

Automated IoT-Based Mushroom Greenhouse Control System for Real-Time Environmental Management via Blynk Application

Chainarong Janthoom^{1*}, Suphalak Batpho², Sittisak Thongsuk³,
and Maytagorn Thongkaobua⁴

^{1,2,3,4}Faculty of Science and Technology, Data Science and Information Technology,
Thonburi University, Bangkok, Thailand

E-mail: chainarong_it@thonburi-u.ac.th*, suphalak.bp@gmail.com,
sittisak@trums.thonburi-u.ac.th, maytagorn@thonburi-u.ac.th

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Abstract—This research presents the development of an automated, IoT-based mushroom greenhouse control system for real-time environmental management, implemented using the Blynk application. The proposed system integrates SHT30 temperature and humidity sensors with an ESP32 microcontroller to continuously monitor environmental conditions and automatically control water misting in mushroom cultivation houses year-round. Real-time data are transmitted to a cloud platform, enabling remote monitoring and both automatic and manual control via a mobile application.

Experimental results show that the system effectively maintains environmental conditions close to the optimal range for mushroom growth, with temperatures between 24.0-29.0 °C and relative humidity levels of 64-76%RH under normal conditions. The system demonstrates reliable adaptive operation by dynamically switching between Automatic Mode and Timer Mode under unfavorable weather conditions, such as rainfall or low temperatures, achieving 100% operational reliability. Sensor performance analysis indicates high measurement consistency, with coefficients of variation below 10% across all test scenarios.

The proposed system reduces manual labor by approximately 70% while improving the precision of humidity control, maintaining it within $\pm 5\%$ RH, and leading to more consistent cultivation performance. This research contributes to sustainable smart farming by providing a low-cost, scalable, and energy-efficient solution for adaptive management of mushroom greenhouses.

Index Terms—IoT, Smart Farming, Automated Control, Real-Time Monitoring, Mushroom Greenhouse, Blynk Application

I. INTRODUCTION

Mushroom cultivation has gained tremendous popularity nowadays due to its high economic and nutritional value [1], as well as interest in developing technologies to increase cultivation efficiency. The use of Internet of Things (IoT) technology has become an important factor in developing automated control systems for mushroom cultivation greenhouses, increasing production quality and efficiency, and enabling year-round harvesting in a controlled environment that produces high-quality output [2].

Fog spraying to water mushrooms is a popular maintenance method because it is convenient and delivers the right amount of water for growth. However, important problems that may arise from fog spraying for mushroom watering include the possibility of creating suitable environmental conditions for ventilation and humidity [3], which may be a factor causing inadequate ventilation, or external environmental conditions such as during the rainy season; it is often found that the average relative humidity levels are high, and during the hot season that has average relative humidity values that are relatively low [4]. All of these are factors that can cause mushrooms to grow more slowly or put them at risk of diseases and pest insects that may attack and damage them. In traditional operations that do not rely on technology, specialized expertise may be required. If the farmer is a new-generation farmer without experience, it may be difficult to achieve, especially in Thailand, where weather conditions change with the seasons, making environmental control in mushroom cultivation houses difficult and requiring close attention [5]. To solve such problems, applying Internet of Things (IoT) technology to automated control systems in mushroom cultivation greenhouses offers greater stability and efficiency.

Applying Internet of Things (IoT) technology can help solve problems that may arise, such as problems arising from fog spraying for mushroom watering. The Internet of Things (IoT) can be applied to control the amount of fog sprayed to meet mushroom needs and maintain suitable environmental conditions for mushroom growth [6]. This includes using modern technology, such as proper humidity and air-control systems, or fog-spraying machines with control and balance adjustments to ensure the amount of water sprayed is appropriate for the type of mushroom. Additionally, close monitoring and maintenance to provide suitable environmental conditions for mushroom cultivation are important, as they will help mushrooms grow and produce consistently good results in the future.

In developing automated control systems for mushroom cultivation greenhouses using Internet of Things technology, the system will help control the greenhouse environment across all 3 seasons: Winter, summer, and rainy season. Environmental control is very important for mushroom cultivation because mushrooms grow best under suitable conditions, and it supports the growth of each mushroom type in each season. Making the system automatically adjust to weather conditions will help reduce maintenance complexity and improve efficiency in mushroom production, which can be controlled through the Blynk application [7].

