Faculty of Electrical Technology and Engineering

THE DEVELOPMENT OF IOT-BASED SHIITAKE MUSHROOM SMART FARMING SYSTEM USING ARDUINO

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Bachelor of Electronics Engineering Technology (Industrial Automation and Robotics) with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
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DEDICATION

This project's success owes everything to your unwavering love, guidance, and support. To my dearest mother, your constant encouragement fueled my determination. To my friends, your camaraderie and assistance were the pillars of this achievement. With heartfelt appreciation, this accomplishment stands as a tribute to your invaluable presence in my life.

ABSTRACT

This project describes the creation of an Arduino-based Internet of Things (IoT) smart farming system for the growing of shiitake mushrooms. The system makes use of several sensors to keep track of the environmental factors, such as temperature, humidity, water pH, and substrate moisture, that are essential for the growth of shiitake mushrooms. The current state of monitoring and managing environmental factors for shiitake mushroom cultivation lacks automation, resulting in inefficiencies, time-consuming tasks, and inconsistent growing conditions. Without a centralized system for data collection and analysis, it becomes challenging to maintain ideal conditions consistently. Therefore, there is a pressing need for a reliable and autonomous system that can control the water supply to the substrate based on moisture levels and continuously monitor temperature, humidity, water pH and substrate moisture level. This system would ensure optimal growth conditions for shiitake mushrooms, streamlining the cultivation process and maximizing efficiency. The scope of this project is The smart watering system is developed on the Arduino board with the water pH sensor, temperature sensor, substrate moisture sensor and air humidity sensor connected. The sensors are then programmed using C++ assembly language to detect the substrate moisture level, temperature level, air humidity, water pH level and control the water flow to the watering. Next is, the IoT based automatic smart farming system is designed and created using Blynk software and last but not least is obtain the result of the smart farming system from the project developed and early out analysis of the system. Microcontrollers built on the Arduino platform are used to interpret and analyse the sensor data and provide real-time feedback on the ideal growing conditions needed to produce shiitake mushrooms. The created smart farming system can automate the environmental control of the mushroom farm for shiitakes, allowing for consistent, ideal growth conditions that increase yields and lower labour expenses. To keep farmers informed of any changes in environmental circumstances that can have an impact on the growth of the mushrooms, the system also sends warnings and messages to them. In conclusion, the Internet of Things (IoT)-based smart farming system for shiitake mushroom production using Arduino presented in this research illustrates the potential for modern technology to improve conventional agricultural practises, leading to more effective, sustainable, and lucrative farming.

ABSTRAK

Projek ini menggambarkan penciptaan sistem pertanian pintar berdasarkan Arduino berdasarkan Internet of Things (IoT) untuk penanaman cendawan shiitake. Sistem ini menggunakan beberapa sensor untuk memantau faktor-faktor lingkungan seperti suhu, kelembapan udara, pH air, dan kelembapan substrat yang penting untuk pertumbuhan cendawan shiitake. Keadaan semasa pemantauan dan pengurusan faktor-faktor lingkungan bagi penanaman cendawan shiitake kurang terautomasi, mengakibatkan ketidakefisienan, tugas yang memakan masa, dan keadaan pertumbuhan yang tidak konsisten. Tanpa sistem terpusat untuk pengumpulan dan analisis data, menjadi mencabar untuk mengekalkan keadaan ideal secara konsisten. Oleh itu, terdapat keperluan mendesak untuk sistem yang boleh dipercayai dan autonomus yang dapat mengawal bekalan air ke substrat berdasarkan tahap kelembapan dan terus memantau suhu, kelembapan, pH air, dan tahap kelembapan substrat. Sistem ini akan memastikan keadaan pertumbuhan optimum bagi cendawan shiitake, menyederhanakan proses penanaman dan memaksimumkan kecekapan. Skop projek ini adalah sistem penyiraman pintar yang dibangunkan pada papan Arduino dengan pengesan pH air, pengesan suhu, pengesan kelembapan substrat, dan pengesan kelembapan udara yang disambungkan. Sensor-sensor itu kemudian diprogram menggunakan bahasa pengaturcaraan C++ untuk mengesan tahap kelembapan substrat, tahap suhu, kelembapan udara, tahap pH air, dan mengawal aliran air ke penyiraman. Seterusnya, sistem pertanian pintar berdasarkan IoT direka dan dicipta menggunakan perisian Blynk dan yang terakhir adalah mendapatkan hasil sistem pertanian pintar daripada projek yang dibangunkan dan menganalisis awal sistem tersebut. Mikropengawal yang dibina di atas platform Arduino digunakan untuk menafsirkan dan menganalisis data sensor serta memberikan maklum balas secara langsung mengenai keadaan pertumbuhan ideal yang diperlukan untuk menghasilkan cendawan shiitake. Sistem pertanian pintar yang dicipta dapat mengautomasikan kawalan persekitaran ladang cendawan untuk shiitake, membolehkan keadaan pertumbuhan yang konsisten dan ideal yang meningkatkan hasil dan mengurangkan kos tenaga kerja. Untuk memastikan petani diberitahu mengenai sebarang perubahan dalam keadaan alam sekitar yang boleh mempengaruhi pertumbuhan cendawan, sistem ini juga menghantar amaran dan mesej kepada mereka. Kesimpulannya, sistem pertanian pintar berdasarkan Internet of Things (IoT) untuk pengeluaran cendawan shiitake menggunakan Arduino yang

dibentangkan dalam penyelidikan ini menggambarkan potensi teknologi moden untuk meningkatkan amalan pertanian konvensional, menghasilkan pertanian yang lebih efektif, mampan, dan menguntungkan.

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CHAPTER 1

INTRODUCTION

1.1 Background

An increasingly common strategy to increase the effectiveness and productivity of agricultural practices is known as "smart farming." There has been an increase in interest of using the Internet of Things (IoT) in farming operations since its inception. In this capstone project, we investigate the creation of an IoT-based smart farming system using Arduino to produce shiitake mushrooms. In this project, synthetic bag log cultivation will be used. Shiitake mushroom farming is a common agricultural practice, and because of their medicinal and nutritional benefits, shiitake mushroom demand has been rising significantly in recent years. Utilizing IoT and Arduino, two smart farming technologies, can help to improve and optimize the cultivation process. For this project, an automated system for smart farming is to be created that can track and regulate the environmental conditions necessary for the growth of shiitake mushrooms. To maintain ideal growing circumstances, the system will use sensors to measure parameters such farm temperature, air humidity, water pH, and substrate moisture. The system will then be built to autonomously alter these parameters. The development of the smart farming system in this project is made feasible and affordable by the usage of Arduino. It offers a platform for data collection and analysis as well as interfaces with sensors and control the water pump. Finally, the goal of this senior project is to use Arduino to create an Internet of Things-based smart farming system for the growth of shiitake mushrooms. The initiative has the potential to advance both the expanding field of smart farming and the effectiveness and productivity of shiitake mushroom production.

1.2 Problem Statement

The goal of this project is to create a system that can automatically monitor and manage a shiitake mushroom farm’s environmental factor, with a particular emphasis on controlling the farm's temperature, air humidity, water pH, and substrate moisture. The objective is to develop a system that can guarantee shiitake mushrooms grow in consistent, ideal conditions, increasing yields and lowering labor costs. The system will gather information about the farm environmental conditions using a variety of sensors to accomplish this. The microcontroller will then analyze and process the data using an Arduino platform and later the farm environmental conditions can be viewed through phone. The program will have the capacity to autonomously manage a pump that controls the water supply to the substrate for mushrooms. The system can keep the substrate at the ideal moisture levels, which are necessary for shiitake mushroom growth, by changing the water supply based on the substrate moisture levels. The device will also be able to modify the farm's temperature and humidity levels. Using a pH sensor and a pH controller, it will also keep track of and modify the pH levels of the water. The overall objective is to develop an effective, automated system that can reliably offer the best growing conditions for shiitake mushrooms, resulting in increased yields and lower labor costs for farmers.

1.3 Project Objective

The main aim of this project is to propose a systematic and effective methodology to develop an Iot-based Shiitake mushroom smart farming system by using Arduino. Specifically, the objectives of the project are as follows:

a) To design and implement a system to monitor the shiitake farm's air humidity, temperature, substrate moisture and water pH to optimize the growth of shiitake mushroom.

b) To develop and integrate a system to control the pump for water optimization by with IoT application and using microcontroller.

c) To analyze the accuracy and consistency of the system in terms of results and the feedback of the system to user.

1.4 Scope of Project

The scope of this research is limited to the following items so that the research could be focused on achieving the stated objectives. To achieve that stated objectives, the work scopes are listed as below:

a) The smart watering system is developed on the Arduino board with the water pH sensor, temperature sensor, substrate moisture sensor and air humidity sensor connected. The sensors are then programmed using C++ assembly language to detect the substrate moisture level, temperature level, air humidity, water pH level and control the water flow to the watering.

b) The IoT based automatic smart farming system is designed and created using Blynk software.

c) Obtain the result of the smart farming system from the project developed and early out analysis of the system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter contains the study, literature review and discussion on related work based on IoT-based smart watering system for shiitake mushroom using Arduino. The reason why this project was chosen instead of another project is stated as well. Other than that, this chapter also includes details of hardware devices and software that are used in this project.

2.2 Shiitake Mushroom Cultivation

There are many different mushroom farming methods used around the globe. These techniques can differ substantially. Depending on the variety, mushrooms require a different set of conditions, which has a big impact on how quickly they grow. The place of production has a significant impact on the monitoring schedule for different specialty items. Periodic inspections of these things are essential[1].

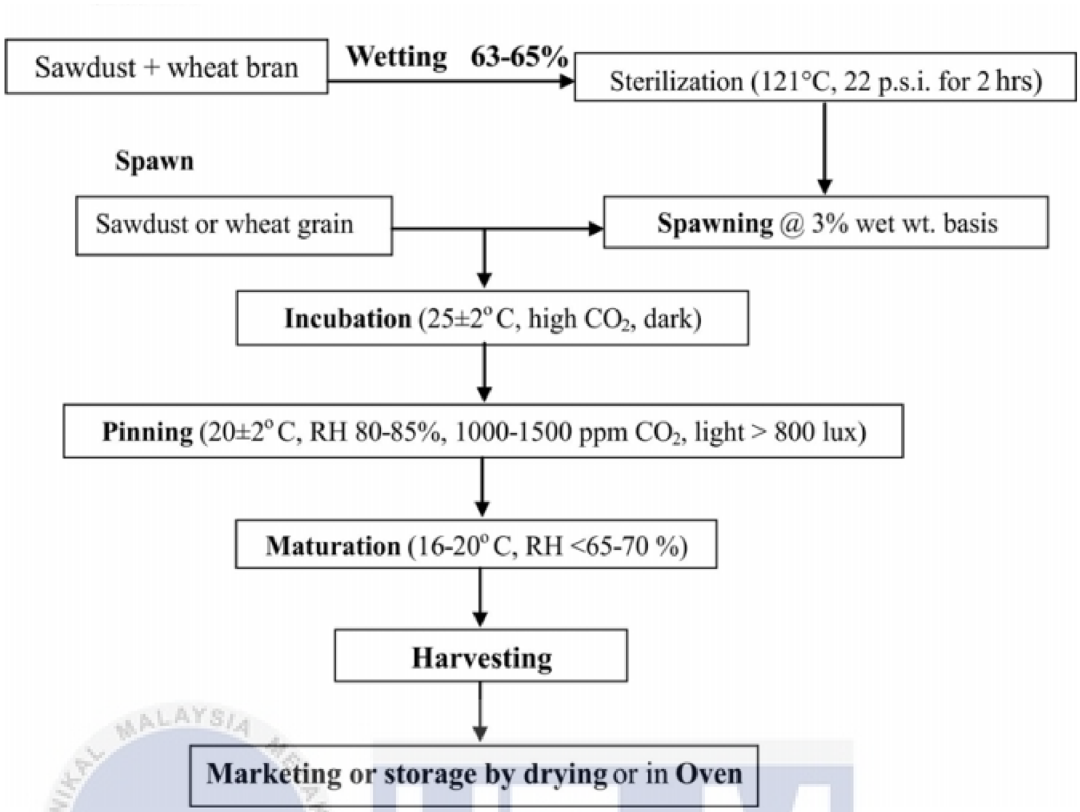

Figure 1: Systematic flow chart for cultivation of shitake mushroom

2.2.1 Substrate preparation.

Shiitake mushroom substrate and spawn are available from reputable vendors. Shiitake spawn is the substrate that has been infected with mycelium and acts as the "seed" for producing mushrooms. Substrate is the substance that gives the mycelium the nutrients it needs to flourish. The substrate use a combination of hardwood sawdust, such as oak, maple, or beech, and other additives, such as wheat bran, rice bran, and gypsum. To eliminate any competing organisms, sterilise the substrate and properly combine the ingredients. A pressure cooker or an autoclave can be used for sterilisation [2].

2.2.2 Bag Filling and Sterilization

Mix the shiitake spawn with the substrate in a clean, hygienic environment once it has cooled following sterilisation. The substrate-spawn combination should be poured into the sterile bags, giving some space for the mycelium to expand. To allow for gas exchange, seal the bags with a filter patch or a self-healing injection port.

2.2.3 Spawning

For successful mushroom production, ideal conditions are essential. It's important to keep the bag temperature at 25°C, the CO_2 content at 5000–6000 ppm, and the daily light cycle at 4-6 hours throughout the spawn run phase. While air circulation and exchange should be minimised, relative humidity plays no significant role. To avoid oversaturation and contamination, it's also not necessary to water during the spawn run.

2.2.4 Incubation

To allow the mycelium to colonise the substrate, place the inoculation bags in a spotless, warm environment. When incubating, shiitake mushrooms prefer temperatures between (21-27 °C). Depending on the strain and the surrounding environment, it could take several weeks for the mycelium to completely colonise the substrate. The strains chosen for cultivation affect the length of the spawn run. The duration varies by strain and is between 45 and 90 days.

