

Development of IoT-Based Temperature and Relative Humidity Monitoring System for Mushroom Cultivation House

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ABSTRACT

Mushrooms are one of the agricultural products that are in great demand because of their high nutritional content and healthy and delicious taste. Nowadays, mushroom cultivation is increasingly widespread and focuses on understanding the optimal environmental conditions for good mushroom production. The main parameters that affect the growth of fungi are the temperature and humidity of the environment, where the fungus will grow optimally at a temperature of 20 to 30°C and a humidity of 60 to 90%RH. But unfortunately, mushroom farmers often find it difficult to monitor at any time the environmental conditions where the mushrooms grow. For this reason, an IoT-based temperature and humidity monitoring system was developed for use in mushroom cultivation rooms. This system is assembled using a DHT11 temperature and humidity sensor, a NodeMCU ESP3866 microcontroller and WiFi module, and an LCD screen. IoT development is carried out using the Thinger.io platform which allows mushroom farmers as users to monitor room conditions directly through a web page. The efficiency of the IoT-based monitoring system in providing the appropriate growth conditions for mushroom cultivation, despite the existence of variable environmental factors, has been demonstrated. The system has been shown to measure temperature and relative humidity levels within the range of 19.4°C to 31.5°C and 43%RH to 82%RH, respectively.

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1. INTRODUCTION

However, in practice mushroom cultivation often has obstacles, one of which is the environment that cannot be monitored properly so that the quality of the mushrooms produced is not good. Besides that, mushroom farmers often experience crop failure when environmental conditions are not properly monitored [10,11]. With the advancement of technology, the internet of things (IoT) offers an opportunity to develop a more efficient and reliable monitoring system for mushroom cultivation houses. Therefore, it is necessary to develop a mushroom cultivation system that is integrated with technology that can monitor the environmental conditions of the mushroom growing media so that it is always in accordance with their habitat.

This article will discuss the development of an IoT-based temperature and relative humidity monitoring system for mushroom cultivation houses. This system utilizes state-of-the-art sensors and wireless communication technology to collect and transmit environmental data in real-time. The

collected data can be accessed remotely, allowing growers to monitor and control environmental conditions more effectively. The hope is, by accurately monitoring and controlling the environmental conditions, such as temperature and relative humidity, growers can achieve better crop yield, quality, and consistency. Additionally, this system can help reduce labor costs and minimize the risk of crop failure due to environmental factors, ultimately leading to a more sustainable and profitable mushroom cultivation industry.

2. SYSTEM DESIGN

This temperature and humidity monitoring tool is designed with a sensor device with a simple microcontroller and uses the Internet of Things (IoT) protocol. In more detail this system is described as follows.

2.1. System Overview

This temperature and humidity monitoring tool that was developed simply consists of several components, namely components of sensors, displays, microcontrollers, and wireless communication modules. Here, the sensor will sense the environmental conditions of the mushroom cultivation room. The sensor reading results will be displayed on a simple display screen near the device, and the data will be sent to the cloud server via the internet. Later, users will be able to see directly the results of sensor readings through the dashboard on the web page.

The working scheme of this system is shown in the block diagram in Figure 1 below.

