Chapter 12
Mushroom House Monitoring System at Pondok Seri Permai, Pasir Puteh, Kelantan

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Abstract In Malaysia, most farmers depend on traditional agricultural practice. The adaptation of modern agricultural technology plays an important role in improving the overall efficiency and productivity. In modern agriculture, the internet of things (IoT) connects farmers to their farms through sensors to facilitate monitor of real-time conditions of their farms from anywhere. Oyster mushroom is widely cultivated among farmers in Malaysian. Although this crop is widely consumed and cultivated, it remains overshadowed by traditional cultivation approaches which result in low productivity, high labor efficiency, high cost and effort. Thus, this study aimed to develop a monitoring system based on IoT on environmental conditions of a mushroom farm, namely temperature, humidity, moisture and light intensity. Oyster mushroom requires an optimum temperature between 26 and 29 °C, humidity from 85 to 95% and carbon dioxide not exceeding 600 ppm. Sensors were placed at fixed locations in the farm to measure the parameter status transmitted to a remote monitoring station via low-power NodeMCU. The data obtained were stored on the cloud platform. The codes for the controller were written in the Arduino programming language, debugged, compiled and burned into the microcontroller using the Arduino integrated development environment. The results showed the success of monitoring environmental conditions through internet access from anywhere. This approach will reduce human efforts and also help to automate production, which benefits farmers in Malaysia.

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12.1 Introduction

The purpose of this project is to monitor the environmental conditions such as temperature, humidity, carbon dioxide (CO_2) and lighting of the oyster mushroom farm at Pondok Seri Permai, Pasir Putih, Kelantan by using the internet of things (IoT). The IoT is a network of physical devices inserted with physics, software, sensors, actuators and properties that allows these objects to attach and exchange knowledge. Since such structures require refinement, a scientifically designed mushroom farm needs large investments which are consequently unaffordable by small and marginal mushroom farmers. In addition, mushroom units need to keep their air conditioners operating most of the year. For large oyster mushroom cultivation, we consider temperature, humidity, light and carbon dioxide. To reduce human effort and enhance yields, this system will provide a novel method of monitoring the farm. Food demand and space or land limitation for agro-economic activities highlight urban agricultural technology and it becomes one of the promising solutions to secure food supply. In addition, extreme weather and climate changes influence crop production, thereby increasing prices and lowering the crop quality produced [1].

Mushroom farming is time-consuming and requires precise methods. Mushrooms have a rough time reproducing if the conditions are not suitable. Most mushroom farmers in Malaysia use time-controlled humidifier, which is inconsistent in preserving humidity and temperature in their fields, resulting in lower productivity [2, 3, 10].

It grows best at an elevation of 800 m above sea level, with temperatures ranging from 16 to 22 °C and relative humidity levels of 60–90% [4, 5]. It is not difficult to cultivate mushrooms in the lowlands if the environment is built in accordance with the real mushroom ecosystem. Temperature, humidity, sun and fresh air are the four elements that make up the atmosphere setting [2]. The air flow of the mushroom growing chamber is critical as it directly influences the CO_2 content of the space [10].

A mushroom cultivation system that is integrated with technology that can detect and maintain environmental conditions that are required by the farmer. It is essential to implement a sensor-based environmental control system. The majority of mushroom farmers in Malaysia have small-scale operations with only few or no employees, and they do not operate 24 h a day [2]. The mushroom farm is almost always deserted. As a result, a remote monitoring system is required to monitor the condition of mushroom farms to avoid unfavorable conditions that could lead to mushroom death. To address the issues raised above, a system that can remotely monitor and regulate environmental conditions is needed [3, 10].