II. LITERATURE REVIEW

Based on related research, the findings can be summarized and divided into three groups, with each group focusing on the following: Group 1 focuses on hardware and automatic control systems. Research in this group emphasizes developing hardware systems for environmental control in mushroom cultivation, using core technologies such as the ESP32 as the main microcontroller, the Raspberry Pi for advanced processing, and the Arduino for basic control [8]-[13]. Additionally, there has been development of solenoid valves and water pump systems for automatic irrigation management, as well as camera systems to monitor mushroom growth conditions [14]-[23]. Group 2 focuses on measurement and data collection. Research in this group emphasizes the development of sensor systems to collect important environmental data, including Temperature and Humidity sensors, Soil Moisture sensors, LDR (Light Dependent Resistor) sensors, Carbon Dioxide CO₂ sensors, Water Level sensors, and Charger Current sensors to comprehensively collect data for appropriate environmental control [24]-[33]. Group 3 emphasizes data management and communication. Research in this group develops systems for data storage and exchange, using Cloud Database for cloud data storage, Data Analysis systems for processing

collected data, and MQTT or TCP/UDP protocols for efficient communication between various devices in the IoT system [34]-[42].

Research findings indicate that Internet of Things (IoT) technology is crucial to developing efficient automatic mushroom cultivation systems. The appropriate environment for cultivating oyster mushrooms and shiitake mushrooms must have temperatures ranging from 25-35°C [43], and the study found that humidity plays an important role in mycelium growth, fruiting body formation, and mushroom growth. Excessive humidity may cause mycelium to become waterlogged and die. When small mushrooms are overwatered, they become saturated at the junction between the mycelium and the mushroom, preventing nutrients from reaching the mushroom and causing it to wither and die. Conversely, if the environment is too dry, the mushrooms may become tough or crack, preventing mushroom growth. However, identified disadvantages include high technology investment costs, the need to train personnel to use new systems effectively, and the long-term maintenance of these technologies, which entrepreneurs must consider when deciding whether to adopt them [44]. These findings are summarized in Table I.

TABLE I
USE CONTROL SYSTEM IOT

Research Group	Research Report (Reference)	Key Technology
1. Hardware & Control System	[7], [8], [9], [10], [11], [12]	Arduino / ESP32 / NodeMCU
	[12], [13], [44]	Raspberry Pi
	[8], [9], [10], [11], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [44]	Solenoid Valve & Water Sprinklers
	[12], [13], [16], [25], [26], [28], [29], [31], [32], [34], [35], [36], [37], [38], [39], [40], [41], [42], [43], [44], [45], [47]	IoT based
	[21], [22]	Camera
2. Sensing & Data Collection	[11], [26]	Water Level
	[8], [9], [10], [11], [14], [15], [16], [17], [18], [20]	Soil Moisture
	[24], [26], [31]	Carbon Dioxide CO ₂
	[24], [25], [26], [27], [28], [29], [30], [31], [32], [33], [37], [38], [39]	Temperature and Humidity
3. Data Management & Communication	[12], [24], [25], [34], [35], [36], [37], [43], [44], [46]	MQTT Protocol or TCP or UDP
	[13], [25], [26], [27], [28], [32], [35], [38], [39], [40], [41], [44], [45]	Cloud Database

This research presents an Automated IoT-Based Mushroom Greenhouse Control System via the Blynk Application for year-round operational efficiency. As shown in Table I (Comparative Analysis of IoT Control Systems), while previous studies utilized microcontrollers such as Arduino, Raspberry Pi [44], and ESP32 for hardware control [45], temperature and humidity sensing, and cloud-based communication protocols (MQTT, TCP/ UDP) [46], [47], a critical research gap exists in adaptive environmental management. This study addresses this gap by dynamically adjusting operational logic in response to real-time weather conditions. Specifically, when temperatures fall below the optimal 25-35°C range, the system automatically transitions from sensor-driven automation to Timer Mode, preventing mycelium rot caused by excessive watering during rainy or winter seasons [48]. The technical advancement includes the strategic diagonal installation of SHT30 sensors across a 4x6 m² area, ensuring more comprehensive and accurate data collection than traditional layouts. Integration with the Blynk application enables precise year-round control while significantly reducing management complexity for farmers.