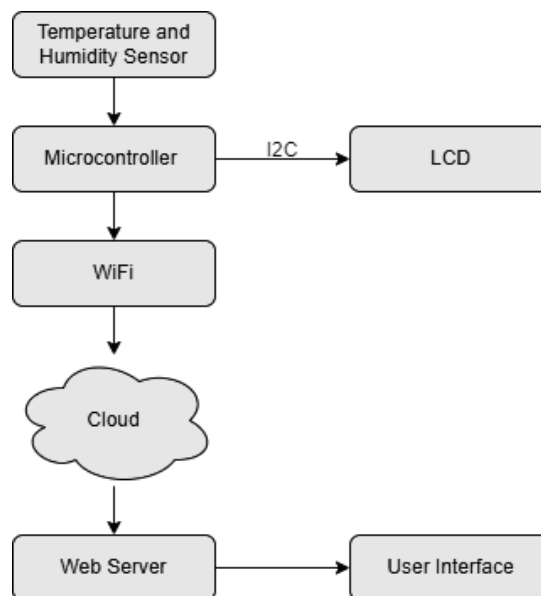


Figure 1. Block diagram of the proposed monitoring system

As shown in Figure 1, the sensor will sense the environmental conditions according to the parameters of temperature and relative humidity (RH) and transmit it to the microcontroller device. Here, the microcontroller will send data based on the I2C protocol to be displayed on the liquid crystal display (LCD). In addition, the microcontroller also sends data on the internet network via WiFi to the cloud and web server, to then display the sensor readings on the dashboard on the web page directly.

2.2. System Architecture

The design of this IoT-based temperature and humidity monitoring system encompasses a comprehensive structure that comprises several essential components, each of which serves a specific function and contributes to the overall functionality of the system. The architecture of this system consists of several constituent components, which are described in Table 1.

Table 1. Components Used in Sensor Board and Control Board

No.	Components	Remarks
1	NodeMCU ESP8266	Microcontroller and UART WiFi Module
2	DHT11	Temperature and relative humidity sensor
3	LCD I2C	Display
4	Micro USB	Power circuitry
5	Adapter	220 V (AC) to 5 V (DC)

As described in Table 1, the system comprises a NodeMCU ESP8266, which serves as both the microcontroller and the UART WiFi module. This low-cost microcontroller is widely used in IoT applications due to its compact size and built-in WiFi capabilities. The DHT11 temperature and relative humidity sensor is used to measure the temperature and relative humidity of the mushroom cultivation house environment, providing growers with accurate environmental data. The LCD I2C display serves as a visual interface that displays the current temperature and relative humidity data collected by the DHT11 sensor. The use of the Micro USB and the adapter, a 220 V (AC) to 5 V (DC) power adapter, provide the necessary power to the system.

These components are assembled on the board as shown in Figure 2.

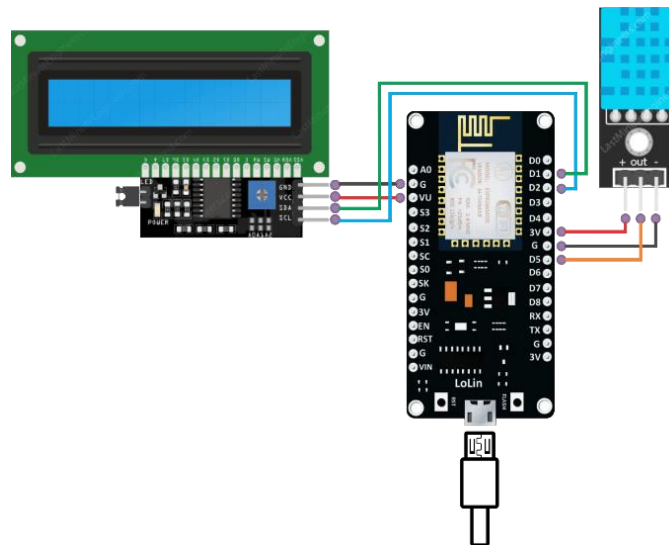


Figure 2. Wiring diagram of the temperature and humidity monitoring system on the NodeMCU module

The assembly of the five components, including the NodeMCU ESP8266, DHT11, LCD I2C, Micro USB, and Adapter, on the board as shown in Figure 2 enables the creation of a reliable and efficient IoT-based monitoring system for mushroom cultivation houses. The compact and streamlined design of the board ensures ease of use and integration with existing cultivation house infrastructure.

2.3. Cloud Configuration

The cloud used in this research is Thingier.io. This platform provides a ready to use cloud service for connecting devices to the Internet to perform any remote sensing or actuation over the Internet [12]. How Thingier.io works is shown in Figure 3.