2.2.5 Bag Conditioning

The bags must be conditioned to encourage fruiting after the mycelium has colonised the substrate. The bags can be subjected to a drop in temperature and a rise in humidity to achieve this. Moving the bags to a colder area (10-15°C) and spraying them with water to increase humidity is one typical technique.

2.2.6 Fruiting

White pinhead-sized particles will start to appear on the substrate surface after the bags have been sealed. This shows that the mushrooms are prepared to produce their fruit. Transfer the bags to an area with suitable lighting, humidity, and ventilation for fruiting. Shiitake mushrooms prefer low temperatures (16–20°C), high humidity (65–70%), and indirect lighting. Maintain these circumstances and regularly mist the bags to encourage mushroom development.

2.2.7 Harvesting

Within a few days to a couple of weeks after being pinned, shiitake mushrooms will mature and grow into full-sized mushrooms. When the caps are fully open but still firm, remove the mushrooms by gently twisting and pulling them from the substrate. When harvesting, take care not to harm the mycelium or the substrate.

2.2.8 Rest

After harvesting, allow the bags to rest for a few weeks to recover before repeating the conditioning and fruiting process. Depending on the strain and environmental conditions, the bags can produce multiple flushes of mushrooms over several months.

2.2.9 Substrate Moisture

Substrate moisture level plays a crucial role in shiitake mushroom cultivation, affecting mycelial growth, primordia formation, and fruiting body development. Maintaining optimal moisture levels throughout the cultivation process is vital for maximizing yield and quality. During the spawn run phase, a moisture level of 60-70% is ideal, while primordia formation benefits from a slightly higher level of 70-80%. For fruiting body development, maintaining a moisture level of 80-90% is recommended. These ranges provide the necessary water content for mycelial expansion, primordial initiation, and proper maturation of shiitake mushrooms[3].

2.3 IOT Based Smart Agriculture

As seen in **Figure 2**, the Internet of Things (IoT) is a clever and innovative technology that offers novel and useful solutions in a variety of fields, including smart cities, smart homes, traffic management, healthcare, smart agriculture, etc. IoT technology has significantly improved farm management in the realm of agriculture. With the use of this technology, it is now possible to connect every piece of agricultural machinery and equipment in order to decide how much fertilizer and irrigation to deliver. The accuracy and effectiveness of sensors that track plant development and even livestock production are improved by smart systems. Data from various sensing devices is collected via wireless sensor networks (WSNs). Additionally, cloud services must be incorporated with IoT in order to process and analyze remote data that supports decision-making[4]. ICT, ground sensors, and control systems mounted on robots, autonomous vehicles, and other automated devices are all necessary for smart farm management. The use of IoT real-time to track and diagnose leaf diseases that impede crop growth using numerous satellite images and sensors placed in farms (paddy and banana crops) depends on high-speed internet, cutting-edge mobile devices, and satellites to provide (images and positioning). The success of smart systems depends on these factors. through the webserver[5].

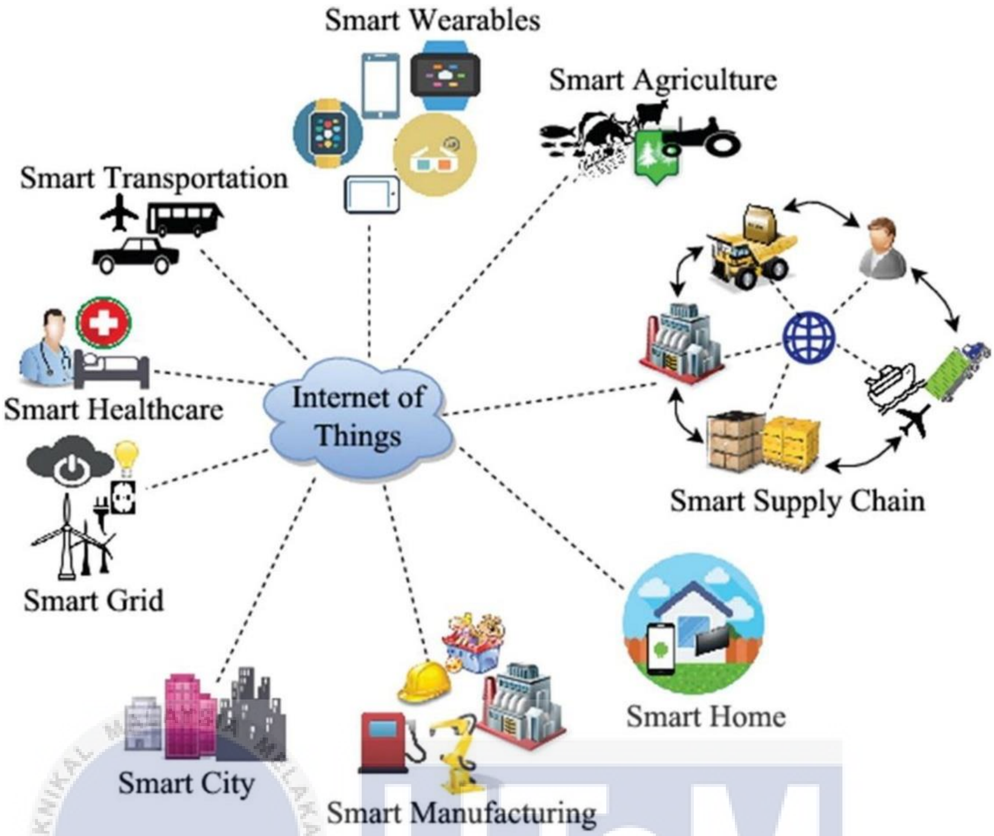

Figure 2: Application of IoT in different area

2.4 Previous Related Research Work

Before moving further with the development of IoT based on smart farming for shiitake mushrooms using Arduino, it is essential to evaluate prior research or articles. Exploring the theories and concepts that were used to address problems that might come up during the project's implementation is the major goal of reviewing prior research. These resources were chosen because they were pertinent to the goals of the study.

2.4.1 A Fuzzy Inference Model For Iot Shiitake Mushroom Farm Monitoring And Control

The journal," A Fuzzy Inference Model for Iot Shiitake Mushroom Farm Monitoring And Control" by Jean De La Croix Ntivuguruzwa[6] say that the farmer should maintain a favourable climate for shiitake mushroom farms by providing real-time surveillance of the farm's temperature, light, air movement speed, soil humidity, and insect avoidance to boost productivity. This system operates in real-time, allowing it to detect any urgent changes in the agricultural environment at any moment and prompt prompt action.

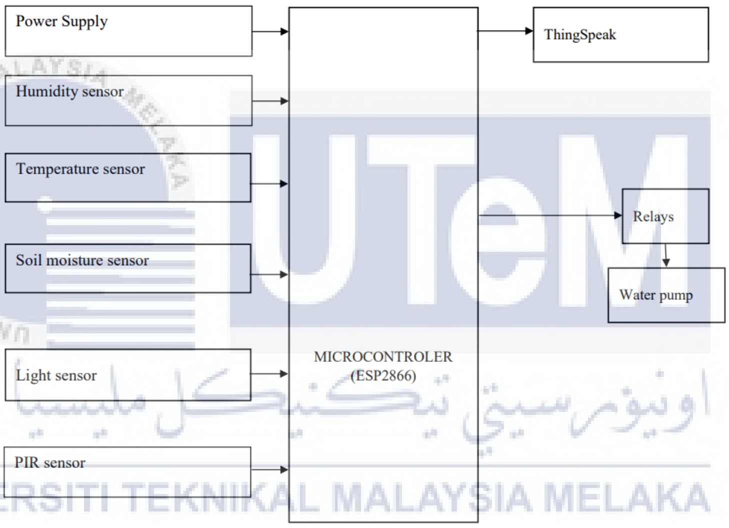

Figure 3: Components of the Proposed system

Based on **Figure 3** it illustrates the system's three primary sides, which are the sensing, controlling, and actuating sides. The sensing side includes a temperature and humidity sensor for measuring the farm's air temperature and humidity, a soil moisture sensor for measuring the moisture content of the substrate, a PIR to detect movement, and a light sensor for measuring the farm's light intensity. An actuating module is built of one 12V DC water pump and one relay so that they may be controlled by a NodeMCU ESP8266. The controlling side is composed of a NodeMCU ESP8266, Arduino UNO, and a cloud platform for data analytics. Because the NodeMCU ESP8266 microcontroller has the benefit of operating at a current of 80 mA with a quiescent current of 5 to 11 mA delivered from power dissipation by its printed circuit.

2.4.2 IoT Based Design Implementation Of Mushroom Farm Monitoring Using Arduino Microcontrollers & Sensors

In their study titled "IoT based design implementation of mushroom farm monitoring using arduino microcontrollers & sensors," Parvati Bhandari and Megha Kimothi[7] argue that in order to maintain ecologically friendly circumstances in a mushroom farm, they had to create a system that is indisputably an environmental monitoring and management system. Users are able to control the temperature and humidity, atmospheric pressure, carbon dioxide fractional laser concentration level, and air quality in a very mushroom farm using an Android smartphone by using the Thing Speak internet platform. Based on sensor data, the control algorithm may run equipment autonomously in a mushroom farm to keep the environment optimal for mushroom growth.

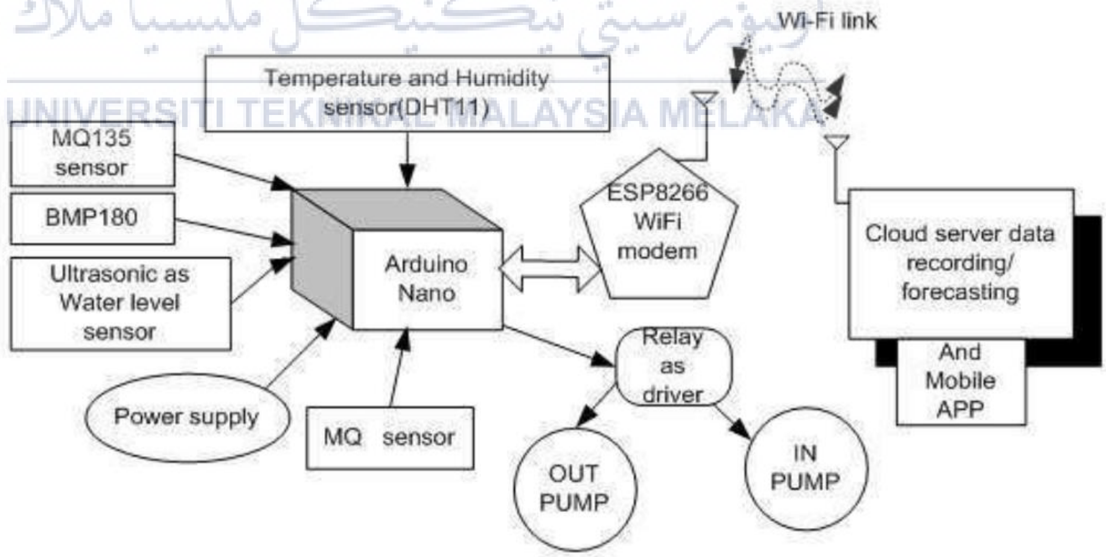

Figure 4: Block diagram of the proposed Work

Figure 4 shows the block diagram of automatic monitoring and controlling system-using internet of things (IoT) for mushroom plant. By writing the necessary code in the

Arduino IDE, an Arduino Nano can sense the temperature, humidity, MQ3 (a gas sensor) replaced by MQ6 Gas Sensors, MQ135 (air quality), BMP180 (air pressure and attitude), and water level. The water pump will turn on and off depending on the water level. Additional data packets will be transmitted to the ESP8266 Wi-Fi modem to reach the cloud. Online data forecasting will be possible thanks to cloud servers and mobile applications.

2.4.3 Solar-Powered Multi-Network Greenhouse: Automated Mushroom Monitoring and Management System Using Microcontrollers and IoT-Based Applications

According Jilven D. Albius, Rica Lorraine B. De La Cruz, John Bert Ivan Gumandoy, William Daryll D. Ofrin & Engr. Paul Enrico F. Puyo in article on" Solar-Powered Multi-Network Greenhouse: Automated Mushroom Monitoring and Management System Using Microcontrollers and IoT-Based Applications"[8]. A protected indoor space called a greenhouse is used to develop and grow plants. Since it offers a microclimate that is much simpler to manage, the mushrooms in the greenhouse are highly cultivated and productively maximized in the agricultural field. To get good results in terms of agricultural output, various important criteria need to be monitored at a greenhouse, according to the same framework. The temperature and humidity, which are frequently assessed physically and manually, are two of these characteristics. Many academics have made numerous attempts to automate and modernize the conventional greenhouse system. To maintain ideal conditions, an embedded system continuously analyses the microclimatic parameters of a greenhouse and activates actuators when safe limits are exceeded.

