

Figure 5 Adafruit Cloud Service

3.16. Arduino IDE

Arduino IDE is a simple application software, with a community-based system and a simple interface too. This program makes coding websites and applications easy. This coding software also comes with several templates.

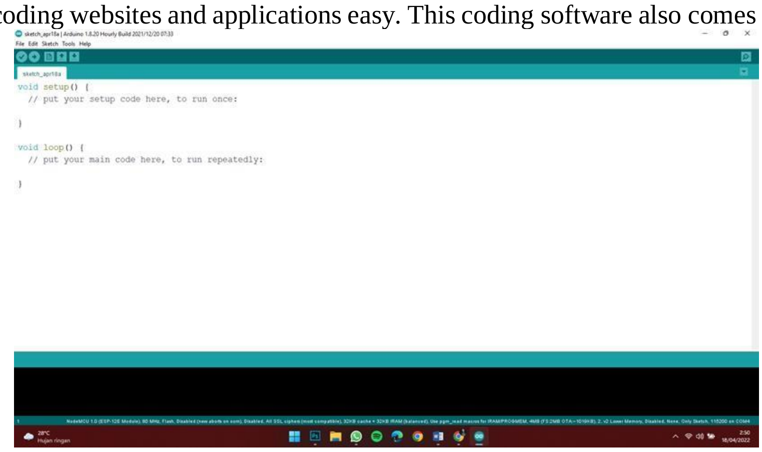

Figure 6 Initial Arduino IDE Interface

4. Results and Discussion

In this chapter, the results will be presented and a discussion regarding whether the tools that have been designed can work and run according to the expected results. The tests that will be carried out are related to hardware testing and software testing.

4.1. Hardware Testing

Hardware testing needs to be carried out so that you can find out if the components used are functioning properly. The testing method is to connect all components and send the program code from the Arduino IDE software to the ESP8266 microcontroller.

4.2. Hardware Prototype Design Results

The results of the hardware prototype design were based on a series of hardware designs, which used 3 sensors, namely the Soil Moisture Sensor on pin A0, the Raindrop Sensor on pin D2 and the Pump Relay on pin D3.

4.3. Program Code

In the program code, the first thing to be written is the library call

<ESP8266WiFi.h> which functions to activate the ESP32 Microcontroller communication with Wifi so that it can connect wirelessly, the <Wire.h> library which functions to activate I2C serial communication on the ESP32, <DHT.h> functions as a receiver for the input value received from the sensor humidity and Temperature DHT11

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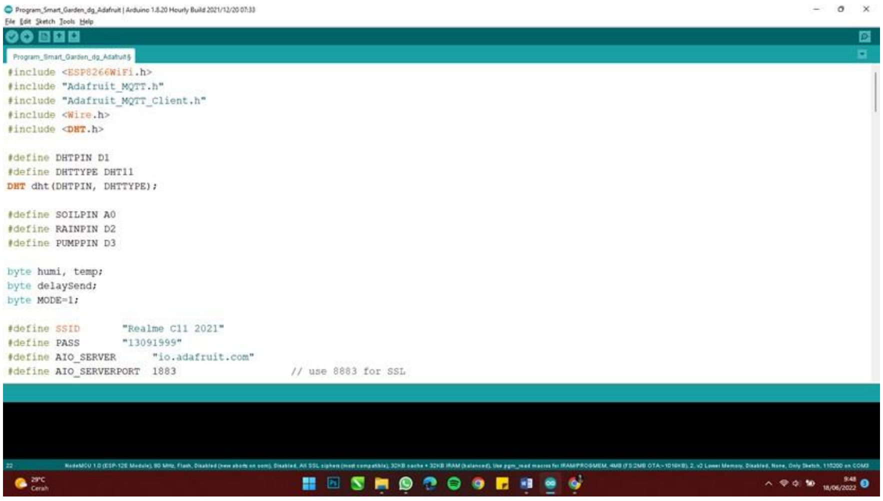

Figure 7 Arduino IDE Library

Next, the #define command is used to define program commands from the Arduino to the MQTT server, for example #define SSID which functions to define the SSID of the Wifi that will be used to connect to the server, then #define PASS which will be used to enter the password for the SSID of the Wifi. is used, then the #define AIO_SERVERPORT command to define the Port to communicate with the MQTT server, then the #define AIO_USERNAME and #define AIO_KEY commands are commands for logging in to the Adafruit.io Web Application which can be obtained when creating an Adafruit account.

