Automatic Climate Control For Community Mushroom House Using IoT Approach

Muhammad Azizi Mohd Ariffin
National Autism Resource Centre
FSKM, UiTM Shah Alam
Selangor, Malaysia
mazizi@fskm.uitm.edu.my

Muhammad Izzad Ramli
National Autism Resource Centre
FSKM, UiTM Shah Alam
Selangor, Malaysia
izzad@fskm.uitm.edu.my

Zarina Zainol
National Autism Resource Centre
FSKM, UiTM Shah Alam
Selangor, Malaysia
zarina@fskm.uitm.edu.my

Nursuriati Jamil
National Autism Resource Centre
FSKM, UiTM Shah Alam
Selangor, Malaysia
liza@fskm.uitm.edu.my

Marina Ismail
National Autism Resource Centre
FSKM, UiTM Shah Alam
Selangor, Malaysia
marina@fskm.uitm.edu.my

***Abstract*—In Malaysia, most of the farmers only depend on traditional agricultural practices. To improve the efficiency as well as the productivity from their farms, modern agricultural technology was proven to be better than traditional practices. Internet of Things (IoT) is usually related in modern agriculture which provides the farmer with a real-time monitoring condition of their farm from anywhere and anytime. Nowadays, Oyster Mushroom is one of the favourite plants to cultivate among Malaysian farmers. However, it still overshadowed by the traditional cultivation approach, which is resulting in high cost, low productivity and more maintenance. Therefore, this work aims to develop an efficient of an automatic climate control system, which can control the condition of the farm as well as optimize the resources. Oyster Mushroom requires an optimum temperature ranging from 20 to 30 °C and humidity from 70% to 80%. Two sensors are placed at the centre and corner of the mushroom house to measure the temperature and humidity and transmitted to the remote monitoring station via a micro-controller unit for further action. An efficient climate control algorithm will envoke the external devices to take action in efficient ways. The result conducted for 6 days shows that an efficient automatic monitoring system, which can control the farm' house as well as minimizes the resources and human efforts.**

***Keywords*—IoT, Climate Control, Smart Farming, Industrial Automation**

I. Introduction

Climate change which occurs on the world today has threatened food security globally and we need to rethink the way we grow food to avoid mass food shortage [1]. To make matter worse, recent Covid-19 pandemic has disrupted the global food chain which has caused rising food price. Malaysia is not exempted from those problems, which food prices in Malaysia rose by 1.6 percent year-on-year in June of 2020, following a 1.2 percent rise in a month earlier [2]. It was the highest food inflation since December last year. To overcome food security is by crop improvement, efficient land management and increasing food yield [1]. We can achieve that by encouraging urban farming among the Malaysian population.

Urban farming is seen as a sustainable practice with the social, economic and urban environment benefits. Its currently seen as having important roles of curbing the impact of rising food prices, reducing urban poverty and food insecurity, supplementing people's income and easing the financial burdens of urban dwellers [3]. Urban farming provides communities in the cities the opportunity to maximize the usage of unused space by growing food. We can see that urban farming has increasing uptake trends among house resident, school and institution in Malaysia. Understanding the benefits of urban farming, the Malaysian government has allocated RM 10 Million through PENJANA program to encourage more Malaysia to involve in urban farming [4]. However, the current practice of urban farming needs to be improved significantly so that it easy and more attractive for adoption by urban dwellers. For example, current practice is tedious and time-consuming as a farmer need to manually water the plant and check its growing condition (e.g. temperature, humidity, light intensity). Moreover, urban dwellers cannot easily move their plant setup in case they need to use the space for other occasions. These limitations may cause urban farming less attractive to urban dwellers which has a busy and dynamic lifestyle.

Meanwhile, Internet-of-Things Technology (IoT) has the potential to act as a catalyst which can increase the yield and efficiency of urban farming especially indoor mushroom cultivation [5]. The IoT can make urban farming easier by automating the process of watering the plant and controlling its growing environment. On top of that, with the advent of cloud computing and machine learning analytic. The sensor data will be processed on the cloud for better analytic and smart decision making. To add further value, the data collected on the cloud can be visualized so that users able to remotely monitor and control their plant via smartphone [6]. IoT components are also small, lightweight and compact which makes it suitable for implementing it to a startup or big scale project.