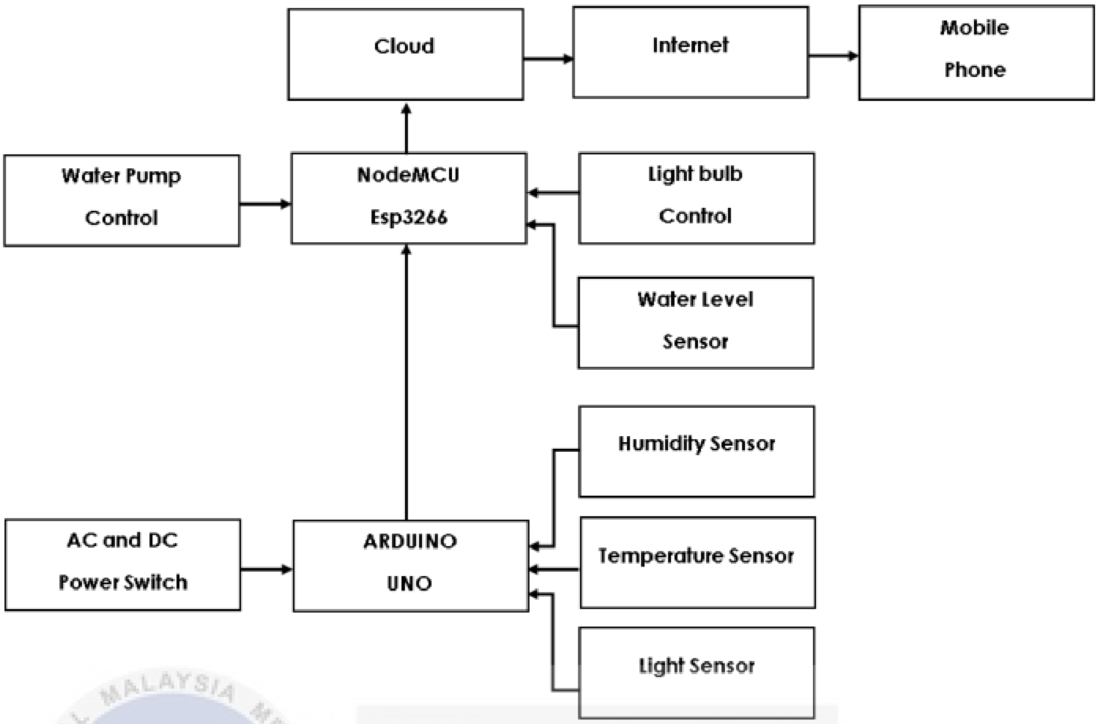

Figure 5: Block Diagram of the flow of inputs and outputs

The **Figure 5** block diagram shows the flow of inputs and outputs of the components of the device. The line arrow pointing inwards to the component is the input while the line arrow pointing outwards to the component is the output.

2.4.4 Intelligent Control of Mushroom Growing Conditions Using an Electronic System for Monitoring and Maintaining Environmental Parameters

According to Žydrunas Kavaliauskas, Igor Šajev, Giedrius Gecevi˘cius and Vytautas ¯ Capas in their article about "Intelligent Control of Mushroom Growing Conditions Using an Electronic System for Monitoring and Maintaining Environmental Parameters" [9] argues that varied technology solutions built on creativity are required to handle today's concerns. One of these industries that need innovative methods for growing and keeping track of environmental conditions is the manufacturing of a variety of edible mushrooms. Mushrooms are cultivated industrially in a variety of places (greenhouses, hangars, etc.) where it is technically and technologically practicable to guarantee the essential conditions for the growing process. In order to optimize the mushroom growth process, it is crucial to provide both observation and monitoring of indoor environmental factors as well as environmental parameter management.

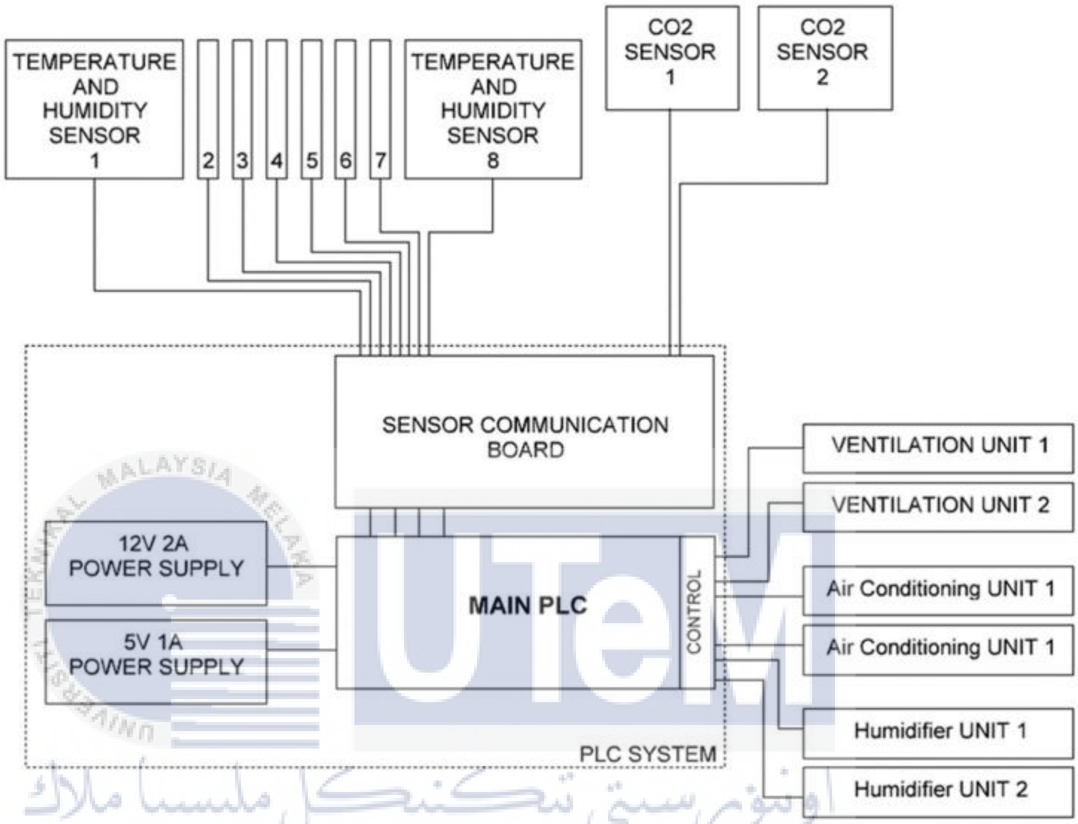

Figure 6: Block diagram automatic control system of environmental parameters

Based on **Figure 6**, a PIC microcontroller-based electronic system was created to monitor and regulate the environmental factors and growth conditions of the mushroom growing room. Humidity, CO2 level, and ambient temperature are the growing environment characteristics that are monitored and managed. The facility for growing mushrooms included 2 rooms with 4 temperature and humidity measurement modules (sensors) and 1 CO2 level measurement module (sensor) set up in them. To manage the climate, air conditioner, recuperator, and humidifier equipment are used. With the aid of a microcontroller (PIC18F25K83), these units are controlled to maintain ambient parameters while taking into consideration data from sensors in the room and the algorithm for mushroom growing.

2.5 Previous Related Research Work

After reviewing previous researcher works, the microcontroller used, the variables measured and the monitoring device in each of the researcher's work is organized.

Table 1: Comparisons of Previous Research

o.	A uthor	ear	Title	Variabl e	Co ntroller	Mo nitoring Device	Clo ud Platform
	Je an De La Croix Ntivuguru zwa	021	A Fuzzy Inference Model for Iot Shiitake Mushroom Farm Monitoring and Control	• Air Humidity • Temperature • Soil Moisture • Light • Motion	No deMCU ESP8266	Pho ne	Thi ngSpeak
	Pa rvati Bhandari & Megha Kimothi	018	Iot Based Design Implementatio nOf Mushroom Farm Monitoring Using Arduino	• Temperature • Air humidity • Water level • Air Quality • Carbon dioxide level	Ard uino Uno	Co mputer	Thi nkSpeak

			Microcontrollers & Sensors	• Air pressure • Altitude • Water pH			
	Jilven D. Albius, Rica Lorraine B. De La Cruz, John Bert Ivan Gumandoy, William Daryll D. Ofrin & Engr. Paul Enrico F. Puyo		Solar-Powered Multi-Network Greenhouse: Automated Mushroom Monitoring and Management System Using Microcontrollers and IoT-Based Applications	• Air humidity • Temperature • Light • Water level	Arduino Uno & Node MCU 8266	Phone	Blynk

4	Zydrunas Kavaliauskas, Igor Sajev, Giedrius Geceviˇcius and Vytautas Capas	022	Intelligent Control of Mushroom Growing Conditions Using an Electronic System for Monitoring and Maintaining Environmental Parameters	• Temperature • Air humidity • Carbon dioxide level	PIC 18F25K83	Computer	-

Based on **Table 1**, the air humidity value and farm temperature are measured in all four projects' research. Meaning to say these two become the easiest thing to control to maximize the harvest of shiitake mushrooms. The PIC18F25K83 and NodeMCU are more expensive options because of their more sophisticated features and capabilities, while the Arduino Uno is the most economical choice. ThingSpeak and Blynk are the cloud platforms used in this project. Blynk is more suitable for creating IoT applications that can communicate with the actual world, whereas ThingSpeak is better suited for tasks that call for data logging, visualization and analyzing. The decision between them is based on the needs of project.

2.6 Comparison Between Arduino Uno, NodeMCU 8266 and PIC18F25K83

Table 2: Comparisons between Arduino Uno, Node MCU and PIC18F25K83

Microcontroller	UNO	Node MCU	PIC18F25K83
Processor	Atmega328P	ESP8266	PIC18F
Flash Memory (kB)	32	4000	32
EEPROM (kB)	1	4	1
(SRAM) (kB)	2	64	2
Digital I/O Pins	14	16	36
Digital I/O with PWM Pins	6	16	4
Analog Pins	6	16	16

As seen in **Table 2** the Arduino Uno has 32 KB of flash memory and 2 KB of SRAM, the NodeMCU has 4 MB of flash memory and 64 KB of SRAM, while the PIC18F25K83 has 32 KB of flash memory and 2 KB of SRAM. This means that the NodeMCU can handle more complex projects that require more memory. The compatibility of Arduino Uno with various sensors, actuators, and components makes it a versatile platform for building a variety of projects, and the large library of code and examples available makes customization easy[10]. the choice between Arduino Uno, NodeMCU, and PIC18F25K83 depends on the specific requirements of your project. The Arduino Uno is a simple and affordable board suitable for basic projects[11], the NodeMCU is ideal for IoT projects that require internet connectivity, while the PIC18F25K83 is a powerful microcontroller board suitable for more advanced projects that require advanced communication protocols. The pin header configuration of the Arduino UNO is indeed swiftly becoming the norm for development boards. Most available development board shields are compatible with Arduino Uno thanks to this pin header[12].

2.7 Comparison Between Blynk, ThingSpeak

Table 3: Comparison Between Blynk and ThingSpeak

Difference	Blynk	ThingSpeak
Functionality	Focused on building IoT applications that can interact with the physical world through various sensors and actuators	Focused on data logging, visualization and analyzing.
Features	Offers a wide range of widgets that can be used to build mobile applications that can control and monitor IoT devices	Provides a set of APIs and tools for logging and visualizing data from sensors,
User Interface	Has a mobile app-based user interface that allows users to control and monitor IoT devices from their mobile devices.	Has a web-based user interface that allows users to create visualizations and dashboards for their data
Integration	Can be integrated with other IoT platforms such as Arduino and Raspberry Pi.	Can be integrated with other platforms and services such as MATLAB and IFTTT.

Blynk is a mobile application that enables users to remotely control Arduino, Raspberry Pi, and NodeMCU devices via their iOS or Android smartphones through the internet as an IoT platform[13]. Blynk and ThingSpeak serve different purposes in the IoT ecosystem. Blynk offers a mobile app interface to control and monitor connected devices, making it the perfect platform for IoT projects that need real-time control and monitoring of devices. ThingSpeak, on the other hand, is more effective in gathering and analysing data from connected devices[14]. As a result, Blynk is more suited for tasks that demand real-time control while ThingSpeak is more appropriate for gathering and analysing data. Blynk is chosen for the project because it enables users to access information and monitor water pH, air humidity, temperature, and substrate moisture of the shiitake mushroom with the swipe of a finger, whenever they like and from wherever they are.

2.8 Comparison Between ESP8266 and ESP32

Table 4: Comparison Between ESP8266 and ESP32

Parameter	ESP8266	ESP32
Microcontroller	Tensilica L106 32-bit RISC	Xtensa LX6 32-bit dual-core LX6
CPU Frequency	Up to 160 MHz	Up to 240 MHz
Wi-Fi Connectivity	802.11 b/g/n	802.11 b/g/n (ESP32-WROOM), 802.11 a/b/g/n/ac (ESP32-WROVER)
Bluetooth Connectivity	No	Bluetooth 4.2 and BLE (Bluetooth Low Energy)
Additional Interfaces	None	UART, SPI, I2C, I2S, CAN, Ethernet, SD/MMC, GPIO, etc.
RAM	Up to 160 KB SRAM	520 KB SRAM
Flash Memory	Up to 16 MB Flash	4 MB Flash
Operating Voltage	3.3V	3.3V
GPIO Pins	Up to 17 GPIO pins	Up to 36 GPIO pins
ADC Channels	1	18 (12-bit SAR ADC)
Touch Sensor Channels	None	Up to 10
Power Consumption	Varies depending on usage	Varies depending on usage
Development Framework	Arduino, Espressif SDK	Arduino, Espressif SDK
Price	Generally lower cost than ESP32	Generally higher cost than ESP8266

Based on **Table 4** the ESP8266 is a preferred choice over the ESP32 due to its low cost, as indicated in the comparison table. It offers a cost-effective solution for projects with budget constraints. Additionally, the ESP8266 supports communication with Blynk, a popular IoT platform, enabling seamless integration and control of IoT devices. Its affordability, along with Blynk compatibility, makes the ESP8266 an appealing option for cost-conscious projects seeking easy connectivity and remote control capabilities[14].

2.9 Comparison Between DHT11 and DHT22

Table 5: Comparison Between DHT11 and DHT22

Parameter	DHT11	DHT22 (AM2302)
Description	Low-cost digital sensor	Upgraded version with higher accuracy and wider measurement range
Measurement Range	Temperature: 0°C to 50°C	Temperature: -40°C to 80°C
Humidity: 20% to 90%	Humidity: 0% to 100%	
Accuracy	Temperature: ±2°C	Temperature: ±0.5°C
Humidity: ±5%	Humidity: ±2-5%	
Power Consumption	Low	Low

Based on **Table 5** The DHT11 is a compelling option when considering low cost, size, and power consumption factors. Its lower price compared to the DHT22 makes it an attractive choice for projects with budget constraints. Additionally, the DHT11's smaller size allows for seamless integration in space-limited designs, making it ideal for compact IoT applications. Furthermore, the DHT11 has a lower power consumption, which is advantageous for battery-powered or energy-efficient devices, extending their operational lifespan. Although the DHT11 may sacrifice some accuracy and a narrower measurement range compared to the DHT22, its cost-effectiveness, compact form factor, and power efficiency make it a suitable choice for various applications where precision requirements are less critical[15].