Figure 8 Arduino IDE Define command

Next, the Adafruit_MQTT command is to connect the Arduino IDE with the feeds on the Adafruit IO, for example "Adafruit_MQTT_Publish TEMP = Adafruit_MQTT_Publish(&mqtt, AIO_USERNAME "/feeds/Temperature")" the following command is used to read the temperature sensor on the DHT11, then "Adafruit_MQTT_Publish HUMI = Adafruit_MQTT_Publish(&mqtt , AIO_USERNAME "/feeds/Humidity");" The following command is used to read the humidity sensor, ultimately all of the following commands will be sent to the Adafruit interface.

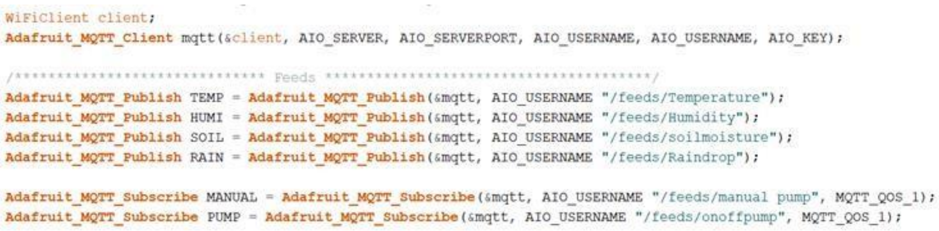

Figure 9 Arduino IDE Adafruit commands on MQTT Server

Next is void setup which contains function calls which will later be displayed via Adafruit, and the following command is to set the On and Off mode for the pump which will later regulate the exit and stopping of water via the Adafruit interface.

```
void onoffMANUAL(char *data, uint16_t len) {
  String message = String(data);
  message.trim();
  if (message == "ON") {MODE=2;Serial.println("MODE: 2");}
  if (message == "OFF") {MODE=1;Serial.println("MODE: 1");}
}

void onoffPUMP(char *data, uint16_t len) {
  Serial.print("PUMP: ");
  Serial.println(data);
  String message = String(data);
  message.trim();
  if (message == "ON" && MODE==2) {digitalWrite(PUMPPIN, LOW);}
  if (message == "OFF" && MODE==2) {digitalWrite(PUMPPIN, HIGH);}
}
```

Figure 10 Arduino IDE Adafruit Pump On/Off command

Next is a void loop which contains function calls which will later be displayed via Adafruit, and the following commands are for measuring and reading the humidity sensor (Soil Moisture Sensor) and temperature (DHT 11 Sensor).

```
void loop() {
  MQTT_connect();
  humi = dht.readHumidity();
  temp = dht.readTemperature();
  if (isnan(humi) || isnan(temp)) {
    Serial.println("DHT22 tidak terbaca... !");
    return;
  }

  word soilMoisture=analogRead(SOILPIN);
  soilMoisture=map(soilMoisture, 0, 1023, 100, 0);

  if(MODE==1){
    if(soilMoisture<25 && digitalRead(RAINPIN)==1){
      digitalWrite(PUMPPIN, LOW);
    }
    else {
      digitalWrite(PUMPPIN, HIGH);
    }
```

Figure 11 Arduino IDE Void Loop Humidity and Soil Moisture Sensor

4.4. Hardware testing results

In the design, the first test carried out is whether or not the sensor used can read temperature, soil moisture and weather conditions.

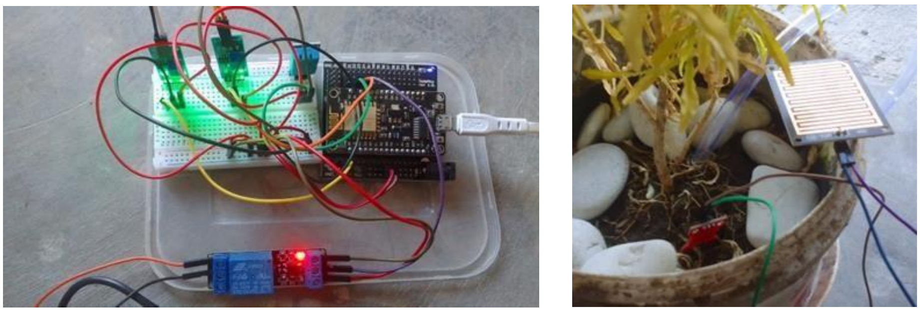

Figure 12 Temperature Sensor, Soil Moisture Sensor, and Rain Sensor The following is the Interface from Adafruit which displays the detection of the Temperature Sensor, Sensor Soil Moisture, and Rain Sensor