There are many plants that were done for urban farming. Mushroom is among the list of plants which are suitable for urban farming as it takes up small space, doesn't require direct sunlight and takes a shorter time for harvest. It is also sustainable and environmentally friendly as we can use agriculture waste (e.g. sawdust, husk) for its growing medium and organic fertilizer [7]. But mushroom cultivation has specific growing conditions (temperature and humidity) for it to produce high yield, therefore we need an IoT system to aid the cultivation process.

Temperature and humidity are the two parameters that need special attention to grow the mushroom. Based on the research, the oyster mushroom does well in a climate with temperatures ranging between 22 to 28°C and humidity with 70 to 90 percent [8]. In this best condition, oyster mushroom able to produce higher quantity, quality and can maximize the harvesting cycle.

Conventionally, the mushroom farmer only depends on the condition of the natural environment. Sometimes, temperature and humidity are controlled by sprinkling the water to the floor manually. This idea is to reduce the temperature and increase humidity. However, it doesn't promise to meet the climate or best condition for temperature and humidity because there are no devices to monitor the exact temperature and humidity in that place. To overcome this limitation, researchers have introduced IoT in the whole urban farming system where it can monitor and control the temperature and humidity in the farm [9]. The IoT devices are usually integrated with a decision support system (DSS) in which rules are developed from the collected data through the network.

Based on the related works conducted by [9]–[11], they have developed a smart system to monitor the room environment of mushroom cultivation farm. The external devices such as water pump, exhaust fan, light bulb and air conditioner are triggered when the parameters exceed the thresholds. However, the resources (electricity and water) are not controlled well and not optimized. As an example, when the temperature and humidity are not dropping upon the water mist has been opened, then the water will keep spraying from time to time. So, it will be wasting the water resources which can increase the cost. Therefore, this project proposes an efficient IoT decision support system for urban farming. The contribution of this paper is introducing an efficient automatic climate control system for community oyster mushroom's house in Malaysia.

II. System Design

The system design discussion is divided into three sections: mushroom cultivation parameters, climate control systems, and the web interface.

A. Mushroom Cultivation Parameters

The system is designed to automatically regulate the oyster mushroom growing environment to its optimal parameters. The optimal growing condition for oyster mushroom is in a climate with a temperature range of 20 – 30 °C and humidity in 70-80% [8], [11]. Besides, the oyster mushroom body cannot be wet as it will increase the risk of micro bacterial infection, which will spoil the plant [12]. During the growing process, the mushroom also needs to be protected from insects and pests. Based on the requirement being discussed regarding the optimal growing environment for oyster mushrooms, an automatic climate control system has been proposed. The overall system design is shown in Figure 1.

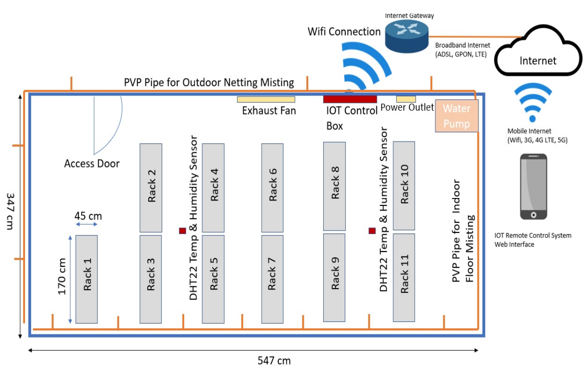

Figure 1. Overall System Design Diagram

The system is designed with several elements such as the mushroom house, IoT control box, and Web Client interface. The mushroom house will provide a controlled environment for mushroom cultivation and protection from external elements such as insects and pests. For protection, the mushroom house wall is built with a fine mesh netting to keep pests outside while allowing free airflow. The mushroom house will be equipped with a water pump to spray the floor and outside netting with water to regulate temperature and humidity level without indirectly wetting the mushroom to avoid it from spoilage. The water will be flowing through PVC pipes before came out to the floor or the netting via a misting nozzle. Moreover, the mushroom house will also be equipped with an exhaust fan for regulating the temperature and humidity.

