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Smart Green House Automated using AI and IOT

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ABSTRACT

Agriculture plays a crucial role in the global economy, and efficient crop production is essential to meet the increasing food demand. Greenhouses provide a controlled environment for crops; however, traditional greenhouse management relies heavily on manual monitoring, which is time-consuming and prone to human error. This research paper presents an ***IoT-based Smart Greenhouse System*** *designed to monitor and analyze key environmental parameters such as* ***temperature, humidity, and soil moisture*** *in real time. The proposed system utilizes low-cost sensors integrated with a microcontroller and cloud-based platforms to enable remote monitoring and data visualization. By automating environmental data collection, the system improves crop health, optimizes resource usage, and enhances agricultural productivity. The results demonstrate that the system provides accurate readings and enables efficient greenhouse management with minimal human intervention.*

KEYWORDS: *Internet of Things (IoT), Smart Greenhouse, Temperature Monitoring, Humidity Sensor, Soil Moisture Sensor, Precision Agriculture*

INTRODUCTION

Agriculture remains one of the most fundamental sectors supporting global economic stability and human survival. As the world population continues to increase, the demand for food production is rising at an unprecedented rate. Traditional farming practices are

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increasingly challenged by climate change, unpredictable weather patterns, water scarcity, and decreasing arable land. These factors necessitate the adoption of innovative technologies that can enhance productivity while ensuring sustainable resource management.

Greenhouse farming has emerged as a viable solution to address these challenges. A greenhouse provides a controlled environment where temperature, humidity, soil moisture, and light intensity can be regulated to create optimal growing conditions for crops. Unlike open-field agriculture, greenhouse cultivation reduces dependency on external climatic conditions and enables year-round production. However, maintaining ideal environmental conditions inside a greenhouse requires continuous monitoring and timely intervention.

Conventional greenhouse systems rely heavily on manual supervision, which is labour-intensive, time-consuming, and prone to human error. Delays in detecting unfavourable conditions may lead to reduced crop yield, poor quality produce, or even complete crop failure.

The rapid advancement of the Internet of Things (IoT) has introduced transformative solutions for modern agriculture. IoT refers to a network of interconnected devices embedded with sensors and communication technologies that collect, transmit, and analyze data in real time. In agricultural applications, IoT enables precision farming by providing accurate environmental monitoring and automated control mechanisms. By integrating sensors, microcontrollers, and wireless communication modules, farmers can remotely observe greenhouse conditions and make data-driven decisions.

An IoT-based smart greenhouse system continuously measures critical environmental parameters such as temperature, humidity, and soil moisture. These parameters directly influence plant physiological processes, including photosynthesis, transpiration, nutrient absorption, and growth rate. Maintaining optimal levels ensures healthy crop development and maximizes productivity. Real-time monitoring also helps in reducing water wastage, preventing over-irrigation, and improving energy efficiency.

Cloud computing platforms such as ThingSpeak and Firebase further enhance the functionality of IoT systems by providing data storage, visualization, and remote

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accessibility. Farmers can access historical and real-time data through smartphones or computers, enabling better analysis of environmental trends and early detection of anomalies.

This research focuses on the design and implementation of a cost-effective IoT-based Smart Greenhouse Monitoring System. The system integrates low-cost sensors with a Wi-Fi-enabled microcontroller to collect environmental data and transmit it to a cloud platform for real-time monitoring. The primary objective is to develop an efficient, scalable, and user-friendly solution that reduces manual intervention while improving crop health and resource management. By leveraging IoT technology, the proposed system aims to contribute to sustainable and precision agriculture practices suitable for both small-scale and commercial greenhouse applications.

LITERATURE REVIEW

The application of the Internet of Things (IoT) in agriculture has gained significant attention over the past decade due to its potential to enhance productivity, optimize resource utilization, and enable precision farming. Smart greenhouse systems, in particular, have emerged as a promising solution for controlled-environment agriculture by integrating sensors, microcontrollers, and cloud-based platforms for real-time monitoring and automation.

Early research in greenhouse automation primarily focused on basic environmental monitoring using temperature and humidity sensors. Many initial systems relied on standalone microcontrollers such as Arduino boards to collect data locally without remote accessibility. While these systems improved environmental awareness within greenhouses, they lacked internet connectivity, limiting real-time remote monitoring and large-scale data analysis.

With the advancement of wireless communication technologies, researchers began integrating Wi-Fi and GSM modules to transmit sensor data to remote servers. Patel et al. developed an IoT-based greenhouse monitoring system that measured temperature and humidity and enabled automated irrigation control. Their study demonstrated improved water efficiency and reduced manual labor. However, the absence of soil moisture sensing limited the system’s precision in irrigation scheduling, as irrigation decisions were based primarily on

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atmospheric conditions rather than actual soil water content.