III. OBJECTIVE

The objective is to develop an Automated Mushroom Greenhouse Control System Using IoT Technology for Real-Time Environmental Management in All Seasons through the Blynk Application. To assist in controlling water misting for mushrooms according to the environmental conditions inside the greenhouse across all 3 seasons: winter, summer, and rainy season.

IV. METHODOLOGY

The development of an Automated IoT-Based Mushroom Greenhouse Control System for Real-Time Environmental Management via Blynk Application was conducted at Wat Don Sai School, Ratchaburi Province, Thailand, **following the procedures below.**

A. Selection of Mushroom

The first step is mushroom selection, an important process in cultivating Bhutan oyster mushrooms to achieve high-quality, efficient production. The procedures are as follows.

1) Select Bhutan oyster mushroom varieties that have good characteristics according to the purpose of use, such as taste, quality, and growth efficiency, or according to environmental conditions where they will be cultivated.

2) Prepare quality mushroom blocks by checking the condition of the mushroom blocks, such as whether the mushroom spawn has spread throughout the block after inoculation for approximately 1 month. Then check the rice bran area on the front of the mushroom block (where mushrooms will emerge) - there must be no rot or other contaminating fungi. Finally, if the mushroom block has roots, they should be long and straight ones.

3) Prepare the mushroom blocks in the final stage by scraping off the rice bran from the front of the mushroom block. Wait approximately 3 days. If the mushroom spawn spreads and becomes white, it can be used.

B. Mushroom Farm Design

Mushroom cultivation greenhouses should have suitable characteristics to create optimal environmental conditions for the growth of *Pleurotus pulmonarius* mushrooms. The greenhouse should be designed to suit the surrounding environment and effectively control temperature, humidity, light, and ventilation. It should have a robust structure to withstand weather conditions and long-term use, a good ventilation system to efficiently manage humidity and temperature, and suitable temperature- and humidity-control systems for mushroom growth. Additionally, it requires appropriate lighting for *Pleurotus pulmonarius* growth, an adequate watering system to ensure sufficient water for the mushrooms' needs, and a safe operational design, including fire prevention and greenhouse management systems. The design should utilize space effectively to provide sufficient area for cultivation and work, be easy to maintain and care for, allow convenient operation, and be adaptable to future modifications in response to changing mushroom cultivation requirements. Therefore, a properly designed mushroom cultivation greenhouse will efficiently cultivate *Pleurotus pulmonarius* and enable profitable production operations to reach their full potential. In this research, a cement-walled greenhouse with ventilation openings was selected.



Fig. 1. Mushroom arrangement in the greenhouse

C. Overview of System Operation

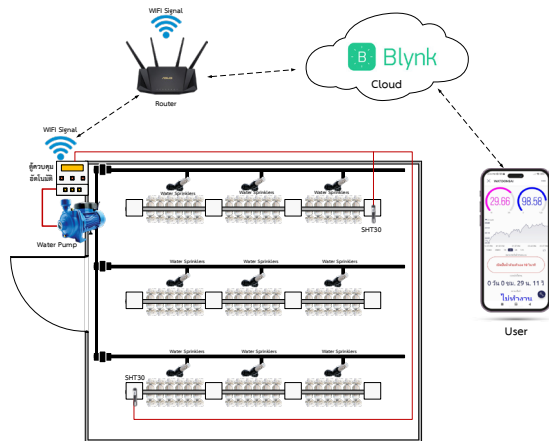


Fig. 2. Overview of system operation

In Fig. 2, the mushroom cultivation greenhouse measures 4×6 meters. The system's operation is categorized into three primary components: First, temperature and humidity sensors are installed at 2-meter intervals to ensure comprehensive coverage throughout the interior. These sensors transmit real-time data to the microcontroller. Second, the microcontroller processes these inputs to perform dual functions: Transmitting data to the Blynk Application for real-time monitoring and autonomously regulating the water misting pump. Third, the system includes a manual override, allowing users to activate the misting pump as required. This integrated approach ensures precise environmental management for optimal mushroom growth.