This study highlights the design of an interface circuit for agricultural sensors, namely light, carbon dioxide, temperature and humidity sensors. A remote monitoring system was also designed including a user interface to display accurate data from sensors and a closed-loop control system to maintain optimum mushroom growth conditions by controlling temperature, humidity and light. In addition, this paper presents an IoT-based monitoring and environmental condition control for oyster mushroom indoor cultivation. This is a smart urban farming system with less maintenance, less manpower and space saving [6, 7]. Moreover, this study intends to improve and enhance the conventional farming system in general. The use of IoT platform will improve the capability of current equipment for remote monitoring purpose and at the same time provide data logs for analysis and reference [8, 9].

12.2 Methodology

The oyster mushroom cultivation was carried out in a room with length of 30 m, wide of 15 m and height of 3 m inside a concrete building as depicted in Fig. 12.1. The wall was made of bricks and the roof of the room was constructed under the main concrete. Four rows of shelves were installed in the room; each shelf contained around 1000 blocks of mushrooms. A 3500 CMH ventilation system for each exhaust fan, 50 watts light for 3000 lumens and cooling pad were installed on the front building to bring air from outside to inside. All the devices installed in position outside the cultivation room were fixed by electrical and electronic devices to monitor temperature, humidity, CO_2 level and light intensity during the experimental procedure as seen in Fig. 12.2. Optimal ranges of temperature, light intensity, CO_2 and humidity for oyster mushroom cultivation were 26–29 °C, 200–500 lx level, 85–95% humidity and 600 ppm CO_2. The humidity and temperature were generated by the exhaust fan and cooling pad system as shown in Fig. 12.3. Light intensity was provided by fluorescent lamps. The ranges of normal conditions for oyster mushrooms indoor cultivation are summarized in Table 12.1.

Fig. 12.1 Inside the building

Fig. 12.2 Installation of irrigation and drainage systems

Fig. 12.3 Cooling system

Table 12.1 Parameters for oyster mushroom cultivation

Parameter	Range	Unit	Controlled equipment
Temperature	26–29	°C	Exhaust fan
Humidity	85–95	RH %	Cooling pad
CO_2	600<	ppm	Exhaust fan
Light	200–500	lux	Lamp

12.3 Software Implementation

In this project, the ESP32 controller was used as the main controller. It was a microcontroller with an integrated WIFI module. It was programmed using the C++ language with Arduino IDE software. All the sensor readings were captured by the ESP32 controller and displayed on the TFT display on the device and also sent to the server. The controller itself has a WIFI capability and was programmed to act as a WIFI client, thus enabling a direct connection to an available a WIFI Router with internet connection. An app known as Blynk was used as the IoT for this platform. The sensor data captured by the controller were sent to the Blynk server, and users can use the Blynk app to display the readings on an Android or iOS phone. Figure 4a, b show the algorithmic data transfer by ESP32 to the Blynk server and from Blynk server to the Blynk app, respectively. The data can be displayed in various types such as sensor value, graph, virtual meters and so on. The working block diagram of the whole system is displayed in Fig. 12.5.

Figure 12.6 depicts the schematic diagram of the greenhouse integrated with IoT. The main controller for this project was ESP32 DOIT DEVKIT V1. It was a 32-bit LX6 microprocessor with clock frequency of up to 240 MHz, supported Wi-Fi connectivity with 150 Mbps speed, supported both classic Bluetooth v4.2 and BLE specifications, 34 programmable GPIOs, up to 18 channels of 12-bit ADC and 2 channels of 8-bit DAC and last but not least serial connectivity including 4 × SPI, 2 × I2C, 2 × I2S, 3 × UART. The sensors used were DHT22 for temperature and humidity input, MH-Z14A infrared gas module for CO_2 reading and VEML7700 ambient light sensor to measure the lumen. The reading capability of the DHT22 sensor was in the range of 0–100% RH for humidity and −40–80 °C for temperature,