The IoT control box contains the climate control system, which will automate the process of regulating the optimal climate for oyster mushroom cultivation. The operation of both water pump and exhaust fan is controlled by the system via the electrical relay. The system is also equipped with sensors to obtain the value of temperature and humidity inside the mushroom house. The minimum sensor quantity for the sensors will be two, and it will be position at the center of the mushroom house ceiling to ensure accurate and reliable reading. Moreover, the system will be connected to the Internet via an Internet gateway using a Wi-Fi connection. The Internet gateway will obtain Internet connection from ISP either via ADSL, GPON, or LTE connection. This allows the system to be remotely accessed from anywhere. Lastly, the system is also designed with a web client interface to provide easy access to the network using any mobile devices.

B. Climate Control System

The brain of the system is the climate control system equipped with several components; the Climate Control System Schematic is shown in Figure 2. The system processing capabilities are provided by Node MCU ESP8266 [13]. It has a Tensilica 32-bit RISC CPU Xtensa LX106 microcontroller, 128KB RAM, 4MB flash memory, and running at 80 MHz clock speed. It is also equipped ESP8266 SOC, which enables the system to connect with IP network using 802.11b/g/n Wi-Fi connection. Since the microcontroller operating voltage is 3.3v and 80mA, it can be powered using batteries and solar panels, but for this project, the system is powered using a 5V 2A USB adapter.

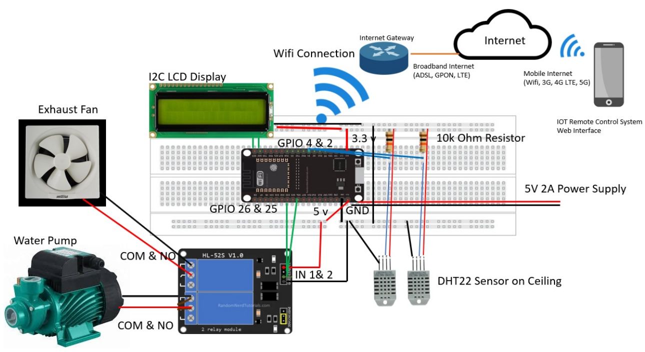

Figure 2. Climate Control System Schematic Diagram

The microcontroller will be loaded with an algorithm to process the input data from sensors and control the water pump and the exhaust fan using a relay. Since the Node MCU ESP8266 is compatible with the Arduino platform, the control algorithm is implemented using the Arduino IDE; the algorithm will be discussed in the system operation section. Internet connectivity also enables the software and algorithm of the system to be updated remotely over the air (OTA). The DHT22 sensor provides the system input in the form of temperature and humidity value. DHT22 is accurate sensors, and more importantly, it is cheap, which makes it suitable for this project [14].

The system controls the water pump and exhaust fan which are running on AC power by using a 5V two-channel relay. When the system algorithm executes a corrective action for environmental regulation, the microcontroller will trigger the relay via GPIO. The relay will switch on or off the water pump and the exhaust fan based on the trigger from the microcontroller. To ease the operation and maintenance, the system will also be equipped with an LCD display that will be connected to the system via the Inter-Integrated Circuit (I2C) Protocol. The LCD will be able to display the current system status, uptime, and temperature and humidity value.

C. Web Client Interface

The web client provides users or stockholders of mushroom plantation with an interface that can be accessed by any mobile devices installed with a web browser. Since the system is connected to the Internet, any mobile device which has access to the Internet either via Wi-Fi or LTE connection will able to access the system using an IP address. The web interface will be displaying the real-time value of temperature, humidity inside of the mushroom house, and system uptime. Figure 3 shows the system's web interface.

