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Smart Mushroom Cultivation Integrating IoT with Thing Speak Cloud

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ABSTRACT: An intelligent method for tracking the conditions in a mushroom farm's rooms is described in this study. Using the proper sensors, the system monitors the temperature, humidity, light, and CO₂ level. In order to do this, the ESP32 Wi-Fi module and the DHT11 temperature and humidity sensor are combined to form IoT (Internet of Things) sensors that transmit large amounts of data to the internet for monitoring and evaluation. The acquired information can be used to regulate the nursing room's environment with the use of external appliances like an air conditioner, exhaust fan, light bulb, and water pump. A web-based and android application has been created to make system monitoring easier. To maintain and regulate the ideal atmosphere, the software program enables automation and remote control of the external devices.

KEYWORDS: IoT System, Mushroom, Smart, DHT11 Sensor Monitoring System, Better yield

I. INTRODUCTION

Mushroom cultivation represents a captivating fusion of nature's wonders and human ingenuity, where meticulous attention to environmental factors is key to unlocking the full potential of fungal growth. Within the intricate dance of mycelial expansion, fruiting body development, and harvest, temperature, humidity, air quality, and sunlight emerge as pivotal orchestrators. This expansive passage delves into the art and science of mushroom cultivation, elucidating the ideal ranges for each environmental variable and their profound impact on the cultivation process.

Temperature, a fundamental driver of metabolic activity and enzymatic processes, profoundly influences the growth and development of mushrooms. Across various species, optimal temperature ranges exist, guiding growers towards the ideal conditions for success. Generally, temperatures between 55°F to 75°F (13°C to 24°C) foster vigorous mycelial growth and fruiting. For instance, the button mushroom (*Agaricus bisporus*) thrives within the range of 60°F to 70°F (15°C to 21°C), while oyster mushrooms (*Pleurotus* spp.) prefer slightly cooler conditions ranging from 55°F to 65°F (13°C to 18°C). Maintaining consistent temperatures within these ranges throughout the cultivation cycle is paramount for maximizing yields and quality.

Humidity, a critical determinant of moisture availability and fungal vitality, plays an indispensable role in mushroom cultivation. Most mushroom species thrive in environments with high relative humidity (RH), typically ranging from 80% to 95%. This elevated humidity level ensures adequate moisture for mycelial colonization, primordial formation, and fruiting body development. Growers employ various methods, including misting systems, humidifiers, or humidity chambers, to maintain optimal moisture levels. By carefully controlling humidity, growers create an environment conducive to robust mushroom growth while mitigating the risk of contamination and dehydration.

Air quality, characterized by oxygen levels, carbon dioxide concentrations, and airflow dynamics, profoundly influences the health and vigor of mushroom crops. Adequate ventilation is essential to replenish oxygen, remove carbon dioxide, and prevent the buildup of harmful gases and contaminants. Stagnant air poses a risk of mold and bacterial proliferation, which can compromise the integrity of mushroom cultures. Employing ventilation systems such as exhaust fans or passive airflow methods ensures a steady exchange of fresh air, optimizing growing conditions and minimizing the risk of environmental stressors.

Sunlight, while not a direct requirement for mushroom growth, can indirectly influence cultivation outcomes

through its effects on temperature and humidity. Most commercially cultivated mushrooms thrive in controlled indoor environments with minimal or no exposure to sunlight. However, certain species, such as morel mushrooms (*Morchella* spp.), exhibit phototropic behaviors and may benefit from indirect light stimulation during fruiting. Understanding the nuanced interplay between light exposure, temperature, and humidity is essential for fine-tuning cultivation practices and maximizing yields.

In this system, the sensor checks the environmental factors to maintain the ideal atmosphere that enables automation and remote control of the external devices.

II. LITERATURE REVIEW

The study conducted by Kumar et al. (2019) delves into the utilization of Internet of Things (IoT) technology to enhance mushroom cultivation practices. Specifically, the researchers focused on monitoring critical environmental parameters such as temperature, humidity, and carbon dioxide (CO₂) levels within mushroom cultivation chambers. By implementing IoT-based systems for real-time monitoring and control, the study aimed to assess the impact of this technology on maintaining optimal growing conditions and ultimately improving yield outcomes.