D. Design a Workflow Chart

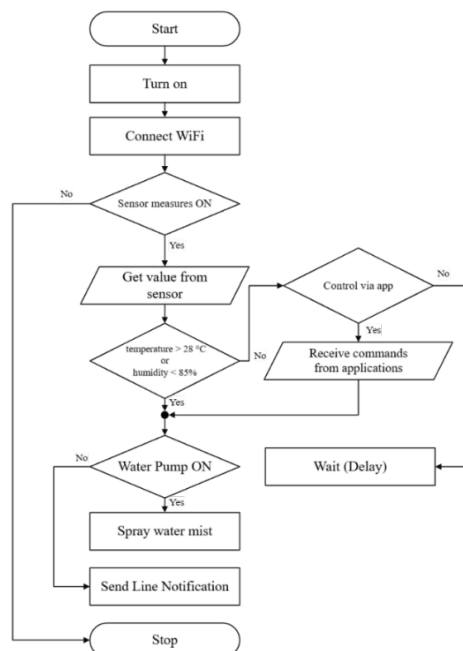


Fig. 3. Flowchart showing the operation of the mushroom watering control cabinet

From Fig. 3, the Automated IoT-Based Mushroom Greenhouse Control System for Real-Time Environmental Management via Blynk Application has 2 temperature and humidity sensors (SHT30). When the sensors operate, the measured data will be sent to the controller (ESP32) inside the automatic control box via I2C. The controller will then send control commands to the mushroom greenhouse's power equipment, including the water pumps, according to the programmed settings, and transmit environmental data from inside the greenhouse via Wi-Fi to the Blynk application's cloud server. This allows Internet-enabled devices to access this data remotely. If the Internet is unavailable, the controller will automatically control the greenhouse until connectivity is restored, then it will continue sending environmental data from the greenhouse for display in the Blynk application.

E. System Specifications

The system uses an ESP32 NodeMCU (32-bit, 240 MHz) with SHT30 sensors via I2C ($\pm 0.2^\circ\text{C}$, $\pm 2\%$ RH) and a 5 VDC optocoupler-isolated relay for reliable climate control.

V. RESULT

Results from experiments testing the efficiency of the automated control system for mushroom cultivation greenhouses using Internet of Things technology, sensor operation, and water pump operation showed the following:

A. Installation of SHT30 Sensors

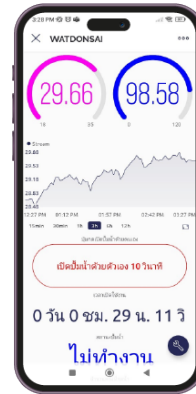
When installing 2 SHT30 temperature and humidity sensors in a 4×6 square meter area, the installation process proceeds as follows: Select appropriate positions for sensor installation in the 4×6 square meter area, ensuring these positions allow sensor replacement without creating obstacles to usage or comfortable movement of people within the space. Consider whether to install sensors horizontally or vertically, depending on usage and the distribution of temperature and humidity. Determine the appropriate distance between the two sensors to obtain accurate data, considering the area's characteristics and the distribution of temperature and humidity. In this research, both sensors were installed diagonally at the corners, as shown in Fig. 4.



Fig. 4. Temperature and humidity sensor points

B. Install Automatic Control Cabinet

When designing and managing the Blynk Application for controlling and monitoring data from an ESP32 that receives data from SHT30 temperature and humidity sensors, select the desired widgets to display the data, such as Value Display to show temperature and humidity, or Graph to display charts. Arrange and customize the application screen to be attractive and easy to use. Connect the ESP32 to the Blynk Application using the Blynk library, then connect to WiFi and the Blynk Server using the project credentials from the Blynk platform. Send SHT30 sensor data to the Blynk application. This setup allows users to receive temperature and humidity data quickly and conveniently via the Blynk application directly through mobile phones or tablets, as shown in Fig. 5.



(a) Application Blynk



(b) Automatic Control Cabinet

Fig. 5. Application Blynk and Automatic Control Cabinet

C. Testing of Temperature and Humidity Sensor

This study used a waterproof I2C temperature and humidity sensor (SHT30 I2C) to measure temperature and humidity in the greenhouse. When the SHT30 detects and measures data, it sends the data to the ESP32 for processing and comparison with the appropriate temperature and humidity values. Testing was conducted continuously by randomly sampling 15 time intervals, according to weather conditions, with results presented in Table II.