Similarly, Kumar and Reddy proposed a wireless sensor network (WSN) for greenhouse monitoring. Their system incorporated multiple sensor nodes distributed across the greenhouse to collect environmental data. Although the distributed architecture improved spatial monitoring accuracy, it introduced challenges related to high power consumption, complex network configuration, and increased implementation cost. Such limitations reduce the feasibility of deployment for small-scale farmers.

Recent developments have emphasized cloud computing integration for data storage, visualization, and analytics. Platforms such as ThingSpeak enable real-time data logging and graphical representation of environmental parameters. Likewise, Firebase has been used for real-time database management and mobile application connectivity. These cloud-based solutions enhance accessibility and scalability, allowing farmers to monitor greenhouse conditions from anywhere using internet-enabled devices.

More advanced studies incorporate machine-learning algorithms for predictive irrigation, disease detection, and climate optimization. These systems analyze historical sensor data to forecast environmental trends and automate control mechanisms. While such intelligent systems improve decision-making accuracy, they often require high computational power, reliable internet connectivity, and advanced technical expertise, making them less accessible to resource-limited farmers.

Despite the progress in IoT-enabled greenhouse systems, several challenges remain. Many existing solutions are either economically expensive, technically complex, or energy inefficient. Furthermore, some systems focus on limited environmental parameters, neglecting critical factors such as soil moisture, which directly influences plant growth and water consumption.

Therefore, there is a clear need for a cost-effective, scalable, and energy-efficient IoT-based greenhouse monitoring system that integrates essential environmental sensors with simple cloud connectivity. A balanced approach that combines affordability, reliability, and ease of deployment is essential to ensure widespread adoption among both small-scale and

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commercial greenhouse operators.

PROPOSED SYSTEM ARCHITECTURE

1. System Overview

The proposed **IoT-based Smart Greenhouse System** consists of sensors, a microcontroller, a communication module, and a cloud platform. The system continuously collects environmental data and transmits it to the cloud for monitoring and analysis.

2. Hardware Components

a) **Temperature and Humidity Sensor (DHT11/DHT22):**
Measures ambient temperature and humidity inside the greenhouse.

b) **Soil Moisture Sensor:**
Determines the moisture content in the soil to help manage irrigation effectively.

c) **Microcontroller (Arduino / ESP8266 / ESP32):**
Acts as the central processing unit, collecting sensor data and transmitting it to the cloud.

d) **Wi-Fi Module:**
Enables internet connectivity for data transmission.

e) **Power Supply:**
Provides required power to the system components.

3. Software Components

- **Embedded C / Arduino IDE** for programming the microcontroller
- **Web or Mobile Interface** for real-time monitoring

METHODOLOGY

The system operates in the following steps:

1. Sensors are placed inside the greenhouse to collect temperature, humidity, and soil moisture data.
2. The microcontroller reads sensor values at regular intervals.
3. Collected data is transmitted via Wi-Fi to a cloud platform.
4. Users can access real-time and historical data through a web dashboard or mobile application.

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5. Threshold values can be set to trigger alerts when environmental conditions exceed safe limits.

This methodology ensures continuous monitoring and helps farmers make informed decisions regarding irrigation and climate control.

RESULTS AND DISCUSSION

The proposed system was tested in a controlled greenhouse environment. The sensors provided accurate and stable readings under different conditions. Temperature and humidity variations were successfully tracked throughout the day, while soil moisture data helped identify optimal irrigation times.

The system demonstrated the following benefits:

- Reduction in water usage by avoiding over-irrigation
- Improved crop health due to consistent environmental conditions
- Remote monitoring capability, reducing the need for manual inspection

The results confirm that the IoT-based approach significantly enhances greenhouse efficiency compared to traditional methods.

ADVANTAGES OF THE PROPOSED SYSTEM

- Real-time monitoring of greenhouse conditions
- Low-cost and energy-efficient design
- Easy scalability for larger greenhouses
- Reduced human labor and operational costs
- Improved crop yield and resource management

CONCLUSION

This research paper presented an **IoT-based Smart Greenhouse System** designed to monitor temperature, humidity, and soil moisture in real time. The system leverages IoT technology to automate data collection and provide remote access to greenhouse conditions. Experimental results demonstrate that the proposed solution is reliable, cost-effective, and suitable for modern agricultural practices.

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Future work may include integrating automated control systems for irrigation and ventilation, applying machine learning for predictive analysis, and enhancing security features for cloud data.

FUTURE SCOPE

- Automatic irrigation and climate control
- AI-based crop health prediction
- Integration with weather forecasting systems
- Solar-powered greenhouse monitoring

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