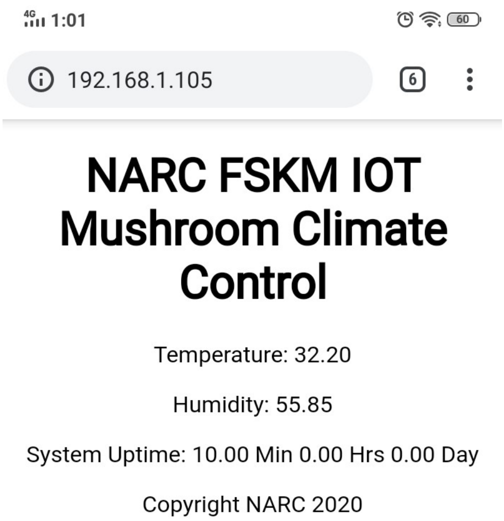

Figure 3. System Web Interface

III. SYSTEM OPERATION

The climate control system will take sensor reading as inputs, process it on the microcontroller based on the pre-defined algorithm, and take corrective action by activating the relay output. The overall system operation is shown in the flowchart in Figure 4.

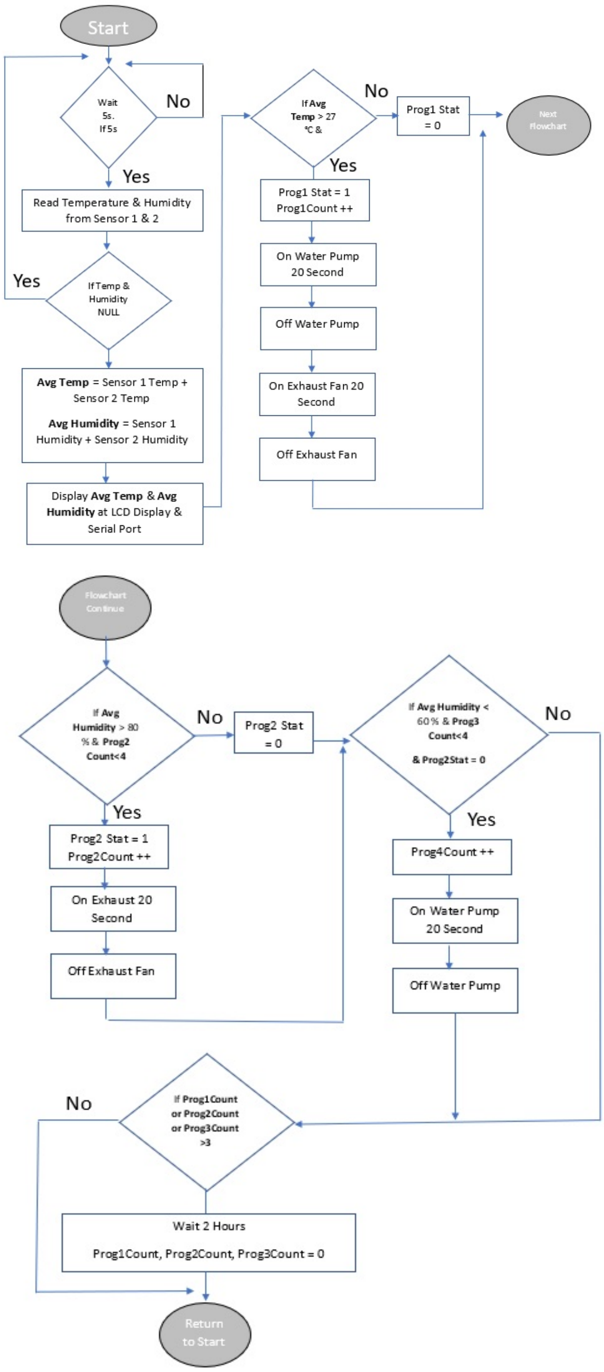

Figure 4. Overall System Operation Flow Chart

Based on the flowchart shown, the system work in a loop until the system is turned off. At the start, the system will wait for 5 seconds before taking a reading from the temperature and humidity sensor. This is because of some sensors, such as DHT22 only able to provide reading after a certain period [15]. After attempting to read the sensor data, if the value is NULL due to error, it will retry to read the data; this is part of the error detection mechanism. If the sensor value is not NULL, the system will calculate the average temperature and humidity value from multiple sensors. Based on the average values, the system will check and decide three sub-programs:

- Program 1 – If the average temperature exceeds the threshold of 27 °C, the system will turn on the water pump and exhaust fan via relay for 20 seconds to cool down the temperature of the mushroom house. Before the program ends, it will increase program 1 counter to keep track of how many times it has been executed.