2.10 Comparison Between Capacitance Sensor and Resistive Sensor

Table 6: Comparison Between Capacitance Sensor and Resistive Sensor

Parameter	Capacitance Sensor	Resistive Sensor
Measurement Principle	Capacitive	Resistive
Sensing Method	Measures changes in electrical capacitance	Measures changes in electrical resistance
Sensing Material	Dielectric material (e.g., ceramic, polymer)	Conductive material (e.g., gypsum, granular matrix)
Measurement Range	Typically wider range	Generally limited range
Sensitivity	Highly sensitive to small changes in capacitance	Moderate sensitivity to changes in resistance
Environmental Effects	Less affected by environmental factors	Affected by environmental factors (e.g., temperature, humidity)
Calibration	Requires calibration for accurate measurements	May require calibration for accurate measurements
Response Time	Generally fast response time	Response time can vary
Cost	Can be relatively higher cost depending on design	Often lower cost compared to capacitance sensors

Based on **Table 6** opting for a Resistive Sensor over a Capacitance Sensor is beneficial for cost-conscious applications, as indicated in the table. Resistive Sensors tend to be more affordable, making them a cost-effective choice. Additionally, they offer advantages such as wider compatibility, simplicity in design, and suitability for various resistive-based applications. When cost is a significant consideration and specific resistive-based sensing requirements are met, Resistive Sensors provide a compelling option[16].

2.11 Comparison Between Glass Electrode pH Sensor and Solid-State pH Sensor

Table 7: Comparison Between Glass Electrode pH Sensor and Solid-State pH Sensor

Parameter	Glass Electrode pH Sensor	Solid-State pH Sensor
Measurement Principle	Ion-selective glass membrane	Solid-state materials (e.g., field-effect transistors)
pH Range	Wide range, typically 0-14	Wide range, typically 0-14
Sensing Method	pH-dependent potential difference	pH-dependent electrical properties
Sensing Material	Glass membrane coated with pH-sensitive material	Solid-state ion-sensitive materials or field-effect transistors
Calibration	Requires periodic calibration	May require periodic calibration
Maintenance	Requires regular cleaning and maintenance	Generally low maintenance
Response Time	Relatively slower response time	Generally faster response time
Temperature Dependency	Some temperature dependency in readings	Varies depending on the specific solid-state material used
Robustness	Sensitive to physical damage and harsh environments	More robust and resistant to physical damage
Compatibility	Compatible with a wide range of samples and environments	Can be more specific to certain applications
Cost	Generally lower cost	Can be higher cost depending on the specific implementation

Based on **Table 7** choosing a Glass Electrode pH Sensor or a Solid-State pH Sensor over a Capacitance Sensor is advantageous considering the factors mentioned in the table. Both glass electrode and solid-state sensors offer distinct benefits in terms of accuracy, wider pH range, and specific pH-dependent properties. While capacitance sensors may be cost-effective, glass electrode and solid-state sensors provide more precise pH measurements, making them suitable for applications where accuracy is paramount[17].

2.12 Summary

The project's information, based on the theories and work of earlier researchers revealed information on the methods those researchers used. As a result, comparisons are drawn between the microcontrollers that were utilized, the variables that were monitored, and the monitoring devices and the sensor that will be used to draw attention to the similarities and differences between the methods employed by prior researchers. The project's methodology will be covered in the next chapter.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The project titled "The Development of Iot-Based Shiitake Mushroom Smart Farming System Using Arduino" will be explained in detail in this chapter. The report thoroughly outlines the techniques utilized to obtain the data as well as the materials employed in the project. Diagrams are used to explain the technique, which comprises the phases of researching, observing, analyzing, and developing, making it simple to comprehend.

3.2 Project Overview

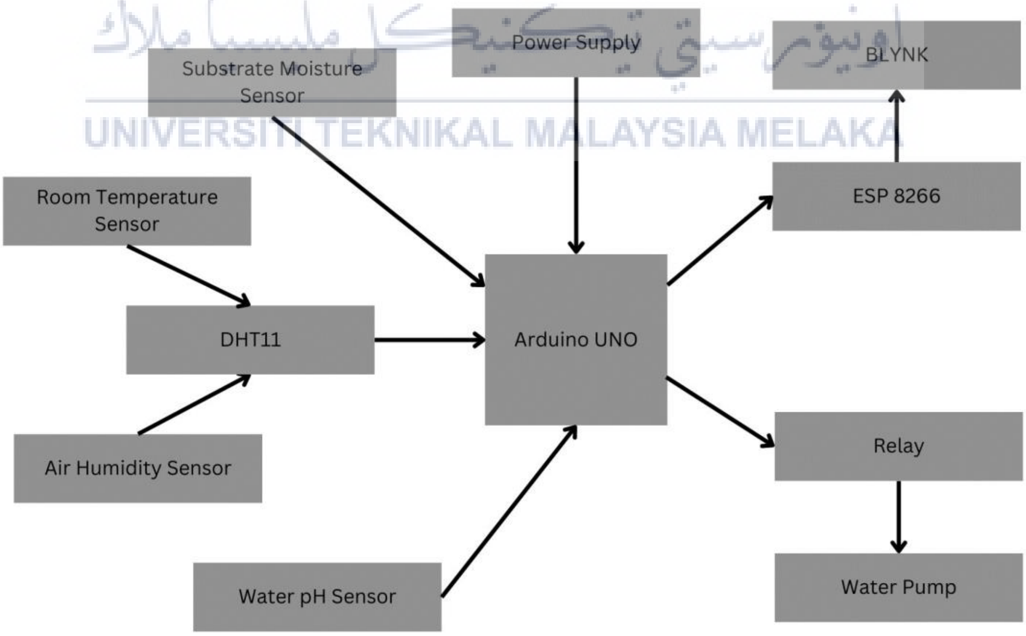

Figure 7: Block Diagram of Project

Figure 7 is a representation of the three main sides of the system—the sensing, controlling, and actuating sides. The sensing side of the system consists of a DHT11 temperature and humidity sensor for detecting the farm's ambient temperature and humidity, a soil moisture sensor for gauging substrate moisture content, and a water pH sensor for gauging water tank pH. One 12V DC water pump and one relay are combined to form an actuation module that may be controlled by an Arduino UNO. An Arduino UNO serves as the controlling component and connected to BLYNK application via ESP8266 wifi module. Blynk will as a cloud platform for data analytics. Because it is inexpensive and can deliver 3.3V power to the ESP8266, Arduino UNO is chosen.

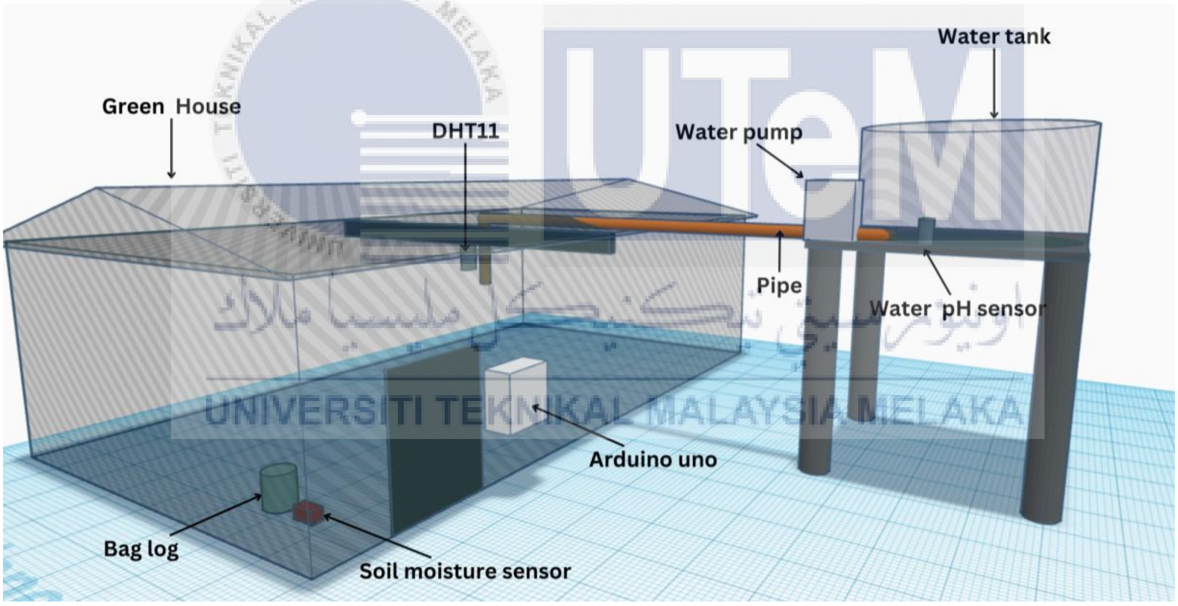

Figure 8: Project Overview

Figure 8 shows how the DHT11 sensor will be placed on top of the space to measure the space's temperature and humidity level. To read the water's pH level, the water pH sensor will then be placed inside the water tank. The substrate moisture level will be measured using the soil moisture sensor. The water pump will be constructed to deliver water to the shiitake room, and the relay will regulate it. The Arduino Uno, which is enclosed in a box for protection, will control the whole operation of the system.

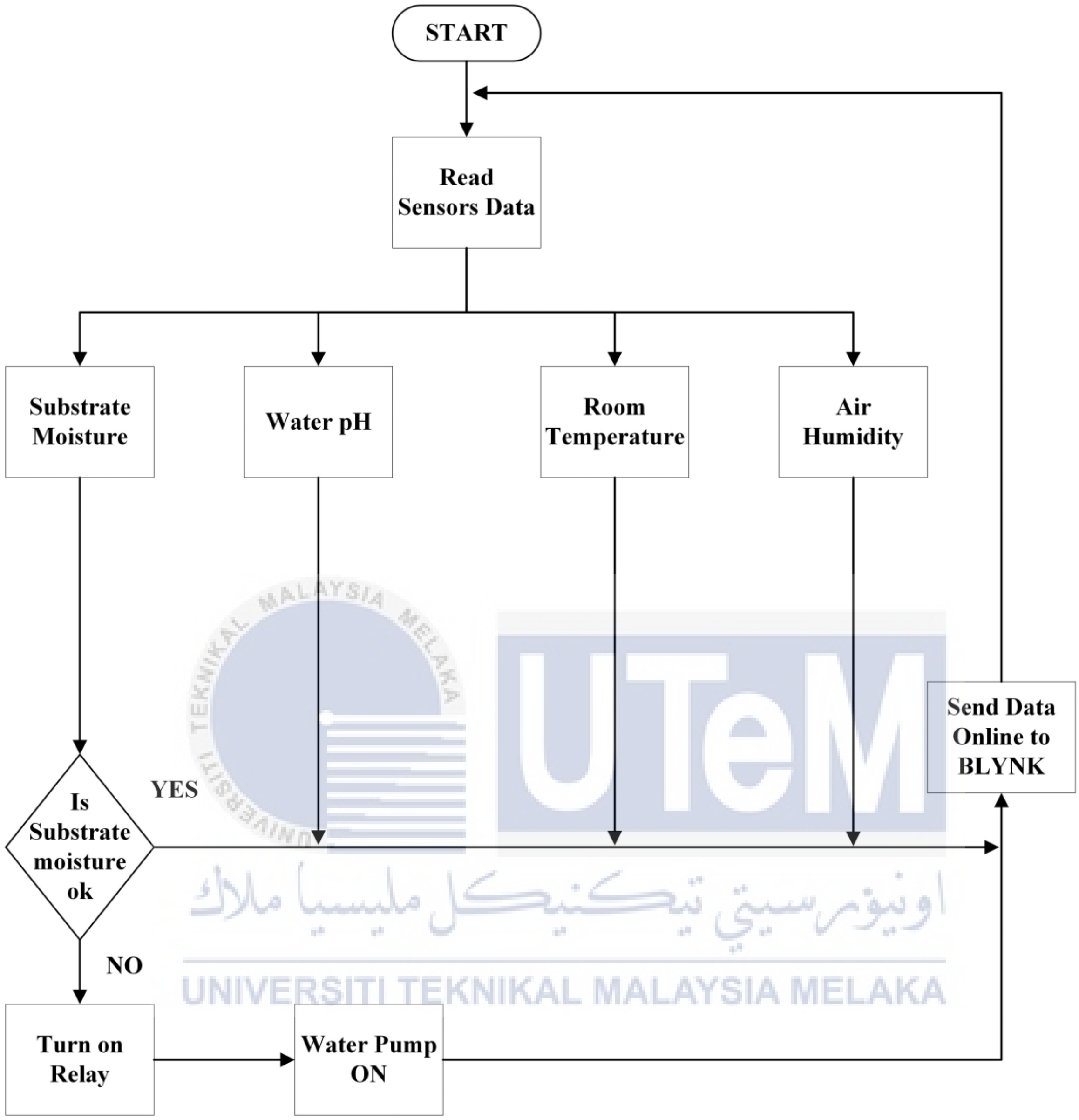

Figure 9: Overall Flowchart of The System

According to **Figure 9**, when the system turns on, the sensors will automatically capture the data. The data will be sent online to the Blynk application and user will be able to monitor the status of all parameters. Since the substrate moisture level is crucial to the growing of shiitake mushroom, it is the primary algorithm. Therefore the data of the substrate level will determine the activation of water pump. The user will be notified when level of substrate is below the acceptable value and the status of water pump activation.