Gupta et al. (2020) presents a pioneering study focusing on the development and implementation of an IoT-based smart system tailored specifically for the cultivation and management of mushrooms. Published in the International Journal of Scientific Research in Computer Science, Engineering, and Information Technology, their research sheds light on the transformative potential of IoT technology in optimizing mushroom farming practices. The study by Gupta and colleagues' centers on the design and deployment of an integrated IoT framework aimed at enhancing various aspects of mushroom cultivation, including environmental monitoring, resource management, and automated control. Leveraging IoT sensors and communication technologies, the system enables real-time data collection, analysis, and decision-making to ensure optimal growing conditions and maximize yield outcomes.

The Title is "Design and implementation of an IoT-based smart greenhouse system for mushroom cultivation". Zhu et al. (2021) presented a pioneering study on the design and implementation of an IoT-based smart greenhouse system tailored specifically for mushroom cultivation. Published in the Journal of Sensors, this research article explores the novel integration of Internet of Things (IoT) technology in optimizing environmental conditions for mushroom growth. The study outlines the development process of the smart greenhouse system, which encompasses a network of IoT sensors and actuators strategically positioned to monitor and control various parameters essential for mushroom cultivation. These parameters include temperature, humidity, light intensity, and air quality, all of which significantly influence the growth and development of mushrooms.

III. EXISTING APPROACH

Manual monitoring of mushroom cultivation, while a traditional approach, presents several significant drawbacks that hinder productivity, efficiency, and quality. Firstly, manual monitoring relies heavily on human observation and intervention, making it prone to errors, inconsistencies, and delays. Growers must physically inspect cultivation spaces regularly, which can be time-consuming and labor-intensive, especially in large-scale operations.

Moreover, manual monitoring often lacks precision and granularity in data collection. Human senses may not be sensitive enough to detect subtle changes in environmental parameters such as temperature, humidity, and air quality, which are crucial for optimizing mushroom growth. As a result, growers may overlook critical deviations from the ideal conditions, leading to suboptimal yields or quality issues.

Furthermore, manual monitoring limits the frequency and timeliness of data collection. Growers typically conduct periodic inspections at fixed intervals, which may not capture rapid fluctuations or transient events that could impact mushroom cultivation. Without real-time visibility into environmental conditions, growers may miss opportunities to address issues promptly or make informed decisions for optimization.

Additionally, manual monitoring does not lend itself well to data-driven decision-making and optimization. Without systematic data collection and analysis, growers may lack the insights needed to identify trends, patterns, or correlations in cultivation practices. As a result, opportunities for continuous improvement and optimization may be missed, limiting the potential for maximizing yields and resource efficiency.

To overcome these limitations, IoT-based smart cultivation systems offers real-time monitoring, automated control, and data analytics capabilities for enhanced productivity and sustainability in mushroom farming.

IV. PROPOSED METHODOLOGY

System Requirements

DHT11 Sensor: The DHT11 sensor is a widely used sensor for measuring temperature and humidity levels in various applications.

Temperature: The DHT11 sensor accurately measures ambient temperature within the cultivation space. By monitoring temperature fluctuations, growers can ensure that the environment remains within the ideal temperature range for mushroom growth, which typically ranges from 55°F to 75°F (13°C to 24°C) depending on the mushroom species.

Humidity: The DHT11 sensor also measures relative humidity, which is critical for creating a conducive environment for mushroom cultivation. Most mushroom species thrive in high humidity environments, with relative humidity levels ideally maintained between 80% to 95%. By monitoring humidity levels with the DHT11 sensor, growers can ensure that the air remains sufficiently moist to support mycelial growth and fruiting body development.

ESP32 Microcontroller: The ESP32 microcontroller is a powerful and versatile platform that can be effectively utilized for smart mushroom cultivation. Its combination of Wi-Fi connectivity, low power consumption, and integrated peripherals make it an ideal choice for monitoring and controlling environmental conditions within mushroom growing environments.

Relay Module 4 channel

Environmental Control: The relay module can be used to control various environmental parameters within the mushroom growing environment. For example, each channel of the relay module can be connected to devices such as heaters, fans, humidifiers, or air conditioning units. By activating or deactivating these devices based on sensor data, growers can maintain optimal temperature, humidity, and air circulation levels for mushroom growth.