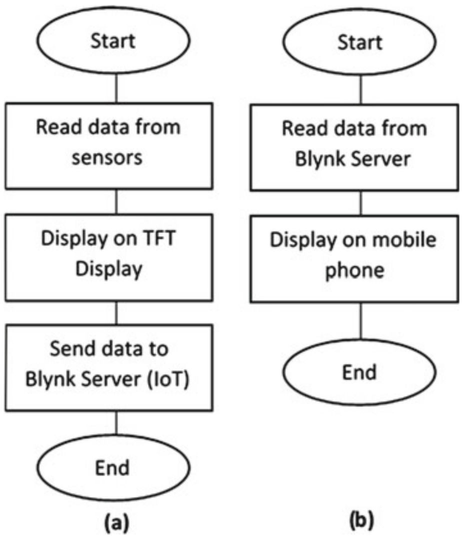

Fig. 12.4 Algorithm data transfer **a** ESP32 to server and **b** from server to application

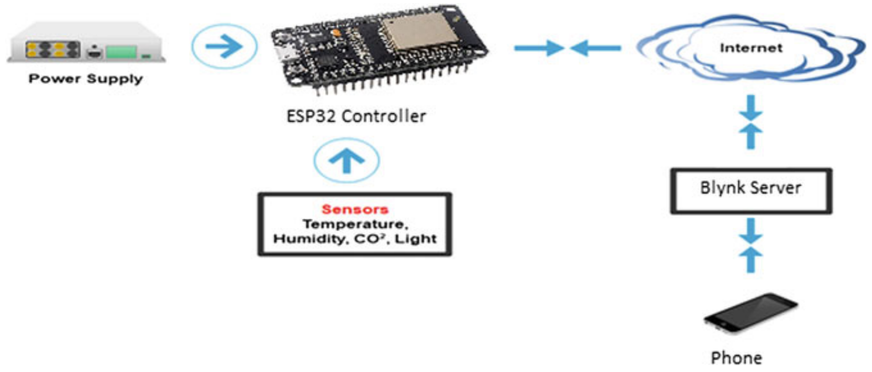

Fig. 12.5 System block diagram

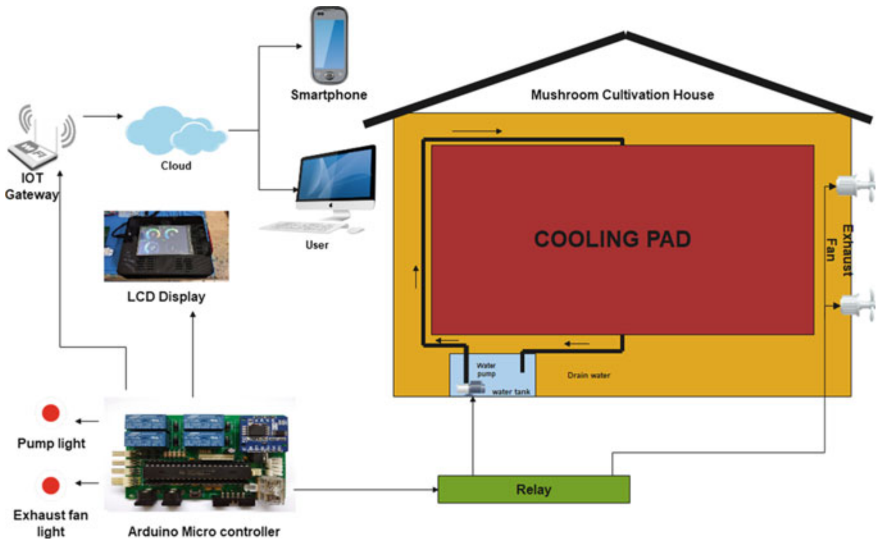

Fig. 12.6 Schematic diagram integrated green house

the MH-Z14A CO_2 sensor can measure up to 5000 ppm of carbon dioxide gas while the VEML7700 can read up to 167 k lux of ambient light. A 4″ TFT LCD was used as the display for the unit. The TFT display used graphical method, so the display was limitless compared to a characteristic LCD. All the main components are shown in Table 12.2. The supply used in this project was 5 V and 3.3 V. The system can obtain an actual time from the internet for timestamp but DS3231 RTC was also used as a backup. Figure 12.7 shows the display of the sensor readings and the controller unit.