3.3 Experimental Setup

In this section, the hardwires and softwires being used and the steps on how to set up the project are explained. It also includes the wiring connection to set up the connection between the microcontroller and smart phone via Wi-Fi system.

3.3.1 Arduino

Figure 10: Arduino Uno microcontroller

The Arduino Uno is a microcontroller board based on the ATMega 328. This microcontroller has 14 digital I/O (6 pins can be used as PWM output) and 6 analogue inputs, 16 MHz crystal oscillator, USB connection, power Jack, ICSP header, and reset button. This microcontroller operates at 5V voltage which is used as a USB-to-serial converter for serial communication to the computer via USB port.

Table 8: Arduino Uno Specification

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7 - 12 V
Input Voltage (limits)	6-20 V
Digital I/O pins	14 (6 of pin PWM)
Analog input pins	6
DC current per I/O pin	40 mA
DC current for pin 3.3 V	150 mA

Flash Memory	32 KB (0.5 KB Used for the bootloader)
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

3.3.2 ESP 8266 (Wifi- Module)

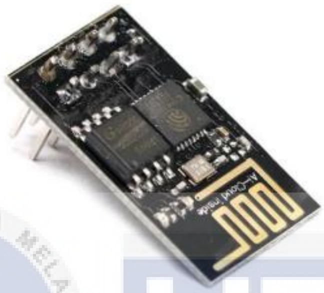

Figure 11: ESP 8266 (Wi-Fi Module)

ESP8266 is a system-on-chip (SoC) which integrates a 32-bit microcontroller, standard digital peripheral interfaces, antenna switches, RF balun, power amplifier, and low noise receive amplifier, filters and power management modules into a small package. The ESP8266 WiFi module is a versatile system-on-a-chip (SOC) that incorporates a built-in TCP/IP stack, enabling seamless WiFi connectivity for any microcontroller. It can function in two ways: as a standalone host, running programs independently, or by offloading the complete Wi-Fi networking functionality to an external application processor like Blynk. The ESP8266 establishes communication with the Blynk server via a Wi-Fi network, facilitating data exchange and control between the two.

3.3.3 Temperature Sensor (DHT11 Sensor)

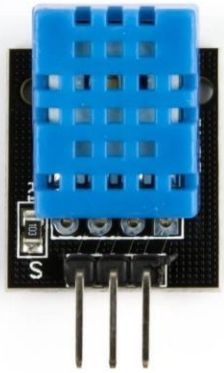

Figure 12: DHT11 Sensor

A temperature sensor is an electronic device that through an electrical signal gives the measurement of the temperature by converting the measured hotness and coldness detected from an object. A humidity sensor is an electronic device to measure the water vapor and convert the measured output into corresponding electrical signals. A humidity sensor is otherwise called a hygrometer because it combines both air moisture and air temperature. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications.

3.3.4 Substrate Moisture Sensor (Resistive Sensor)

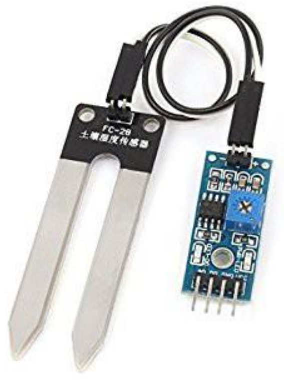

Figure 13: Resistive Sensor

A resistive sensor is a type of sensor that utilizes changes in resistance to measure or detect physical quantities such as temperature, pressure, or strain. It typically consists of a resistive element whose resistance varies in response to the applied stimulus. The change in resistance is then measured and correlated to the desired parameter, providing a means for sensing and monitoring various environmental or mechanical conditions.. This sensor widely used by farmers due to its simplicity and low cost.

3.3.5 Water pH Sensor (Glass Electrode pH Sensor)

Figure 14: Glass Electrode pH Sensor

In IoT smart farming, a glass electrode pH sensor is a specialized sensor used to monitor and control pH levels in agricultural systems. It consists of a glass membrane that detects hydrogen ion concentration in the soil or nutrient solution. By integrating this sensor into an

IoT network, farmers can remotely monitor and adjust pH levels, ensuring optimal conditions for plant growth and maximizing crop yield in smart farming applications. This sensor driven by an Arduino is proven to be cost effective, reliable and farmer friendly.

3.3.6 Relay

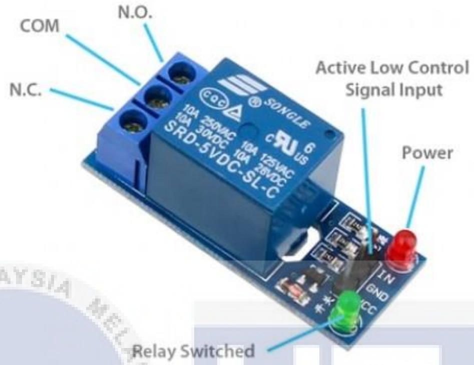

Figure 15: Relay

A relay is a device that becomes active automatically when an electrical current is passed. Relays are like switches operated by the current. Relays are used to protect the systems and control power distribution. Relays turn on the corresponding devices like sprayer, light, door, and water motor. A relay can be managed at low voltage like 3.3 volts that are got from the pins of the ESP8266 and allows it to control high voltages such as 12V, 24V, etc.

3.3.7 Water Pump

Figure 16: Water Pump

A water pump, which is a direct current motor, is an electronic machine that converts direct current into mechanical power. A 12V DC water pump is mostly applied in IoT systems including smart irrigation projects due to its small size and low-cost.

3.3.8 Blynk

Figure 17: Blynk Application

Blynk is an internet of things platform which allows controlling electronic devices remotely using its iOS and android apps. It can remotely manage devices, display sensor data, store data, visualize, and do a variety of other fun things. By compiling and delivering the proper addresses on the accessible widgets, the application is used to construct a graphical interface or Human Machine Interface (HMI). Users can create one or more projects. Each item may include graphical widgets such as virtual devices. Tons, value displays, and even text terminals, as well as communicate with one or more devices.

3.3.9 Arduino IDE Software

Figure 18: Arduino IDE software

The Arduino open-source software (IDE) makes it simple to create and upload code to the board. This software is compatible with any Arduino board. The Arduino Integrated Development Environment (IDE) software contains a code editor, a message area, a text 23 console, a toolbar with buttons for basic functions, and other menus. It communicates with the software and uploads to the Arduino hardware. The software is a set of instructions that informs the hardware of what to do and how to do it. When compared to other microcontroller platforms, one of the advantages of Arduino is that it is a low-cost programmable board. Because it is easy and convenient, it is a common first pick. Additionally, the Arduino software allows users to connect pre-built circuit boards known as shields, which provide extra features that allow users to experiment with various sensors, displays, and inputs.

3.3.10 DEV C++

Figure 19: Dev C++ Programming

Dev-C++ is a human-readable programming language and a free full-featured integrated development environment for programming in C and C++ published under the GNU General Public License. The Arduino compiler currently accepts C and C++. In fact, many of the libraries are written in C++. The underlying technology is not totally object oriented, but it has the potential to be. As a result, "Arduino language" refers to C++ or C

3.3.11 Wiring Connection

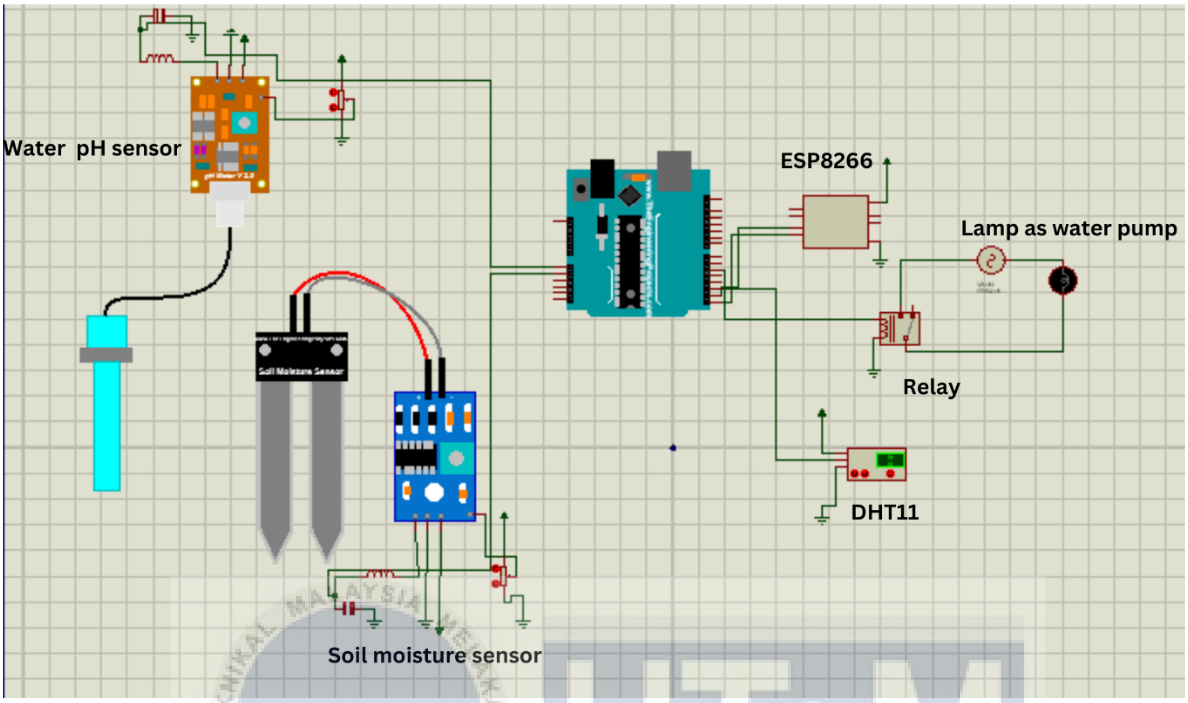

Figure 20: Wiring Connection

3.4 Parameters

Parameters are defined as a numerical or other quantifiable factor that is part of a collection that defines a system or determines its operating conditions. The parameters that will be measured in this study in this project are substrate moisture level, water pH, air humidity and room temperature.

3.4.1 Substrate Moisture level

The substrate moisture level is crucial for successful shiitake mushroom cultivation. It impacts water availability, hydration, metabolic activity, fruit initiation, and disease prevention. Proper moisture ensures the mushrooms can absorb and transport nutrients, promotes growth and development, influences enzymatic activity and respiration, triggers fruiting, and prevents the growth of competing organisms. Based on **Table 9** the ideal level for the substrate moisture is 60 %.

Table 9: Substrate Moisture Level During Process

Process	level
Spawning	65-75%
Incubation	60-70%
Bag Conditioning	55-65%
Fruiting	50-60%
Harvesting	50-60%

3.4.2 Room Temperature level

Maintaning the correct temperature level is important in shiitake mushroom cultivation as it directly influences growth, colonization, fruiting initiation, growth rate, and overall productivity. Providing the optimal temperature conditions creates an environment that promotes healthy mushroom development and maximizes the chances of a successful harvest. Based on **Table 10** the ideal temperature for their cultivation is typically between 20°C and 24°C.

Table 10: Room Temperature level During Process

Process	level
Spawning	24-27°C
Incubation	24-27°C
Bag Conditioning	20-24°C
Fruiting	16-20°C
Harvesting	18-24°C

3.4.3 Humidity level

Air humidity is important in shiitake mushroom cultivation as it directly influences hydration, mycelial growth, fruiting body formation, moisture balance, disease prevention, and prevention of drying out. Maintaining the appropriate humidity level creates an environment conducive to the optimal growth and development of shiitake mushrooms, resulting in healthy and abundant harvests. The ideal air humidity is 80% based on **Table 11** below.

Table 11: Humidity Level During Process

Process	level
Spawning	80-90%
Incubation	80-90%
Bag Conditioning	70-80%
Fruiting	80-90%
Harvesting	70-80%.

3.4.4 Water pH level

The pH level of water is important for shiitake mushrooms because it affects their growth and overall health. Shiitake mushrooms have specific pH preferences, and maintaining the appropriate pH level in their growing environment is crucial for successful cultivation. The ideal pH range for shiitake mushrooms is between 6.0 and 6.5, slightly acidic. Deviating from this range can hinder nutrient absorption, stunting growth or causing death. pH affects nutrient availability and microbial balance, crucial for optimal mushroom development.