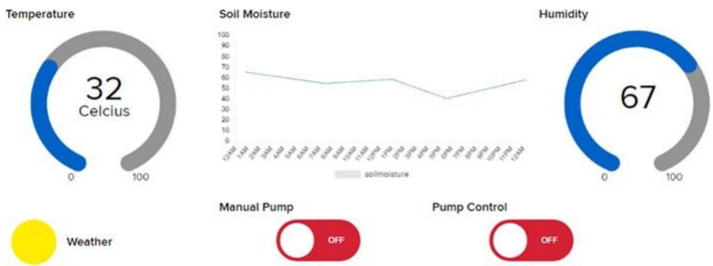

Figure 13 Detection of Temperature Sensor, Soil Moisture Sensor, and Rain Sensor. Seen in Figure 13, the sensor successfully detected temperature (32 degrees Celsius), Humidity and weather conditions (not raining), and also the pump automatic sensor is in OFF condition

4.5. Software Testing

Software testing is also almost the same as hardware testing, namely by finding out whether the hardware mechanism can work according to the input commands from the software and display the sensors correctly.

4.6. Software Design Results

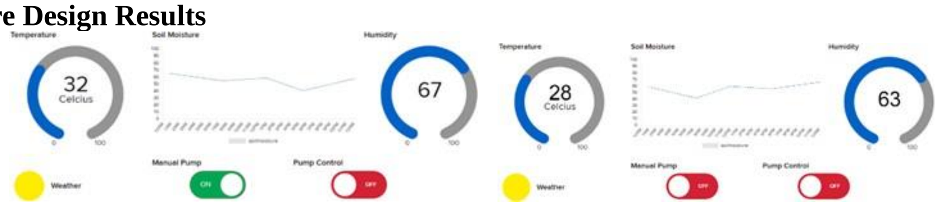

Figure 15 Conditions when the pump is ON

As seen in Figure 15, when the pump is ON, the pump will turn on and water the plants, then the display on the interface also shows numbers according to those detected by the Soil Moisture sensor, Temperature Sensor and Rain Sensor. Here are some Prototype tests.

Pengujian	Soil Moisture	Raindrop	Temp.	RH	Manual Pump	Pump On/OFF	Pompa Menyala
Pertama	20	Kuning	32	58	OFF	OFF	YA
Kedua	20	Kuning	31	59	ON	OFF	TIDAK
Ketiga	70	Kuning	32	60	OFF	ON	Throttle
Keempat	70	Biru	32	62	ON	ON	YA
Kelima	80	Biru	31	62	OFF	OFF	TIDAK
Keenam	85	Biru	31	62	ON	OFF	TIDAK