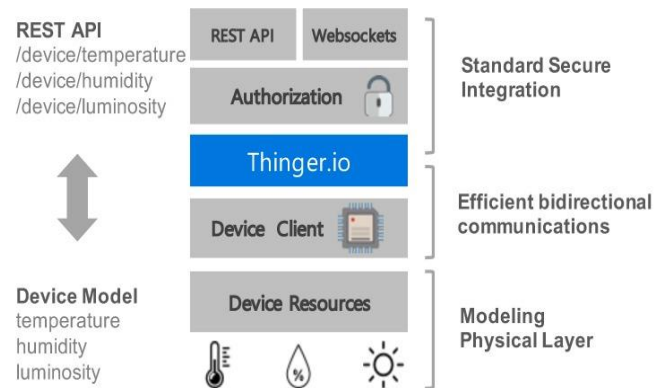


Figure 3. Mechanism of data transfer from device model with REST API [12]

Thinger.io platform allows device models to be defined which are automatically converted to REST APIs and can be deployed from any external application in real time.

3. RESULTS AND DISCUSSION

3.1. System Installation

The proposed system is installed in a mushroom cultivation house located in Cangkringan District, Sleman Regency, Yogyakarta Special Region Province, Indonesia. Sleman Regency itself is the largest mushroom producing area in the Special Region of Yogyakarta [2]. Here, the tool is installed in a mushroom house belonging to a small business private cultivator on a pole at the edge of the cultivation room. This installation is shown in Figure 4.

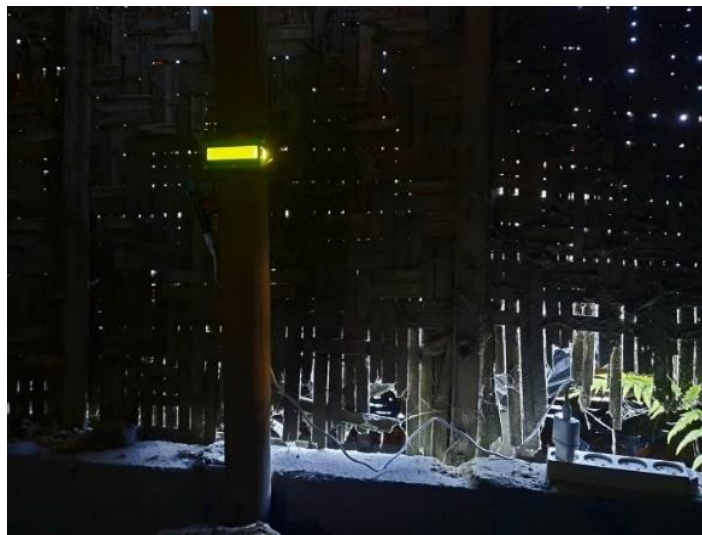


Figure 3. Installation of monitoring tools in mushroom cultivation house

3.2. Data Interfacing

The temperature and humidity monitoring system developed for mushroom cultivation rooms includes two types of displays: an on-site display using an LCD screen installed in the cultivation room and a virtual dashboard screen created on the Thinger.io platform. The LCD screen is designed to display the current temperature and relative humidity values based on the readings from the DHT11 temperature and humidity sensor, as well as an indicator showing the status of the WiFi network connection. The screen layout of the LCD display is depicted in Figure 5, providing users with real-time environmental data that can be used to adjust and optimize growing conditions for mushroom cultivation.



Figure 5. LCD screen display on mushroom cultivation house to display sensor readings and WiFi connection status

As shown in Figure 5, the LCD display not only shows the temperature and relative humidity readings obtained from the DHT11 sensor, but it also displays a WiFi network connection status indicator, which indicates whether the device is connected to the network or not. This indicator serves as a helpful feature for growers, as it allows them to quickly identify any connectivity issues with the device, such as intermittent connection loss, and take necessary measures to resolve them. The WiFi network connection status indicator on the LCD display provides growers with real-time information on the connectivity of the device, showing whether it is currently connected or disconnected from the network. This feature helps ensure that the data obtained from the device is accurate and reliable, enabling growers to make informed decisions based on real-time data.

In addition, sensor measurement results are also displayed on a dashboard created from the Thingier.io IoT platform. The dashboard displays sensor measurement results, which include temperature and humidity values, as well as graphs showing changes in temperature and humidity over the last 24 hours. Figure 6 illustrates the display of the dashboard. This allows for continuous and remote monitoring of the environmental conditions in the mushroom cultivation room, providing valuable data to ensure optimal growth conditions for mushrooms.

