Development of IOT based Greenhouse Monitoring System

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Abstract— A greenhouse provides a controlled environment to optimize plant growth by regulating key factors such as temperature, humidity, light, and soil moisture. This project introduces an IoT and Arduino-based greenhouse monitoring system that automates environmental control to enhance agricultural efficiency. The system incorporates sensors for temperature, humidity, soil moisture, and light intensity, enabling real-time monitoring and automation. A Raspberry Pi processes data and controls components like a DC fan, bulb, and water pump to maintain optimal conditions. The soil moisture sensor triggers irrigation, while the LDR sensor controls lighting in low-light conditions. An IoT module transmits sensor data every 30 seconds, allowing remote monitoring and control. By integrating automation, the system reduces manual labor, optimizes resource utilization, and enhances crop yield. This technology-driven approach promotes sustainable farming by minimizing water and energy wastage while ensuring year-round plant growth.

Keywords— Greenhouse automation, IoT monitoring, soil moisture control, temperature regulation, smart irrigation etc.

I. INTRODUCTION

Agriculture plays a crucial role in sustaining human life by providing food, raw materials, and economic opportunities. However, conventional farming methods are often susceptible to climate fluctuations, seasonal changes, and external environmental factors such as pollution and pests. To address these challenges, greenhouse farming has emerged as an efficient and controlled agricultural practice that enables year-round cultivation by regulating key environmental factors. A greenhouse provides an enclosed environment where temperature, humidity, soil moisture, and light intensity can be monitored and adjusted to ensure optimal plant growth. This method not only enhances crop yield but also minimizes resource wastage and reduces dependency on unpredictable weather conditions.

In recent years, technological advancements, particularly in the Internet of Things (IoT) and automation, have significantly improved greenhouse farming. Traditional greenhouse management involves manual monitoring, which is labor-intensive and prone to inefficiencies. To overcome these limitations, automated greenhouse control systems have been developed to regulate environmental parameters without human intervention. This project presents an IoT and Arduino-based greenhouse monitoring system that continuously detects and controls temperature, humidity, soil moisture, and light intensity. By integrating smart sensors and automation, the system ensures optimal conditions for plant growth while reducing manual labor and operational costs.

The proposed system consists of multiple sensors, including a temperature sensor, soil moisture sensor, humidity sensor, and Light Dependent Resistor (LDR) sensor. These sensors collect real-time data, which is processed by an Arduino microcontroller and a Raspberry Pi to make automated decisions. For instance, when soil moisture levels drop below a predefined threshold, the system automatically activates the irrigation pump to supply water to plants. Similarly, the LDR sensor detects light intensity and switches on an artificial light source when natural light is insufficient. A temperature sensor regulates greenhouse temperature by activating a DC fan for cooling when temperatures rise above a certain level. Additionally, an IoT module transmits sensor readings to a remote server every 30 seconds, enabling farmers to monitor greenhouse conditions in real time via a mobile application or web interface.

This automation system significantly improves agricultural efficiency by reducing water and energy wastage while ensuring that crops receive optimal growing conditions. Traditional irrigation methods often result in excessive water consumption, leading to resource depletion and increased costs. However, with automated soil moisture monitoring and smart irrigation, water usage is optimized, preventing over- or under-watering of plants. Similarly, temperature regulation through automated cooling systems prevents heat stress, thereby protecting crops from extreme weather conditions.

The integration of IoT technology in greenhouse farming allows for remote monitoring and timely decision-making. Farmers can access real-time data and receive alerts in case of unfavorable conditions, enabling them to take immediate corrective actions. This approach not only enhances crop productivity but also promotes sustainable agricultural practices. By leveraging automation and sensor technology, this project aims to provide an intelligent and cost-effective solution for modern greenhouse management.

The implementation of an IoT and Arduino-based greenhouse monitoring system represents a significant advancement in precision agriculture. By automating key processes such as irrigation, temperature control, and lighting management, this system ensures enhanced plant growth, reduced operational costs, and increased crop yields. With the growing demand for sustainable farming practices, such smart greenhouse solutions pave the way for more efficient and environmentally friendly agriculture.