Figure 16 Test Results

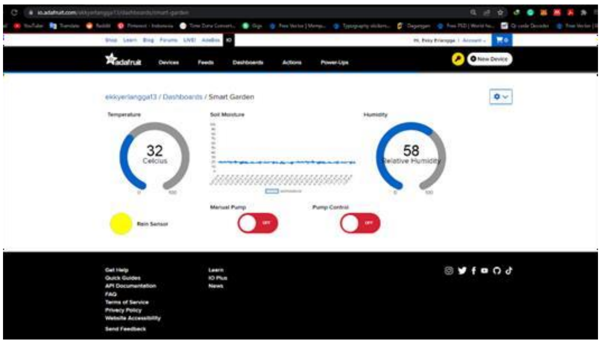

Figure 17 Test image 1

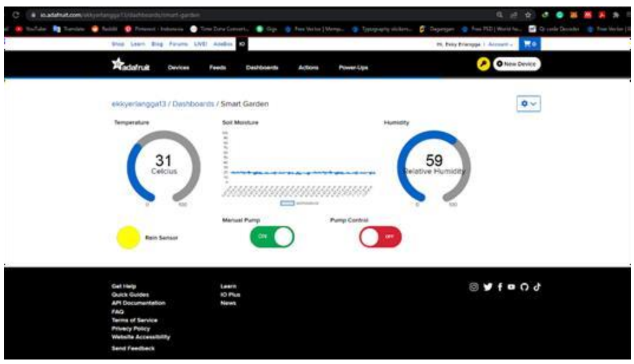

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Figure 18 Test Image 2

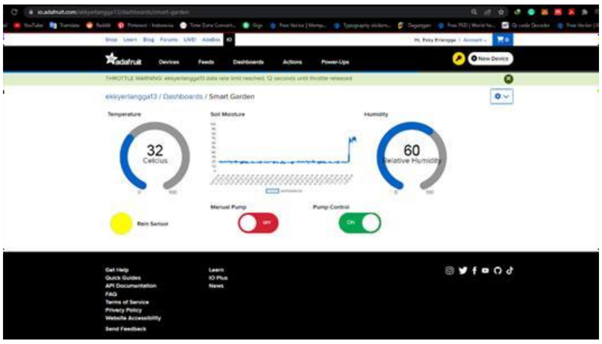

Figure 19 Test Image 3

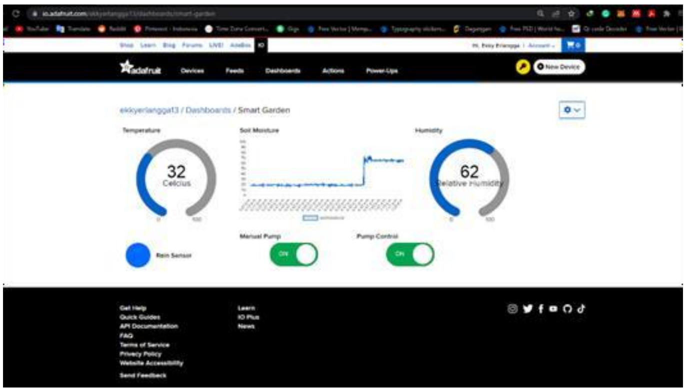

Figure 20 Test Image 4

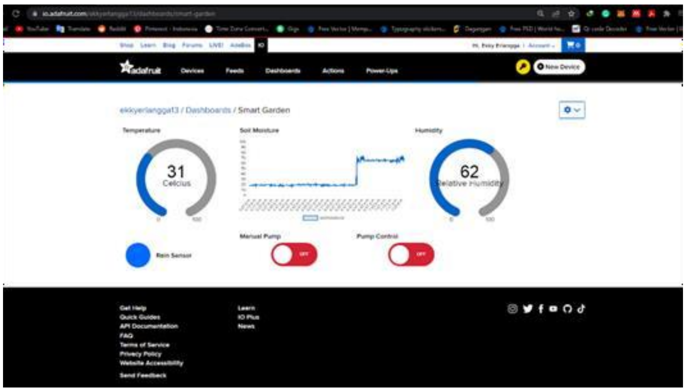

Figure 21 Test Image 5

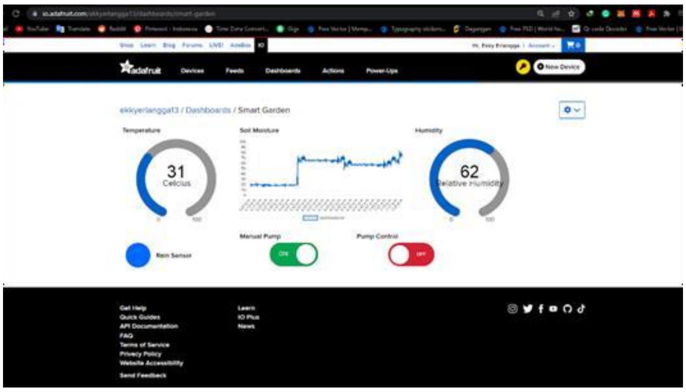

Figure 22 Test Image 6

5. Discussion

After testing both in terms of hardware and software, everything can work as expected. So it can be said that the IoT Smart Garden Prototype with Soil Temperature and Humidity Monitoring can run well. With a very simple application interface, it will certainly make it very easy for users to monitor soil temperature and humidity.

There were several errors during the experimental process, where the sensor numbers displayed in the application did not change. This is caused by various factors including poor internet connection, poorly manufactured sensors, and sometimes problems with the Dupont cable, or often there are problems with the MQTT data processing server.

During the analysis phase of research, when the study is evaluated in terms of its strengths and weaknesses. All kinds of benefits for writers and readers are taken into account. It is hoped that any shortcomings in this research will give rise to ideas for creating better research.

6. Conclusion

Based on the results of research and system design, the following conclusions can be drawn:

1. On the hardware side, the appearance of the Raindrop Sensor sometimes still cannot detect rain properly
2. The pump can work properly according to the Arduino program commands and also the application
3. This IoT Smart Garden must require an internet connection to still be able to run the application
4. Sensor readings sometimes experience interference

6.1. Suggestion

The author realizes that the design of the IoT Smart Garden with Soil Temperature and Humidity Monitoring that has been designed is still not, in fact, far from perfect. Therefore, there are several suggestions that can be used for further research, perhaps to be able to develop some of the concepts of IoT Smart Garden, it can be further expanded and especially for application software, maybe it can be developed and much better, then the prototype results can be better and neater.

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