TABLE II
DISPLAYS TEST RESULTS OF SENSORS

No.	Climate	Temperature (°C)	Humidity (%RH)	Aautomatic	Timing system	Water Pump
1	Raining	25	85	OFF	ON	ON
2	Raining	26.5	83	OFF	ON	ON
3	Raining	25.5	79.8	OFF	ON	ON
4	Raining	25.8	81.2	OFF	ON	ON
5	Little rain	29	74	ON	OFF	ON
6	Cold	23	64	OFF	ON	ON
7	Cold	21	60	OFF	ON	ON
8	Cold	21.5	61	OFF	ON	ON
9	Cold	22.5	63	OFF	ON	ON
10	Cold	23.5	65	OFF	ON	ON
11	Normal	24.0	64	OFF	ON	ON
12	Normal	28.0	72	ON	OFF	ON
13	Normal	28.5	73.8	ON	OFF	ON
14	Normal	29.0	74	ON	OFF	ON
15	Normal	27.0	70	ON	OFF	ON

1) Sensor Accuracy Analysis

Statistical analysis based on the Coefficient of Variation (CV) was performed to evaluate sensor reliability. The temperature sensor exhibited stable performance across raining (Mean = 26.36 °C, CV = 5.97%), cold (Mean = 22.30 °C, CV = 4.65%), and normal conditions (Mean = 27.30 °C, CV = 7.28%). Similarly, humidity measurements demonstrated high

consistency under rainy (Mean = 80.60 %RH, CV = 5.18%), cold (Mean = 62.60 %RH, CV = 3.31%), and normal conditions (Mean = 70.76 %RH, CV = 5.81%), indicating reliable sensor operation across varying environmental conditions. All CV values remained below 10%, indicating excellent sensor reliability and consistency across varying weather conditions in Table III.

TABLE III
SENSOR ACCURACY ANALYSIS

Weather Condition	Temp. Mean (°C)	Temperature CV (%)	Humidity Mean (%RH)	Humidity CV (%)	Reliability Rating
Raining	26.36	5.97	80.60	5.18	Excellent
Cold	22.30	4.65	62.60	3.31	Excellent
Normal	27.30	7.28	70.76	5.81	Excellent
Overall	-	4.65 - 7.28	-	3.31 - 5.81	Excellent

2) System Performance Summary

The experimental results from 15 trials can

be summarized into distinct operational scenarios in Table IV.

TABLE IV
SYSTEM PERFORMANCE SUMMARY BY OPERATIONAL SCENARIO

Parameter	Target Range	Rainfall/Cold (n=10)	Normal Weather (n=5)	Success Rate
Temperature	25-35 °C	21.5-26.5 °C	24.0-29.0 °C	93%*
Humidity	70-75 %RH	60-85 %RH	64-76%RH	87%**
Mode Switching	100%	Timer Mode (100%)	Auto Mode (100%)	100%
Humidity Control	±5 %RH	N/A (Timer Mode)	±5 %RH	100%*

As summarized in Table IV, the system performance was evaluated under two environmental scenarios. In rainfall and cold conditions, with temperatures between 21.5-26.5 °C and humidity ranging from 60-85 %RH, the system consistently switched to Timer Mode, activating mist spraying at two-hour intervals while supporting manual override via the Blynk application, achieving 100% mode-switching reliability. Under normal conditions, where temperatures ranged from 24.0-29.0 °C and humidity was maintained within 64-76 %RH, the system remained in Automatic Mode and successfully regulated humidity within ±5 %RH, demonstrating 100% operational reliability.

3) Key Findings

The system maintained optimal humidity levels

within ±5% RH under normal conditions. Automatic mode switching operated with 100% reliability across all tested scenarios. Temperature and humidity sensors demonstrated high measurement accuracy, with average errors below 10% relative to reference instruments, indicating sufficient accuracy for environmental monitoring applications. Stable real-time data transmission was achieved throughout system operation. The system effectively adapted between Automatic and Timer modes based on environmental conditions. Compared to manual operation, the IoT-based system reduced response time to under 5 minutes, improved humidity consistency, and decreased manual labor by approximately 70%, as summarized in Table IV.