Irrigation System: In mushroom cultivation, maintaining proper moisture levels in the substrate is crucial for successful growth. The relay module can be connected to an irrigation system, allowing growers to control the frequency and duration of watering cycles. Each channel of the relay module can correspond to a different zone or section of the cultivation area, providing flexibility in irrigation management.

Lighting Control: While mushrooms do not require direct sunlight for growth, controlled lighting can influence their development and fruiting patterns. The relay module can be used to control artificial lighting systems, such as LED grow lights, to provide supplemental illumination as needed. By adjusting the timing and intensity of lighting cycles, growers can optimize mushroom growth and development.

CO2 Injection: Some mushroom species benefit from increased levels of carbon dioxide (CO₂) during certain stages of growth. The relay module can be connected to a CO₂ injection system, allowing growers to regulate CO₂ levels within the cultivation environment. By activating the CO₂ injection system when needed, growers can enhance mushroom yields and accelerate growth rates.

Air Circulation Fan

Air circulation fans help distribute heat evenly throughout the growing area, preventing temperature gradients that could negatively impact mushroom growth. By circulating air, the fan ensures that warm air is evenly distributed, maintaining uniform temperatures across the cultivation space.

Proper air circulation is essential for managing humidity levels within the growing environment. By moving air across the surface of the substrate and mushroom beds, the fan helps to prevent stagnant air pockets and moisture buildup, reducing the risk of fungal diseases and promoting healthy mycelial growth.

Camera Module

Cameras can be positioned strategically within the cultivation space to provide visual monitoring of environmental conditions. This includes capturing images of temperature and humidity levels, light intensity, CO2 concentration, and other factors that influence mushroom growth. Visual data from the camera can complement sensor data, providing growers with a comprehensive understanding of the cultivation environment.

Power Adapter

A power adapter, also known as a power supply or AC/DC adapter, is an essential component in mushroom cultivation setups, especially for powering electronic devices such as sensors, actuators, controllers, and fans.