Table 12.2 List of components

Main controller board and Wifi	ESP32 DOIT DEVKIT V1
Humidity and temperature sensor	DHT 22
CO_2 sensor	MH-Z14A infrared gas module
Light sensor	VEML7700 ambient light sensor
Display	4″ TFT LCD
RTC	DS3231

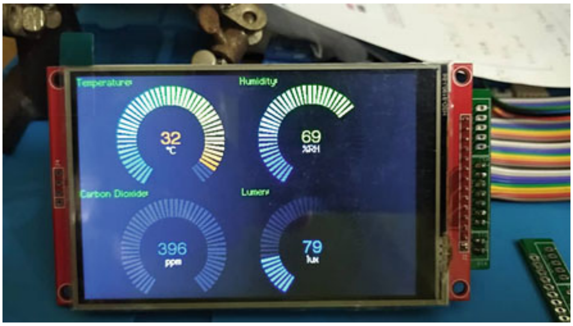

Fig. 12.7 System for environmental condition monitoring oyster mushroom indoor cultivation

12.4 Result and Discussion

This project reevaluates the concept among farms and agronomists. It is believed that IoT has revolutionized data monitoring, management and analysis. Temperature and humidity sensors were examined and the data obtained were sent to the IoT platforms for access and monitoring. Moreover, environmental parameters for mushroom farming require continuous monitoring. This system will play a crucial role in automation of mushroom cultivation. This project is beneficial for automation and monitoring of mushroom cultivation. It will also assist farmers in increasing agriculture yields and managing mushroom production efficiently. This system will also provide assistance to farmers to obtain proper live feed from ambient temperature and moisture with more accurate results with minimum manpower.

Figure 12.8 shows the graphical interface of the dashboard app used in the system. In this system, four parameters were monitored at a 10-min sampling rate, namely room temperature, relative humidity, light intensity and carbon dioxide. Figure 12.8 also shows the data with function of time which were obtained from the IoT server platform. Apart from using a browser, the data can be duplicated and monitored by users via third-party apps on android. This method provides flexible monitoring system to users. After implementing this system, the mushroom grew rapidly as shown in Fig. 12.9.

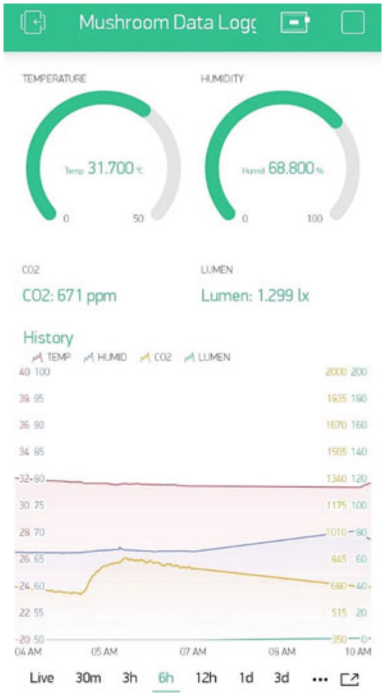

Fig. 12.8 User interface

Fig. 12.9 Oyster mushroom productivity after monitoring environmental conditions

12.5 Conclusion

In conclusion, monitoring and control of environmental conditions for oyster mushroom indoor cultivation were successfully conducted. The IoT-based monitoring system is an optimistic technology which can enhance the mushroom production based on the following reasons:

1. The system framework is based on open-source platform with low capital cost.
2. Easy and user-friendly for data migration.
3. The system is modular which can be expanded and easy to increase the number of data/sensors.

Nevertheless, this system has limitations that need to be considered, such as remote monitoring depending on the quality of internet connection which is currently not recommended. However, this can be resolved with the proposed system. In addition, hardware and internet data costs, operating costs (monthly/yearly) of cloud server platform should be considered as well. Many platforms are only free for personal or non-commercial use with limited access. Furthermore, data security on IoT is not undisclosed.

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