3.5 Preliminary Result

Table 12: Ideal level for All Parameter

Parameter	level
Substrate Moisture	50%
Temperature	20℃ - 24℃
Humidity	80%
Water pH	6.0 - 6.5

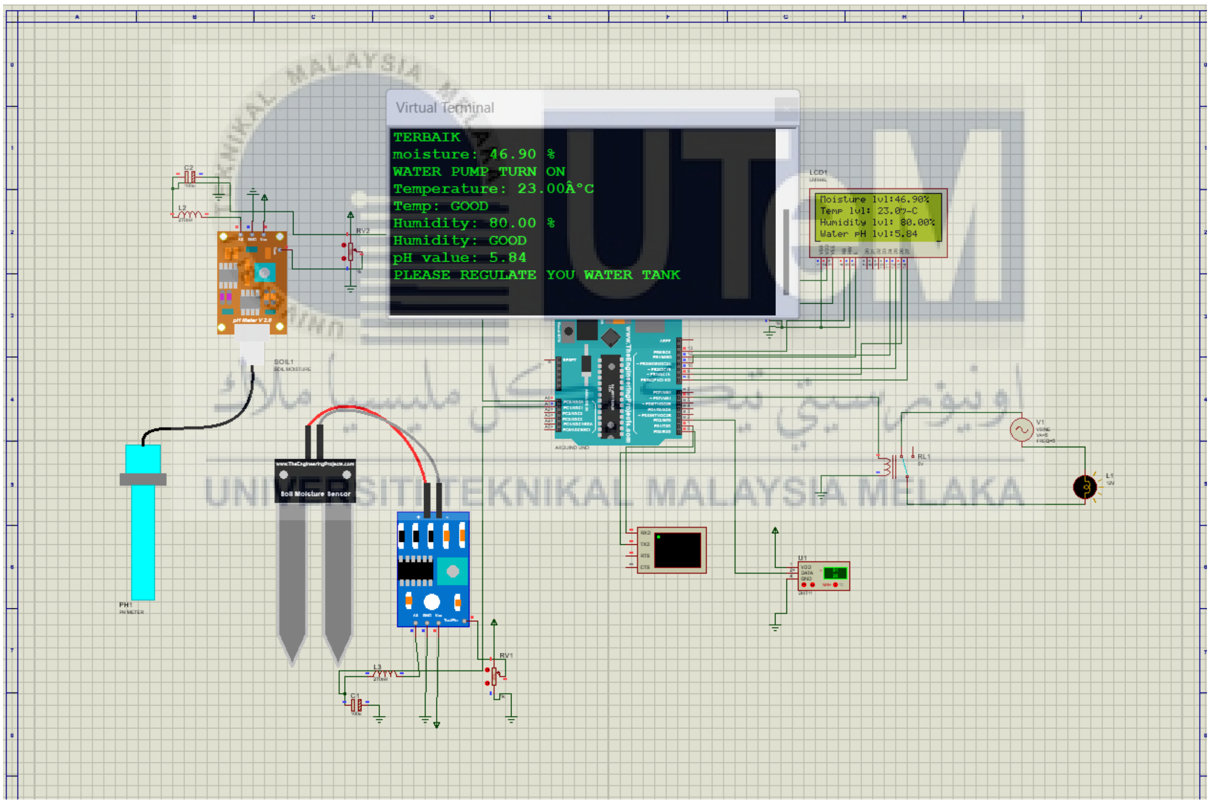

Figure 21: First Preliminary Result

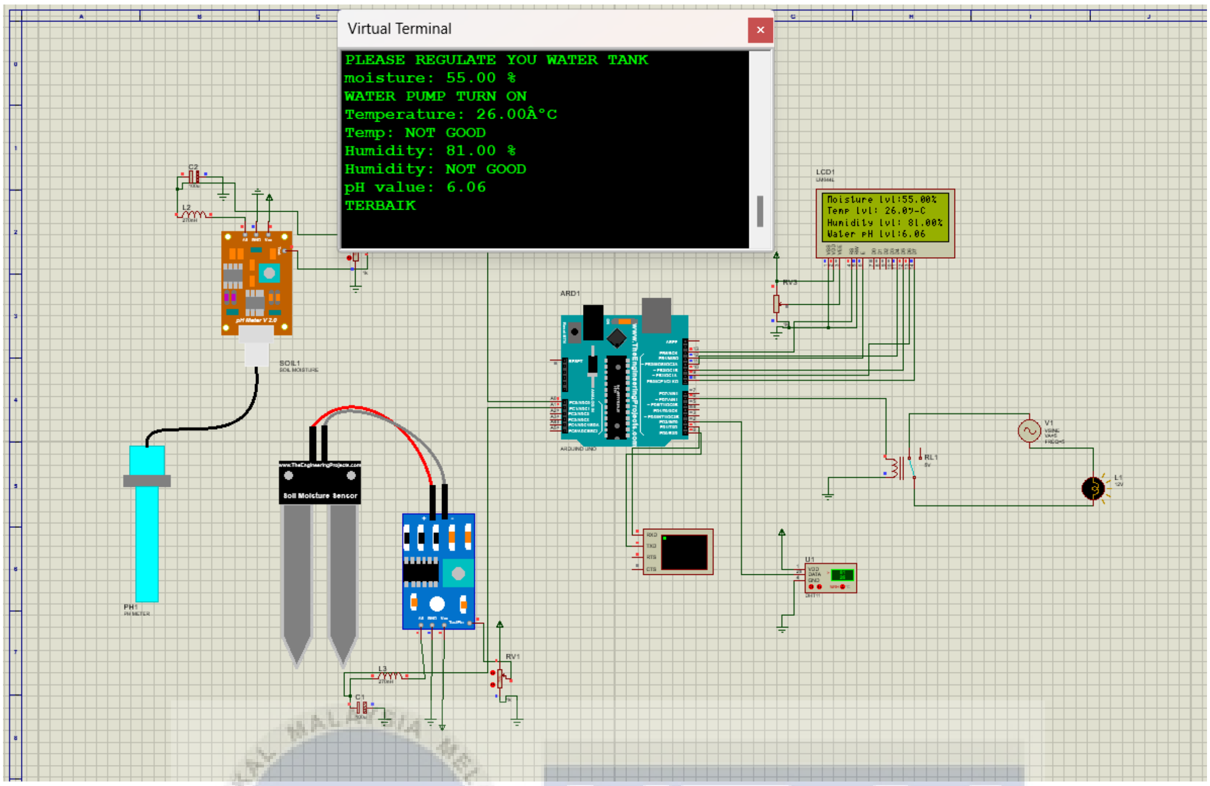

Figure 22: Second Preliminary Result

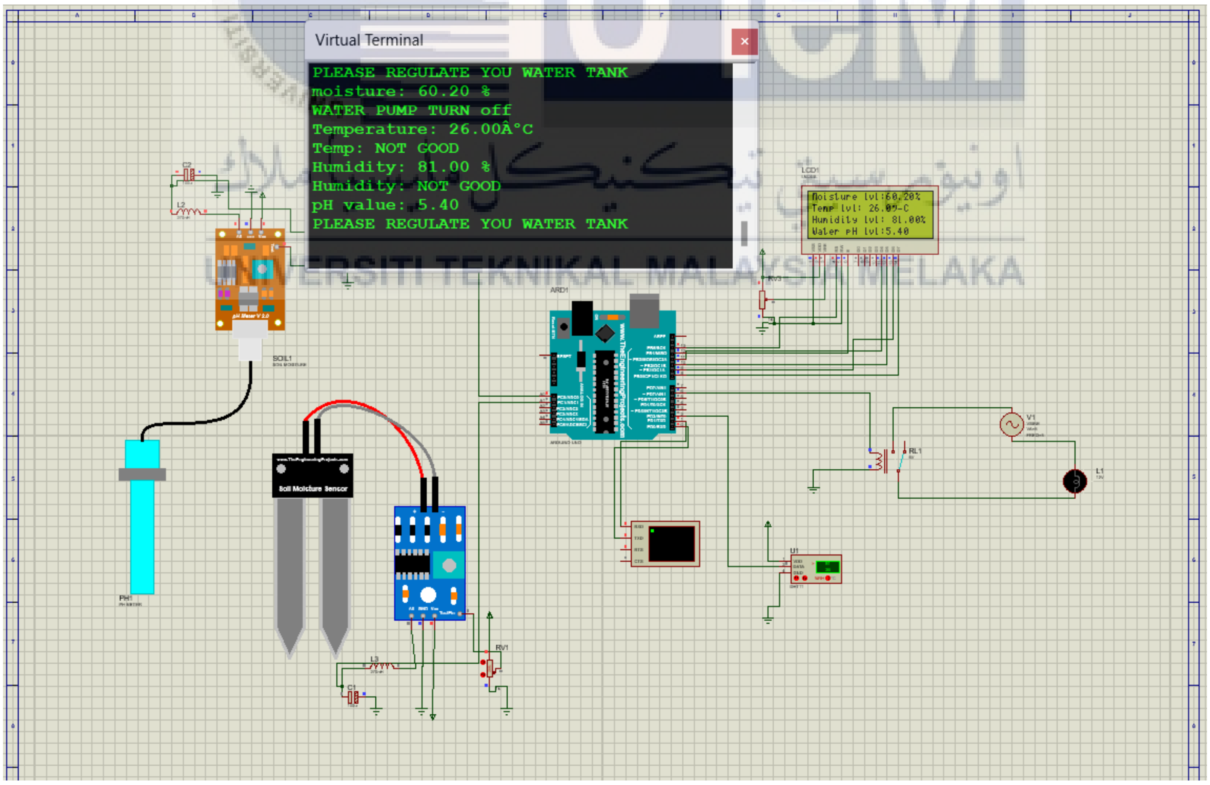

Figure 23: Third Preliminary Result

Based on figure 21, 22 and 23 when the moisture level is at the optimal level, a message reading "WATER PUMP TURN OFF" will be shown and a message reading "WATER PUMP TURN ON" when it moisture level under 60%. Next, the message "NOT GOOD" will be displayed for the temperature and humidity levels when they are not at the appropriate levels and "GOOD" will be displayed when they are. When the pH level of the water is optimal, the message "TERBAIK" will be displayed; when it is not optimal, the message "PLEASE REGULATE YOUR WATER TANK" will be displayed. The relay will automatically cut off the current utilized to turn on the water pump when the moisture level rises above 60%.

3.6 Limitation of proposed methodology

Limitations are issues or occurrences that develop during a study that are beyond the researcher's control. It narrows the extent of a study and, in some cases, has an impact on the overall outcome and conclusions that can be reached. Every study has limits, no matter how carefully it is conducted or constructed. In this study, one of the limitations is the budget allocated for the study which is RM 200. The total price of components used on the proposed system is RM160.30 not including BLYNK application plan and delivery payment. If more cost of expenditure is given, more sensors such as carbon dioxide sensor to measure the water level, analog dissolved oxygen sensor which is to measure CO2 can be used to monitor and control the CO2 levels in the growing environment and light sensor level to measures the intensity or presence of light in its surrounding environment. PIR sensor also useful to detect unwanted thing that can harm the shiitake mushroom.

3.7 Summary

The methodology is formulated to achieve the objectives of this project that is to develop a smart farming system which helps in monitoring the substrate moisture level, room temperature level, air humidity level and water pH level and the development of pump water optimization. For the monitoring of smart farming, it is proposed that Arduino UNO AtMega328 is being used as a microcontroller to operate the entire network of this project and BLYNK application as the medium of the monitoring. The Arduino microcontroller is hardware-based and able to run various devices such as sensors, wifi module and the sensors that will be used in the project are water pH sensor, substrate moisture sensor, humidity sensor and temperature sensor. This chapter also shows the working principle of the project in the form of flowcharts, the parameters will be measured and its ideal values, the setup of the project in terms of hardware and software that will be used and the limitations of the methodology.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presented the results and analysis of the development of an IoT-based shiitake mushroom smart farming system using Arduino. This technological intervention facilitated real-time monitoring of environmental conditions. An analysis of the gathered data highlighted correlations between optimized conditions and improved yield rates. The system's ability to control water supply to maintain ideal moisture levels positively affected the growth cycle, ensuring consistent quality produce. Additionally, user feedback during the initial phase emphasized the system's user-friendly interface and the convenience it offered in remotely managing farm conditions. The early findings underscored the potential of this IoT-enabled solution to revolutionize the shiitake mushroom farming landscape in Malaysia, addressing the industry's challenges of low productivity and labor intensiveness. These preliminary results lay a robust foundation for further analysis, emphasizing the system's role in not just increasing yields but also making mushroom cultivation a more sustainable and economically viable venture for small-scale farmers.

4.2 Prototype

Several stages had to be completed for the project prototype. The prototype comprised an Arduino UNO, a pH and soil moisture sensor, a DHT11, an ESP 8266 wifi module, a water pump, and a 5V AC current. All connections between the parts needed to be firmly established before the power supply was turned on. Once the findings became reliable and accurate, an box for the Arduino UNO was created to hide the wires and other components from wet. **Figure 27** shows the configuration system in blynk website and figure 28 is the configuration using blynk application in mobile phone.