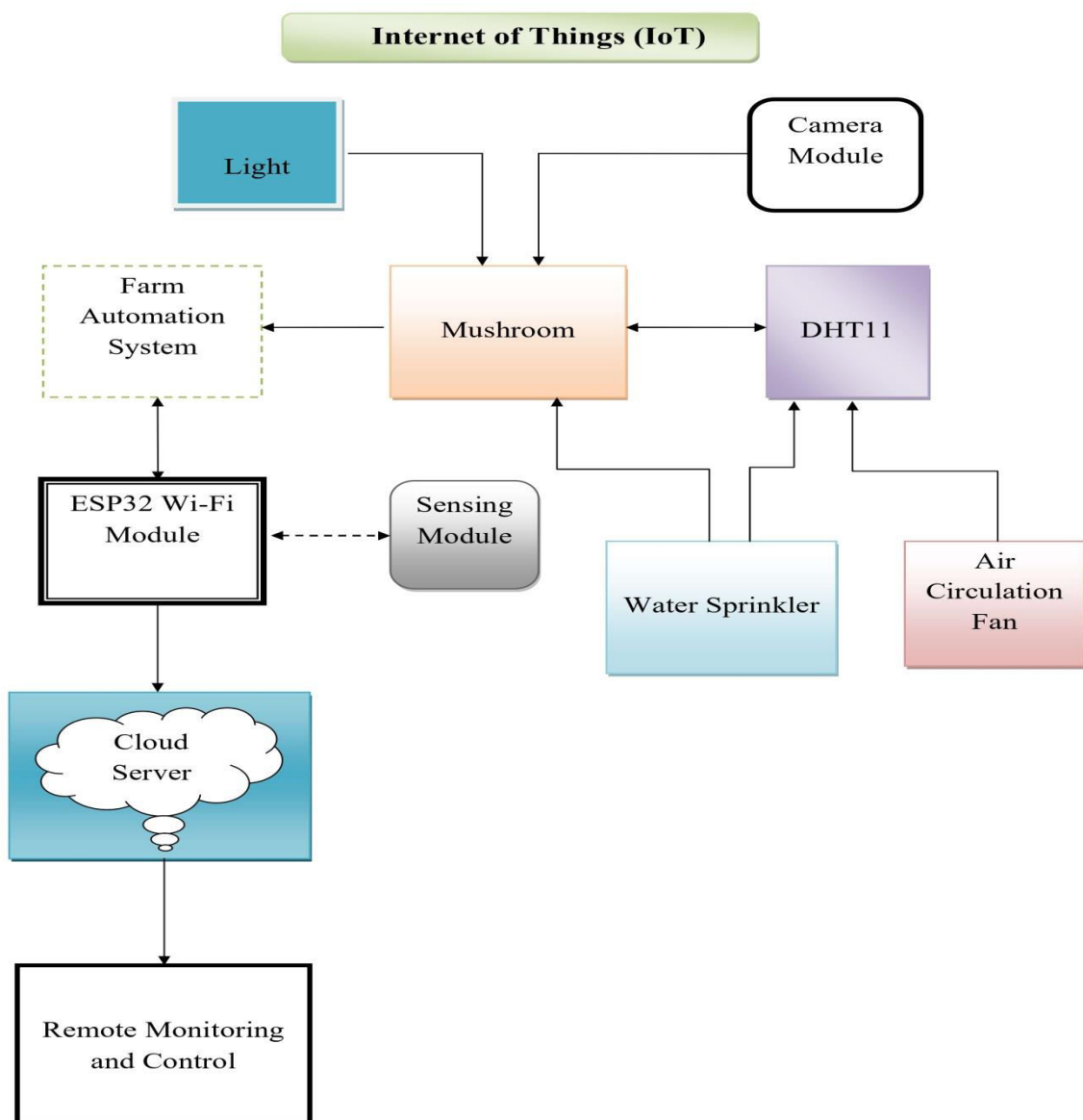


Fig.1.Architecture diagram

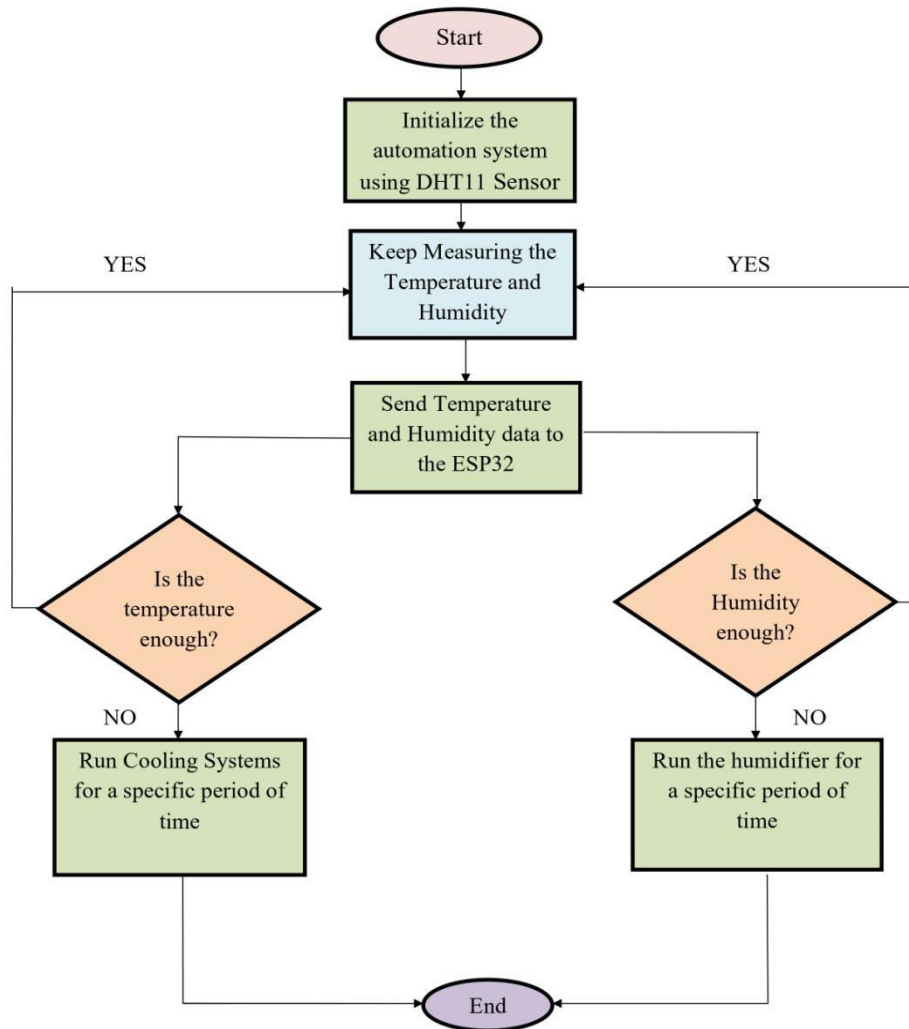
Proposed System

1. The DHT11 sensor is strategically placed within the mushroom cultivation chamber to accurately measure temperature and humidity levels. It should be positioned in a location where it can provide representative readings of the overall conditions.
2. The ESP32 microcontroller is programmed to read data from the DHT11 sensor at regular intervals, typically using its GPIO pins and appropriate libraries.
3. The sensor readings (temperature and humidity) are then processed by the microcontroller.
4. Actuators like fans or heaters to control the environment inside the mushroom cultivation chamber. The ESP32 microcontroller connects to the local Wi-Fi network, enabling it to transmit the sensor data to a central server or cloud platform.
5. Alternatively, the ESP32 could communicate directly with a smartphone or a dedicated IoT gateway.
6. The ESP32 microcontroller connects to the local Wi-Fi network, enabling it to transmit the sensor data to a central server or cloud platform.
7. Upon receiving the sensor data, the central server or cloud platform can analyze it to determine if any adjustments are needed in the mushroom cultivation environment.
8. For example, if the humidity level is too low, the system might activate a humidifier or misting system to increase humidity.
9. Based on the analysis, the system can send control commands back to the ESP32 microcontroller to adjust environmental parameters.
10. The microcontroller can then actuate the necessary devices, such as turning on/off fans, heaters, or humidifiers, to maintain optimal conditions for mushroom growth.
11. Throughout the cultivation process, the system continues to monitor environmental conditions and adjust parameters as needed.
12. Users can access real-time data and receive notifications or alerts via a web interface, mobile app, or email, allowing them to remotely monitor the progress of their mushroom cultivation and intervene if necessary.
13. By integrating the DHT11 sensor, ESP32 microcontroller, and appropriate control mechanisms, an IoT-based smart mushroom cultivation system can provide an automated and efficient solution for optimizing mushroom growth conditions while enabling remote monitoring and control capabilities.