- Program 2 – If the humidity level of the mushroom house environment exceeds 80% and program 1 is not currently running, the system will turn on the exhaust fan via relay for 20 seconds. Before the program ends, it will increase the program 2 counter to keep track of how many times it has been executed.
- Program 3 – If the humidity level of the mushroom house environment is less than 60% and program 1 and 2 is not currently running, the system will turn on water pump via relay for 20 seconds. Before the program ends, it will increase program 3 counter to keep track of how many times it has been executed.

Before the system return to start at the end of the loop, it will check whether program 1, 2, and 3 has been running more than three times. If it has been running more than three times, the system will enter the rest state to wait for 2 hours before resuming its operation. This ensures the system is not wasting water and electricity resources while implementing corrective action to reduce the temperature and humidity of the mushroom house. Moreover, running parallel in the system background is the IoT subsystem, which maintains web server connection and display sensors data to the external web client. The IoT subsystem is also displaying the current running program and system uptime to the web client. Figure 1 shows a Smart Mushroom House, where the critical environmental parameters are fully monitored and managed.

Figure 5. Mushroom bags in a Oyster Mushroom House.

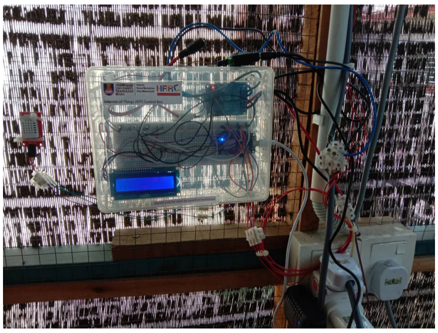

Figure 6. Control Unit

Figure 7. Control Unit

Figure 8. Water pump

Figure 9. Mist spray

IV. RESULTS

Figure 10 and Figure 11 show the results related to the average of temperature and humidity monitored for 6 days respectively. For each day, the temperature and humidity readings are taken 3 times, which is at 10 am, at 12 pm and at 2 pm. Then the average is calculated.

The graph in Figure 10 indicates that the temperature average is lower most of the day after implementing the IoT. Even though the reading of temperature average on day 5 is a bit higher, nevertheless overall reading is still lower. The same result appears in the humidity average graph in Figure 11, whereby the humidity is higher after implementing the IoT. These results proven that the iOT concept can be applied in maintaining and controlling the environmental requirement automatically for mushroom house implementation.

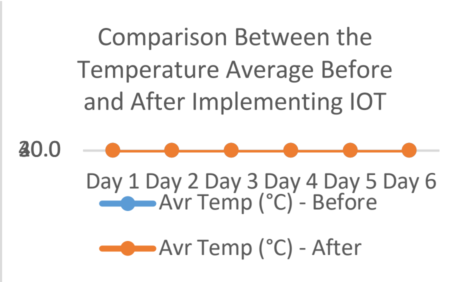

Figure 10. Comparison Between the Temperature Average Before and After Implementing the IOT.

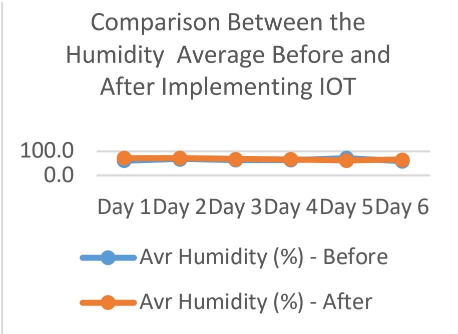

Figure 11. Comparison Between the Humidity Average Before and After Implementing the IOT.

V. CONCLUSION

In this paper we have designed and implemented the automatic climate control for mushroom house using IoT devices. The successful implementation of this system improve the productivity of mushroom farming especially the labour needed in monitoring and maintain the mushroom house environment requirement. The system is considered as self-sustained system, whereby it can be adopted by any "mushroom-preneur".

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