Figure 24: Full view of project prototype

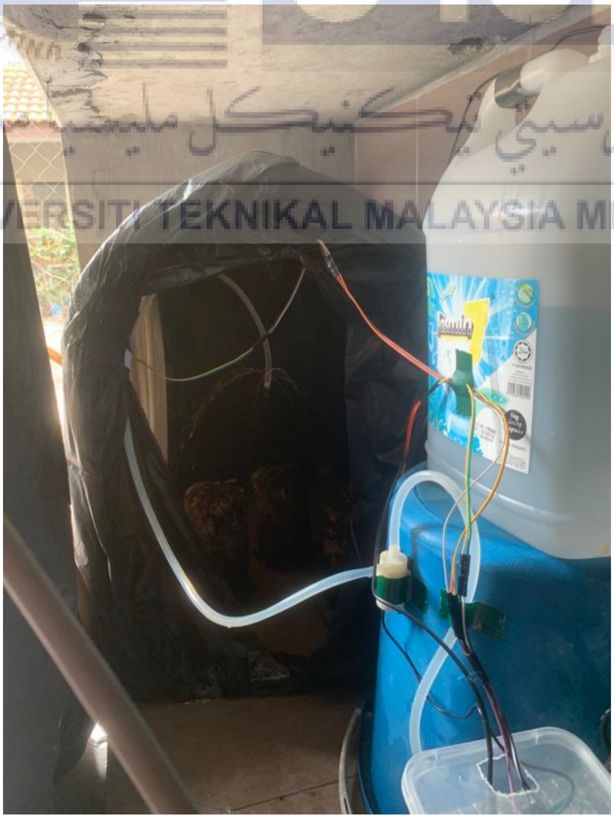

Figure 25: Front view of project prototype

Figure 26: Arduino Uno box

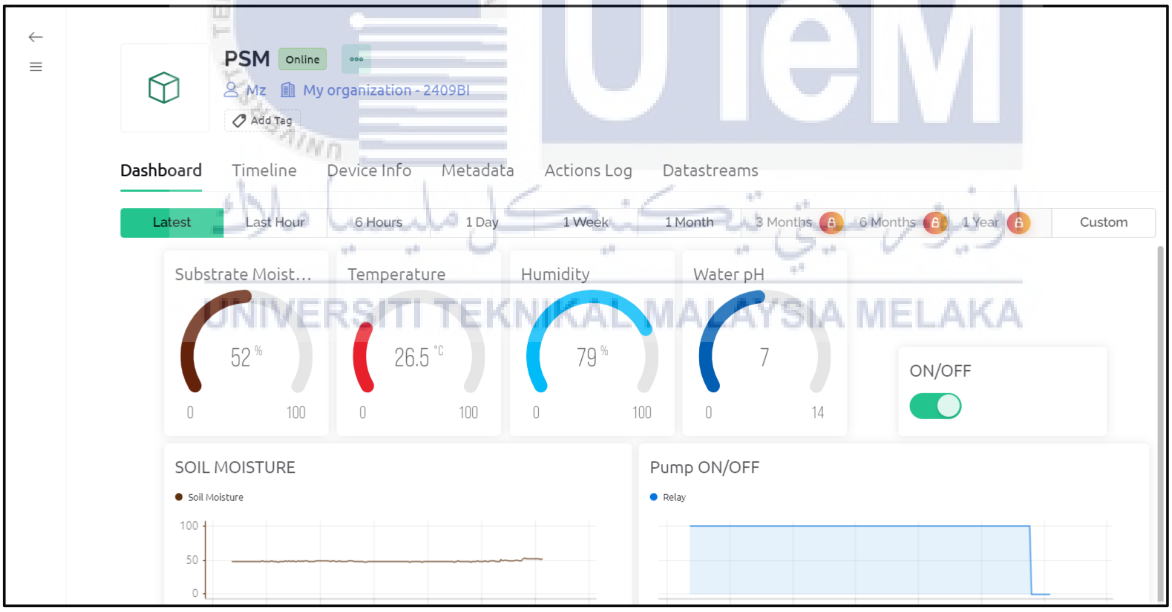

Figure 27: Configuration on Blynk website

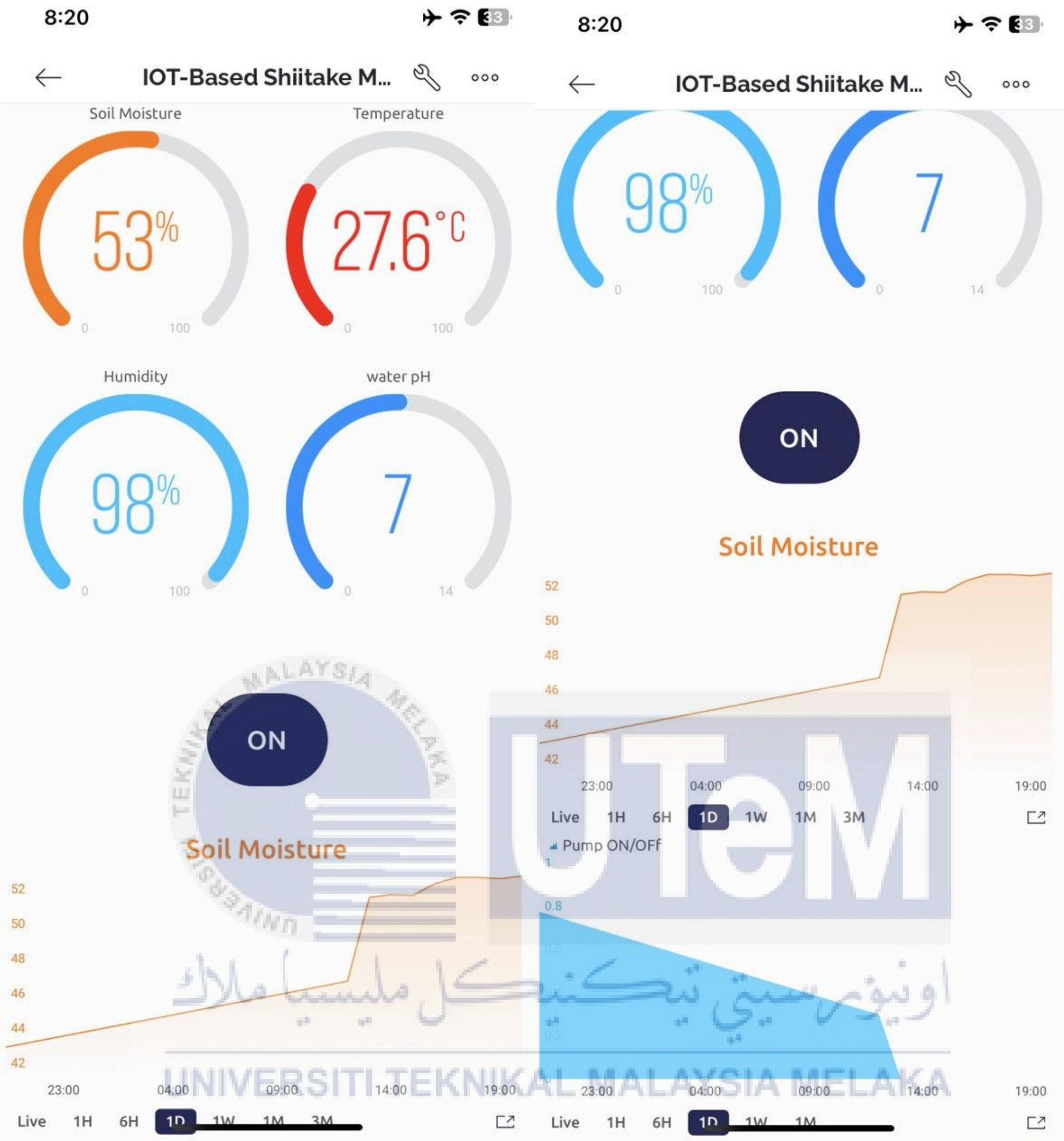

Figure 28: Configuration on Blynk application on mobile phone

4.3 Results

The substrate moisture level, temperature level, humidity level, and pH water level values were taken everyday from 5 January 2024 until 10 January 2024.

4.3.1 Data obtained

The measurement was displayed on the Blynk website based on **Figure 29**. It displayed the pH water level (7), room temperature (27.6°C), room humidity (98%), and soil moisture content (52%). The graph also showed that the water pump would automatically shut off when the substrate moisture level rose above 50%. However, if the substrate moisture content fell below 50%, the water pump would automatically activate. This result was taken after an hour of running the system.

Figure 29: Data Displayed by Blynk

In **Table 13, 14** and **15** the readings display substrate moisture, room temperature, room humidity, and water pH used for watering shiitake mushrooms. The table reflects system operations over 5 days period, obtained through a downloaded report in Blynk. By analyzing the substrate moisture column and relay column, it can be concluded that the water pump will consistantly turn on when the substrate moisture falls below 50% and turn off once it reaches 50% and above. However, there is some data loss in **Table 15** due to a sensor breakdown.

Table 13: Data on 1 January 2024

Time	Substrate Moisture	Temperature	Humidity	Relay	Relay
1/10/2024 9:54	53	28.5	95	7	0
1/10/2024 9:53	52	28.5	95	7	0
1/10/2024 9:53		28.5	95	7	
1/10/2024 9:53	52	28.5	95	7	0
1/10/2024 9:51	52	28.5	95	7	0
1/10/2024 9:51	53	28.5	95	7	0
1/10/2024 9:50					0
1/10/2024 9:50	53	28.5	95	7	
1/10/2024 9:49				7	0
1/10/2024 9:49	53	28.5	95		

Table 14: Data on 9 January 2024

Time	Substrate Moisture	Temperature	Humidity	Relay	Relay
1/9/2024 12:24	56	28.5	98	7	0
1/9/2024 12:24	56	28.5	98	7	0
1/9/2024 12:24	56	28.5	98		
1/9/2024 12:23		28.5	98	7	0
1/9/2024 12:23	53	28.5	98	8	0
1/9/2024 12:18	34	28.5	98	8	1
1/9/2024 12:17	33	28.5	98	8	1
1/9/2024 12:16			98	8	1
1/9/2024 12:16		28.5			
1/9/2024 12:16	35				

Table 15: Data on 5 January 2024

Time	Substrate Moisture	Temperature	Humidity	Relay	Relay
1/5/2024 19:10	39			7	1
1/5/2024 19:10				7	
1/5/2024 19:10	39			7	1
1/5/2024 19:10	39			7	1
1/5/2024 19:10	39			7	1
1/5/2024 19:10	39			7	1
1/5/2024 19:10	39			7	1
1/5/2024 19:10	39			7	1
1/5/2024 19:10	37			7	1
1/5/2024 19:10	37			7	1

4.3.2 Feedback by Blynk application

The **Figure 30** showed the feedback from the Blynk app when any of the pH water level, substrate moisture level, or temperature level were not in the ideal condition. This indicates that Blynk had succesfully send a notification to the user. **Table 16** shows the ideal condition of all parameter.

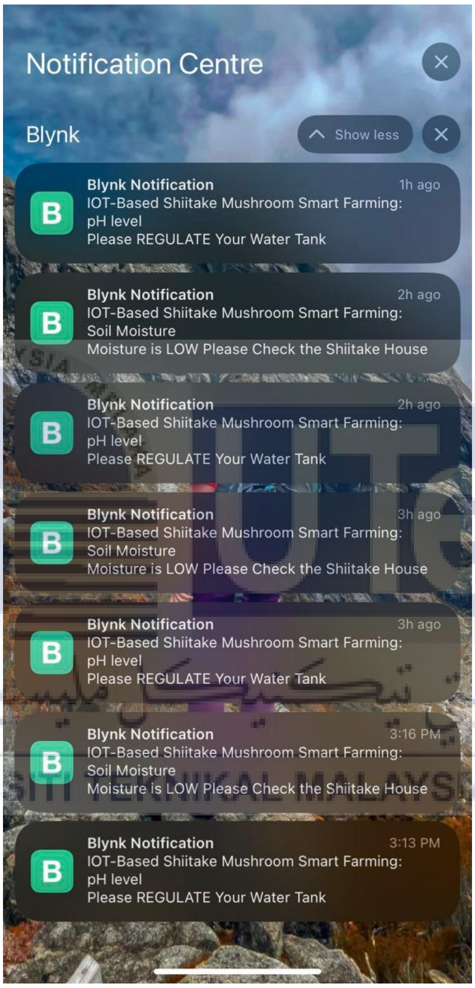

Figure 30: Feedback through Blynk apps

Table 16: Ideal level

Parameter	level
Substrate Moisture	50%
Temperature	20℃ - 24℃
Humidity	80%
Water pH	6.0 - 6.5

4.4 Analysis for pH water level sensor

The **Figure 31** showed that the pH of the water used to irrigate the shiitake mushrooms was 6 by using litmus paper. However, according to sensor data in **Figure 29**, the pH of the water was indicated as 7. This suggested that there were only few slight variations in the readings. This somehow indicates the percentage error of the sensor is around 16.67%.

Figure 31: Water pH testing using litmus paper

4.5 Analysis for Wi-Fi module (ESP8266) status

Table 15 showed the activities occurring on the ESP8266. Upon coming online, it connects to the Blynk server, which subsequently sends warning notifications to a mobile phone. However, after prolonged operation, the ESP8266 overheats, disconnects from Wi-Fi, and goes offline. When the Wi-Fi module overheats, attempts to reconnect to the Blynk server fail, leading to repeated disconnections. The ESP8266 can only regain its online status after this cooldown period. To prevent issues, it's advisable to avoid using the ESP8266 WIFI module, as it tends to overheat and disconnect from the Blynk server.

Table 17: ESP8266 Status

Time	Event Type	Name	Description
1/10/2024 0:04	WARNING	Temperature, Humidity	Please Check Your SHIITAKE
1/9/2024 23:04	WARNING	Temperature, Humidity	Please Check Your SHIITAKE
1/9/2024 22:03	WARNING	Temperature, Humidity	Please Check Your SHIITAKE
1/9/2024 21:43	WARNING	pH level	Please REGULATE Your Water Tank
1/9/2024 21:02	WARNING	Temperature, Humidity	Please Check Your SHIITAKE
1/9/2024 20:09	WARNING	pH level	Please REGULATE Your Water Tank
1/9/2024 20:02	WARNING	Temperature, Humidity	Please Check Your SHIITAKE
1/9/2024 19:14	OFFLINE	Offline	
1/9/2024 19:14	ONLINE	Online	
1/9/2024 19:14	OFFLINE	Offline	

4.6 Analysis for temperature sensor accuracy in DHT11

The **Figure 32** showed the temperature inside the shiitake mushroom as 25.9℃ using the mobile application, and according to **Figure 30**, it indicated the temperature reading was 26.5℃. However, this temperature does not align with the ideal conditions outlined in **Table 17**.

Figure 32: Room temperature using mobile application

Table 18: Ideal temperature for shiitake plantation

Process	Level
Spawning	24-27°C
Incubation	24-27°C
Bag Conditioning	20-24°C
Fruiting	16-20°C
Harvesting	18-24°C

4.7 Summary

This chapter presented case studies demonstrating the operation of the shiitake mushroom smart farming system, which communicates feedback via Blynk. By regulating the water pump, this prototype maintains substrate moisture in the greenhouse. The moisture content determines the water pumping rate, activating when the substrate moisture falls below 50%. Additionally, analyses were conducted to assess the accuracy of the DHT11 for temperature measurement and the pH water sensor. Litmus paper was used to measure water pH, and temperature apps on mobile phones were employed to compare temperature readings. Minor differences were observed in these comparisons. Because the wifi module tends to overheat, its status was also examined. After being online for a while, it overheated; this resulted in numerous disconnections and reconnection failures to the Blynk server, which required avoidance for stability.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This thesis presents a method for automatically controlling the water pump based on the substrate moisture level. Parameters such as substrate moisture level, room temperature, room humidity, and pH water level can be monitored through the Blynk app on a mobile phone. The performance of the water pump can also be monitored through this app, aiding in optimizing water usage.