Fig.1. Smart Green House

II. PROBLEM FORMULATION

- Manual Monitoring Challenges – Traditional greenhouse farming requires continuous manual monitoring of temperature, humidity, soil moisture, and light, leading to inefficiencies and increased labor costs.
- Unoptimized Water Usage – Over- or under-watering plants due to lack of precise soil moisture monitoring can reduce crop yield and waste water resources.
- Temperature Fluctuations – Inconsistent temperature control can negatively impact plant growth, especially in extreme weather conditions.
- Energy Wastage – Continuous operation of irrigation and lighting systems without automation leads to unnecessary energy consumption.
- Lack of Real-Time Monitoring – Farmers often lack real-time data and alerts to take immediate corrective actions, affecting overall productivity and plant health.

III. OBJECTIVE

- Implement a system that automatically monitors soil moisture levels and activates irrigation when necessary, ensuring optimal water usage.
- Continuously monitor and control temperature, activating cooling systems as needed.
- Use light sensors to ensure adequate exposure for plant growth.
- Implement IoT for real-time monitoring and timely decision-making.
- Provide an LCD display for easy access to system data.
- Minimize water and energy wastage, reducing overall operational costs.
- Maintain optimal conditions to enhance crop yield and quality.

IV. LITERATURE SURVEY

Smith et al. (2018) developed an IoT-based greenhouse monitoring system integrating temperature, humidity, and soil moisture sensors. Their study demonstrated how real-time monitoring and automated irrigation improved crop yield by 20% while reducing water usage by 30%. The system used Arduino and WiFi modules to transmit data to a mobile application, enabling remote monitoring. The research highlighted the significance of IoT in precision agriculture and recommended further improvements in automation and machine learning integration for predictive analysis of plant health.

Kumar and Patel (2019) explored an Arduino-controlled greenhouse system that optimized plant growth conditions using automatic ventilation, lighting, and irrigation mechanisms. Their findings showed that automated systems reduced labor costs by 40% and improved plant survival rates in controlled environments. The study emphasized the role of low-cost microcontrollers in smart farming and recommended integrating artificial intelligence for better decision-making in greenhouse management.

Rahman et al. (2020) implemented an intelligent greenhouse system powered by Raspberry Pi and IoT. Their research focused on using machine learning algorithms to predict plant health based on sensor data. Results indicated a 15% increase in crop yield and a 25% reduction in power consumption. The study concluded that integrating AI with IoT-based greenhouse management systems could further enhance efficiency, making agricultural practices more sustainable and cost-effective.

Gonzalez and Lee (2021) designed a cloud-based greenhouse automation system that continuously monitored environmental parameters and adjusted conditions accordingly. The research demonstrated how cloud computing and IoT enhanced data accessibility, allowing farmers to receive instant notifications about unfavorable conditions. The study reported a 35% improvement in crop health and suggested the inclusion of blockchain technology for secure and transparent agricultural data management.

Sharma et al. (2022) investigated the impact of smart irrigation techniques in IoT-enabled greenhouses. They developed a moisture-controlled irrigation system using real-time soil data, which reduced water wastage by 50%. Their research highlighted the benefits of integrating IoT with smart sensors for sustainable agriculture. The study concluded that automated irrigation systems could significantly improve resource management while maintaining optimal plant growth conditions.

We have examined numerous earlier studies conducted in this area by various researchers. Using technology in agriculture is crucial for both improving output and minimizing labour requirements.

V. CONCEPT AND METHODOLOGY

A. Block Diagram

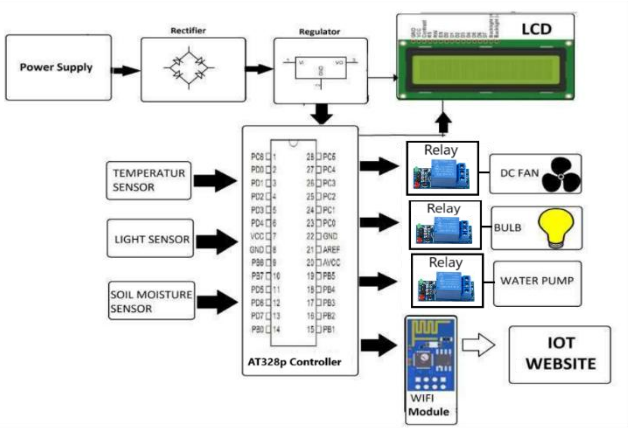

Fig.2. Block Diagram

B. Working of system

A. Sensor Data Collection – The system consists of temperature, humidity, soil moisture, and light sensors that continuously monitor environmental conditions inside the greenhouse.

B. Real-Time Data Processing – The collected data is sent to an Arduino or Raspberry Pi, which processes the information and determines necessary actions based on predefined thresholds.

C. Automatic Irrigation – If soil moisture levels drop below the threshold, the system activates a water pump to irrigate the plants. Once adequate moisture is detected, the pump turns off.