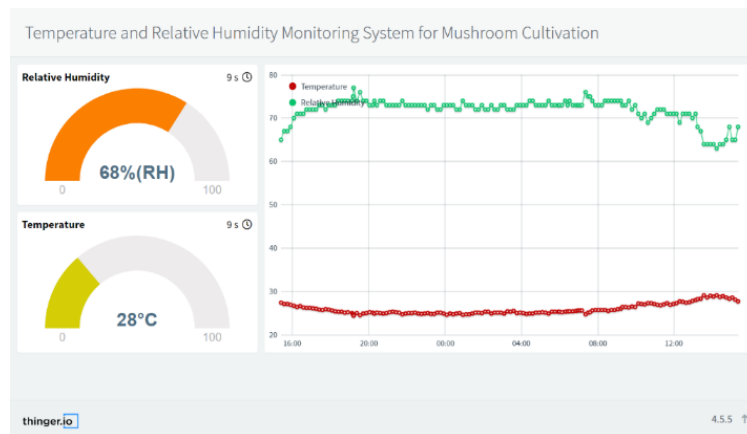


Figure 6. Dashboard display on the developed web page

The dashboard display created as part of this system has been evaluated by mushroom farmers who have reported finding it user-friendly and easy to read, allowing for easy access to the sensor measurement results through a web page interface. This feature enables farmers to quickly obtain valuable data on environmental conditions, which is essential for optimal mushroom growth. At the same time, the developers of this system can also continuously monitor its performance and status through the same platform, which can provide them with valuable information to improve the system's functionality and reliability.

The user-friendly dashboard display allows farmers to obtain an overview of the current environmental conditions in their mushroom cultivation room, including temperature and humidity readings, as well as graphs depicting changes over time. The continuous and remote monitoring capability of the system provides real-time updates on the room's conditions, enabling farmers to quickly

respond to changes and take action if necessary. The ability for developers to monitor the system's performance through the same platform also enhances the system's reliability, as they can identify and address any issues that arise promptly.

3.3. Data Measurement

The temperature and humidity monitoring tool that has been made has been installed in the mushroom cultivation house. For testing purposes, the temperature and humidity monitoring tool was installed in a mushroom cultivation house for 7 days, from August 10, 2022 to August 17, 2022. During this period, the temperature and relative humidity of the mushroom cultivation room were continuously measured using a data logger module on the Thingier.io platform.

To ensure the quality of the recorded data, a time step of 10 minutes was chosen to record the temperature and humidity levels in the mushroom cultivation house. This time step was selected because it is relevant to the mushroom cultivation process, where sudden changes in temperature and humidity can adversely affect mushroom growth. The temperature and humidity data collected were then presented as daily graphs, as shown in Figure 7 and Figure 8, respectively. These graphs provide a detailed view of the daily temperature and humidity variations, which can be useful in optimizing the growth conditions for mushrooms.