In conclusion, the proposed system achieved all three objectives. First, it successfully designed and implemented a system to monitor shiitake farm air humidity, temperature, substrate moisture, and water pH to increase the harvest. This was evident from the readings displayed in the Blynk app and website for all four parameters.

Secondly, the system effectively developed a pump control system for water optimization by using microcontroller and linked to Blynk application. The graph in the Blynk application served as evidence, displaying substrate moisture level and water pump status. The pump activated when the substrate moisture level fell below 50% and switched off when it reached and exceeded 50%.

Lastly, regarding the third objective of analyzing the accuracy and consistency of the system and gathering user feedback, Also, the system was successful since it kept accurately reading the parameters and consistently optimizing the water, even though there were some overheating issues with the ESP8266. Remarkably, this entire system was developed for less than RM200, making this technology affordable even for small-scale shiitake mushroom growers.

5.2 Potential for Commercialization

The IoT-based Shiitake Mushroom Smart Farming System using Arduino holds significant commercialization potential. This innovative system, which comprises hardware components, circuit connections, software, and algorithms, can precisely control and monitor the environmental parameters essential for mushroom cultivation. This precision leads to an increased yield and improved quality compared to traditional methods. It not only enhances mushroom production and quality but also positively impacts the economic market analysis of mushroom cultivation. Therefore, this system provides valuable insights to farmers, agricultural professionals, and policymakers about the future of mushroom cultivation. Thus, the IoT-based Shiitake Mushroom Smart Farming System using Arduino presents a compelling case for commercialization.

5.3 Future Works

For future improvements, the shiitkae mushroom smart farming system could be enhanced as follows:

i) Add sprinkler to get unifrom watering.

ii) Add light sensor to helps regulate optimal light levels for growth, ensuring ideal conditions for their development and yield.

iii) Add nitrogen and carbon dioxide sensors in a shiitake mushroom house to monitor and assess the availability of essential nutrients for the mushrooms growth. This allows farmers to optimize the environment by adjusting nutrient supplementation or ventilation to maintain ideal conditions for healthy mushroom growth.

iv) Install a thermostat connected to cooler to maintain low temperature.

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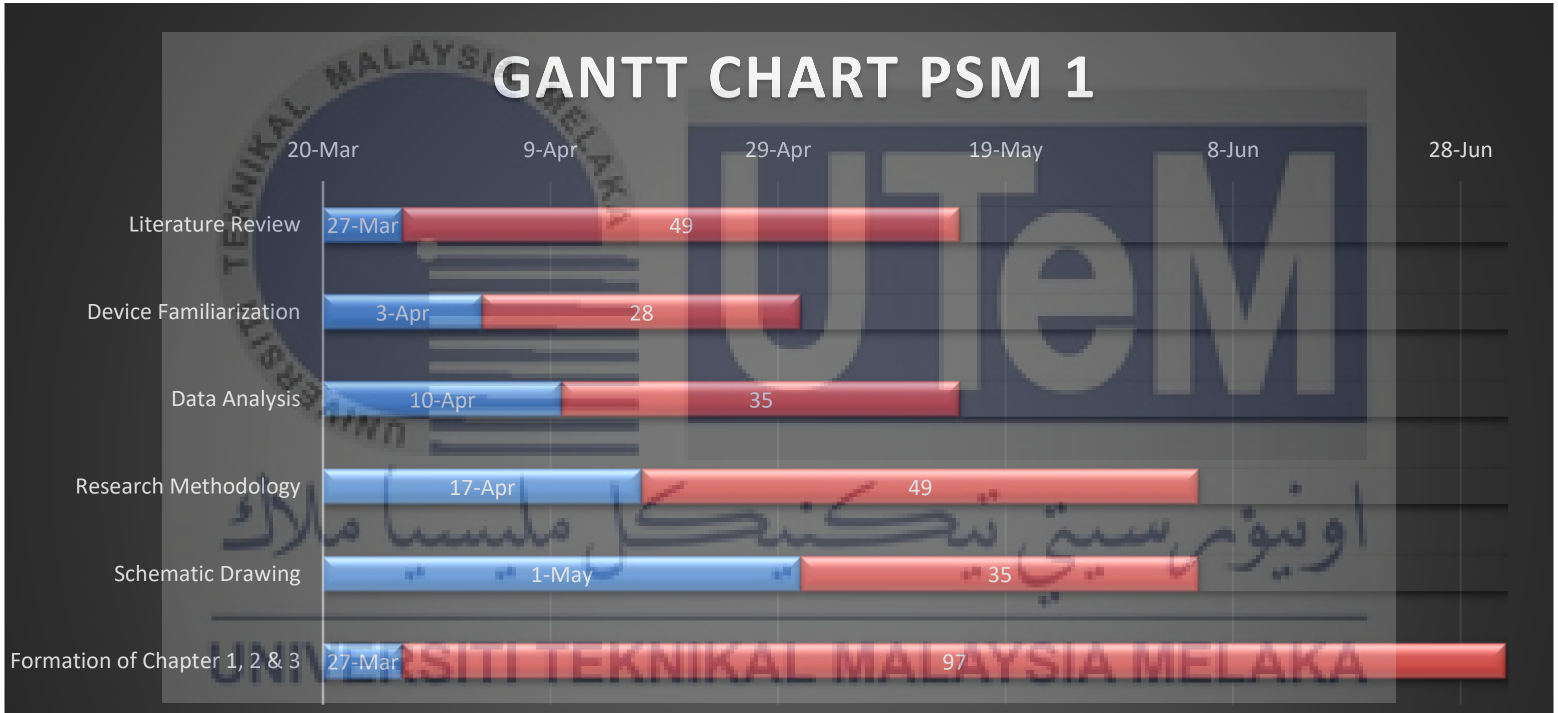
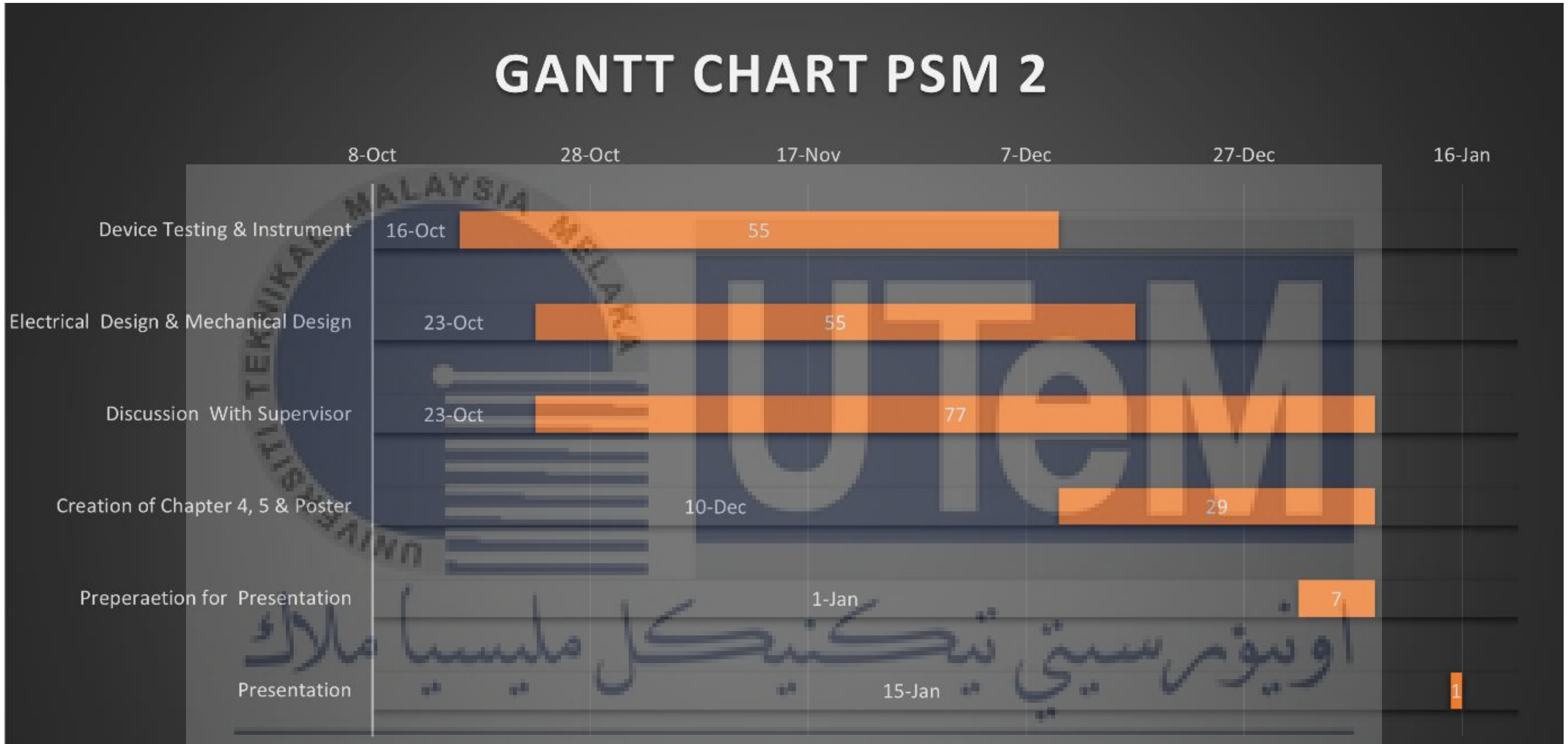
APPENDICES

Appendix A: Gantt Chart PSM 1



	Formation of Chapter 1, 2 & 3	Schematic Drawing	Research Methodology	Data Analysis	Device Familiarization	Literature Review
Start Date	27-Mar	1-May	17-Apr	10-Apr	3-Apr	27-Mar
Duration (Days)	97	35	49	35	28	49
End Date	2-Jul	5-Jun	5-Jun	15-May	1-May	15-May

Appendix B: Gantt Chart PSM 2



	Presentation	Preperaetion for Presentation	Creation of Chapter 4, 5 & Poster	Discussion With Supervisor	Electrical Design & Mechanical Design	Device Testing & Instrument
Start Date	15-Jan	1-Jan	10-Dec	23-Oct	23-Oct	16-Oct
Duration (Days)	1	7	29	77	55	55
End Date	16-Jan	8-Jan	8-Jan	8-Jan	17-Dec	10-Dec

Appendix C: Project Code

```
#define BLYNK_TEMPLATE_ID "TMPL6widLB33a"
#define BLYNK_TEMPLATE_NAME "PSM"
#define BLYNK_AUTH_TOKEN "XD7sCHZdd-zmRqt-wUIiB1Galg-E3NIi"

char ssid[] = "Nokia01_4GHz";
char pass[] = "Assingmentbelambak01";

#define BLYNK_PRINT Serial
#include <ESP8266_Lib.h>
#include <BlynkSimpleShieldEsp8266.h>
#include <DHT.h>
BlynkTimer timer;

bool isV5Pressed = false;
bool isRelayOn = false;

const int relayPin = 7;
bool relayState = HIGH;

const int Soilmoisture = A0;
int value = 0;
int moistureThreshold = 50;

DHT dht(A1, DHT11);
double T, P;
char status;

const int WaterpH = A2;
int phval = 0;

#include <SoftwareSerial.h>
SoftwareSerial EspSerial(2, 3); // RX, TX

#define ESP8266_BAUD 38400

ESP8266 wifi(&EspSerial);

void setup() {
  Serial.begin(115200);

  pinMode(Soilmoisture, INPUT);
  pinMode(WaterpH, INPUT);
  pinMode(relayPin, OUTPUT);
  digitalWrite(relayPin, LOW);
```

```
  EspSerial.begin(ESP8266_BAUD);
  delay(10);
  dht.begin();

  Blynk.begin(BLYNK_AUTH_TOKEN, wifi, ssid, pass, "blynk.cloud", 80);
  timer.setInterval(1000L, checkSensors);
}

void loop() {
  Blynk.run();
  timer.run();
}

BLYNK_WRITE(V5) {
  isV5Pressed = !isV5Pressed; // Toggle the state of isV5Pressed each time V5 is pressed
}

void checkSensors() {
  if (isV5Pressed) {
    int Value = analogRead(Soilmoisture);
    int moisturePercentage = map(Value, 0, 1023, 0, 100);
    moisturePercentage = (moisturePercentage - 100) * -1;

    float temperature = dht.readTemperature();
    float humidity = dht.readHumidity();

    if (temperature > 24){
      Blynk.logEvent("temperature_humidity"); // Send notification to Blynk
    }

    float phval = analogRead(WaterpH);
    phval = map(phval, 0, 1023, 0, 10); // Adjust the mapping based on the pH sensor characteristics

    if (phval < 6.5 || phval > 7.5) {
      Blynk.logEvent("ph_level"); // Send notification to Blynk
    }

    Blynk.virtualWrite(V0, moisturePercentage);
    Blynk.virtualWrite(V1, temperature);
    Blynk.virtualWrite(V2, humidity);
    Blynk.virtualWrite(V3, phval);

    // Print the values to the Serial Monitor
    Serial.print("Soil Moisture: ");
    Serial.println(moisturePercentage);
    Serial.print("Temperature: ");
```

```
    Serial.println(temperature);
    Serial.print("Humidity: ");
    Serial.println(humidity);
    Serial.print("Water pH: ");
    Serial.println(phval);

    if (moisturePercentage < moistureThreshold) {
      turnRelayOff();
      Blynk.logEvent("soil_moisture");
    } else if (moisturePercentage > (moistureThreshold + 1)) {
      turnRelayOn();
    }
  }
}

void turnRelayOn() {
  if (isV5Pressed) {
    digitalWrite(relayPin, HIGH);
    relayState = LOW;
    Blynk.virtualWrite(V4, relayState);

  }
}

void turnRelayOff() {
  if (isV5Pressed) {
    digitalWrite(relayPin, LOW);
    relayState = HIGH;
    Blynk.virtualWrite(V4, relayState);

  }
}
```