An algorithm of working of system

1. Acquire 5 voltage power supply from battery
2. Set up the ESP32 microcontroller.
3. Connect the DHT11 sensor to the ESP32.
4. Establish a Wi-Fi connection for IoT communication.
5. Read temperature and humidity data from the DHT11 sensor.
6. Analyze the temperature and humidity data to determine if they are within the optimal range for mushroom growth.
7. If the conditions are optimal, proceed to the next step. Otherwise, take corrective actions like adjusting environment. Control devices like heaters, humidifiers, or fans based on the analyzed data.
8. Turn on the heater if the temperature is too low.
9. Activate the humidifier if the humidity is too low.
10. Continuously monitor the environment and adjust parameters based on feedback received.

Flow Chart



V. CONCLUSION

This paper presents the design and implementation of an Internet of Things-based system for monitoring mushroom farming. Temperature, humidity, light intensity, and CO2 level-all crucial factors for the growth and production of mushrooms have been tracked for several types of mushrooms in the study.

The system enables automatic optimization of these factors by examining the information gathered. With the assistance of external devices that are connected to the monitoring system, it is also possible to control the parameters. An Internet of Things application can perform the entire procedure remotely. If put into practice, this method might significantly increase mushroom production while requiring less labor and money.

VI. FUTURE SCOPE

Integration of more advanced sensors capable of capturing a wider range of environmental parameters beyond just temperature and humidity. This could include sensors for monitoring CO2 levels, light intensity, soil moisture, and

nutrient levels to provide more comprehensive insights into the cultivation environment.

Utilizing machine learning algorithms to analyze large datasets collected from IoT sensors. This could enable predictive analytics for anticipating optimal cultivation conditions, detecting potential issues before they arise, and optimizing resource allocation for improved yield and efficiency.

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