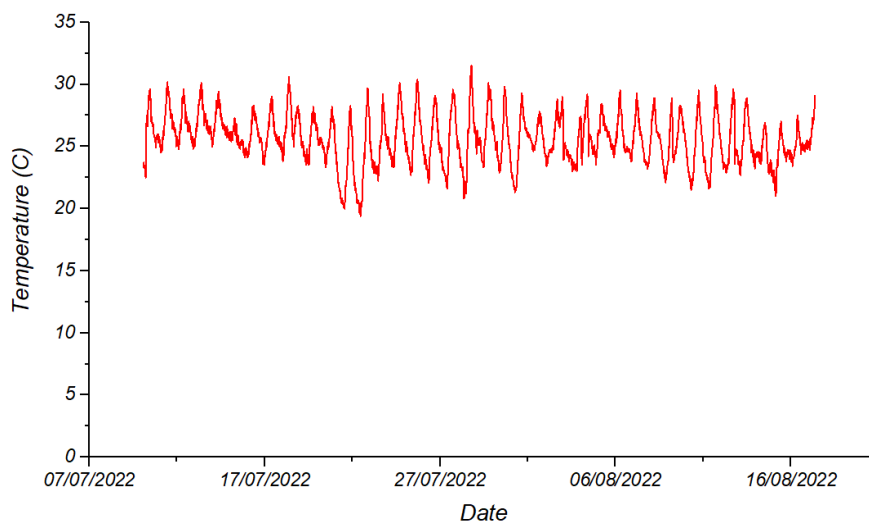


Figure 7. Daily graph of temperature in mushroom cultivation room

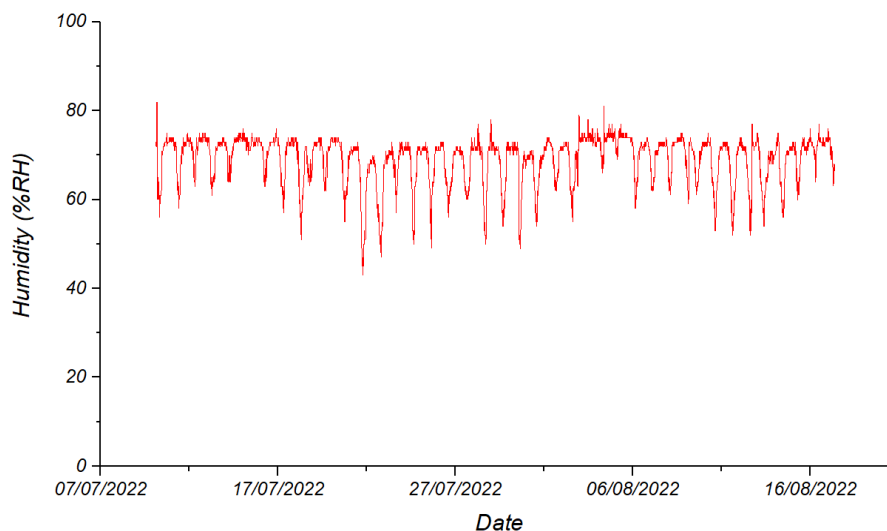


Figure 8. Daily graph of relative humidity in mushroom cultivation room

According to the data presented in Figure 7 and Figure 8, the measured temperature and humidity in the mushroom cultivation house are in the range of 19.4 °C to 31.5 °C and 43%_{RH} to 82%_{RH}, respectively. These measurements are well within the recommended range for mushroom cultivation, which typically requires a temperature range of 20 to 25 °C and relative humidity between 70% to 90%. The accuracy and consistency of these measurements are essential to ensure optimal growing conditions and prevent the growth of harmful microorganisms.

Furthermore, the measured temperature and humidity in the mushroom cultivation house are relevant to the local climate conditions. The temperature and humidity levels in the mushroom cultivation house must be monitored and controlled to compensate for fluctuations in the local climate, such as changes in temperature and humidity due to weather patterns or seasonality. By monitoring and controlling the environmental conditions in the mushroom cultivation house, growers can ensure a stable and consistent growing environment, regardless of external climate conditions. Overall, the data presented in Figure 7 and Figure 8 demonstrate the effectiveness of the IoT-based monitoring system in maintaining optimal environmental conditions for mushroom cultivation, even in the face of changing environmental conditions.

4. CONCLUSION

The design and implementation of a temperature and humidity monitoring system for mushroom cultivation using the IoT platform is already presented. Sensor readings in the form of temperature and humidity parameters obtained from the DHT11 sensor are sent to the NodeMCU ESP8266 and displayed on the LCD screen and virtual dashboard on a web page developed on the Thingier.io IoT platform. The experimental results obtained indicate that in general the system can run well and can sense, record data, transmit, and display data on both displays. The IoT-based monitoring system has been shown to be highly effective in ensuring the optimal growth conditions for mushroom cultivation, even in the presence of fluctuating environmental variables. Seeing its promising performance and very helpful for mushroom farmers, further development is needed to connect it to the sensor network and integrate it with the actuator system.

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