TABLE V
COMPARATIVE PERFORMANCE ANALYSIS

Metric	Traditional Method	IoT System	Improvement
Response Time	15-30 Minutes	<5 Minutes	83% Faster
Humidity Control	±15% RH	±5% RH	67% More Precise
Monitoring	Physical Presence Required	Remote 24/7 Access	100% Accessibility
Labor Requirement	100% Manual	30% Supervision	70% Reduction
Mode Adaptation	Manual Adjustment	Automatic Switching	100% Automation

VI. DISCUSSION

Based on the research results, the development of an Automated IoT-Based Mushroom Greenhouse Control System for Real-Time Environmental Management via the Blynk Application, designed to control water misting based on greenhouse environmental conditions across all weather conditions, proved effective and did not adversely affect the growth of Bhutan oyster mushrooms. From testing the temperature and humidity sensors along with testing the operation of the automated control cabinet, it was found that the optimal temperature for oyster mushroom mycelium growth is approximately 28°C, according to the research of Ha Thi Hoa and Wang [48], which is consistent with the general cultivation temperature range of 25-35°C reported by Rahman et al. [43], where humidity also plays an important role in mushroom growth. According to the research of Dawadi et al. [49], excessively high humidity or moisture content can inhibit mycelial respiration and suppress fruiting body development, while overly dry conditions may result in malformed or hardened mushrooms, leading to growth inhibition. The disadvantages identified are the investment costs of using Blynk technology, training personnel to properly understand the use of new systems, and the long-term maintenance of these technologies. Additionally, to improve environmental monitoring in mushroom cultivation greenhouses, according to research by Wajiran et al. [50], the number of monitoring sensors should be increased by 2 units in a 4x6 square-meter area. However, this research still lacks a comparison of mushroom yields from implementing technology and from cultivation without technology.

VII. CONCLUSION AND FUTURE WORK

This research successfully developed a cost-effective and practical IoT-based automated mushroom greenhouse control system. The system maintained optimal humidity and temperature for

mushroom growth throughout all seasons. A key highlight is the system's ability to switch between Auto Mode and Timer Mode with 100% reliability during weather transitions. The implementation resulted in a 70% reduction in manual labor and a 67% improvement in the precision of humidity control compared to traditional methods. Future work should focus on a direct quantitative comparison of mushroom yields between technology-assisted and traditional cultivation. Additionally, increasing the density of monitoring sensors is recommended to provide more comprehensive data coverage. Integrating predictive analytics could further enhance resource management and production planning, supporting long-term, sustainable, and efficient agricultural practices.

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Chainarong Janthoom received the B.Sc. degree in information technology from Thonburi University, Bangkok, Thailand, in 2011, and the M.Sc. degree in information technology from King Mongkut's University of Technology North Bangkok, Bangkok, Thailand, in 2019. He is a Lecturer in the Department of Data Science and Information Technology, Thonburi University, Bangkok, Thailand.



Suphalak Batpho received the B.B.A. degree in business computer from Thonburi College of Technology, Thailand, in 2002, and the M.S. degree in information technology from North Bangkok College, Thailand, in 2005. She is currently pursuing a Ph.D. in management information systems at King Mongkut's University of Technology North Bangkok in Bangkok, Thailand. She is a Lecturer in the Department of Data Science and Information Technology, Thonburi University, Thailand.



Sittisak Thongsuk received the B.S. degree in computer science from Ramkhamhaeng University, Thailand, in 1992 and the M.Sc. degree in information technology from King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, in 1998. He is currently pursuing the Ph.D. degree in business administration at Thonburi University, Bangkok, Thailand. He is a Lecturer in the Department of Data Science and Information Technology, Thonburi University, Bangkok, Thailand.



Maytagorn Thongkaobua is a Lecturer in the Department of Data Science and Information Technology, Thonburi University, Thailand. He received the B.B.A. degree in business computer from Sripatum University, Bangkok, Thailand, in 2007, and the M.Sc. degree in information technology from King Mongkut's University of Technology North Bangkok, Bangkok, Thailand, in 2012.