D. Temperature and Humidity Control – The temperature sensor triggers the cooling fan when the temperature exceeds a set limit. When the temperature drops to optimal levels, the fan turns off.

E. Light Intensity Adjustment – An LDR sensor detects low light levels and automatically turns on a grow light to ensure sufficient exposure for plant growth.

F. IoT-Based Monitoring – Sensor data is transmitted via an IoT module to a cloud platform or mobile application, allowing remote monitoring and control in real time.

G. User Interface and Alerts – An LCD display provides real-time updates, and users receive alerts on their smartphones about critical environmental changes, enabling timely action.

VI. COMPONENTS REQUIREMENT

- **Arduino Uno (12v)**

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.

- **Liquid Crystal Display (5v)**

LCD stands for Liquid Crystal Display. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.

- **Moisture sensor**

The sensor was constructed using two cylindrical galvanized metal probes. The probes were slotted firmly into a block of varnished with a spacing of four centimetres between them in the block. An insulated conducting wire was attached to each probe.

- **Temperature and Humidity sensor**

Thermo-hygrometer is a device that gives you a measurement of the temperature and humidity of a place with one device. They prove to be very important in fields where temperature and humidity play an important role.

- **IOT Module (5V)**

The Internet of Things ("IoT") refers to the ability of everyday objects to connect to the Internet and to send and receive data. The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network.

- **Relay Board (12v)**

A relay is usually an electromechanical device that is actuated by an electrical current. The current flowing in one circuit causes the opening or closing of another circuit. Relays are like remote control switches and are used in many applications because of their relative simplicity, long life, and proven high reliability.

- **LDR Sensor (5V)**

The LDR sensor module is used to evaluate the frequency of the sun The analogue output pin and the digital output pin are given The LDR's resistance decreases with increasing strength of light As light intensity reduces, the resistance to LDR increases figure 6 There is an LDR sensitivity adjustment with a potentiometer button on the sensor The strength of an LDR will normally be as follows

- Daylight 5000 Ω
- Dark 20000000 Ω

VII. CIRCUIT DIAGRAM

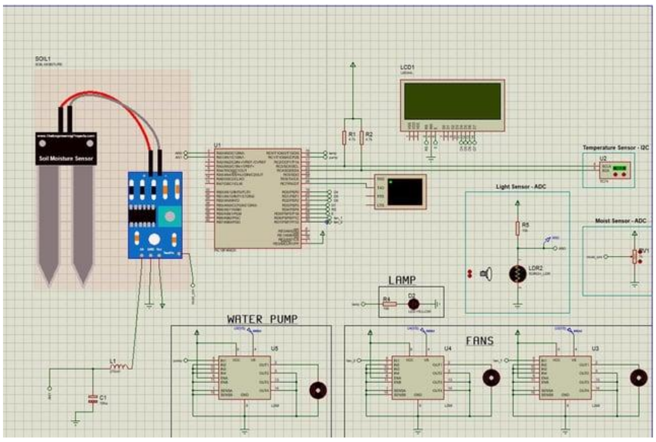

Fig.3. Circuit Diagram

I. RESULTS & DISCUSSION

The IoT-based greenhouse monitoring system effectively automates and optimizes plant growth conditions by integrating various sensors and control mechanisms. The system continuously monitors temperature, humidity, soil moisture, and light intensity, ensuring optimal conditions for plant development. Experimental results demonstrate that automatic irrigation significantly reduces water wastage while maintaining proper soil moisture levels. The temperature control mechanism, activated by a DC fan, efficiently regulates internal climate conditions, preventing overheating or excessive cooling.

The light control system ensures that plants receive adequate illumination, activating artificial lighting when natural light levels drop. The IoT module provides real-time data transmission, allowing remote monitoring and timely decision-making, which enhances operational efficiency and reduces manual labor. Users receive alerts and updates through a mobile application, ensuring immediate responses to unfavorable conditions.

The integration of automation in greenhouse farming results in improved crop yield, reduced resource consumption, and lower operational costs. The system's ability to self-regulate and adjust environmental parameters makes it an efficient solution for precision agriculture. Future improvements could include AI-based predictive analysis for better climate control and automated fertilization. The results indicate that implementing this technology can significantly enhance productivity, sustainability, and efficiency in greenhouse farming.

A system to track temperature, humidity, and soil moisture levels was developed, and this project offers a chance to examine the current systems, their benefits and shortcomings. One of the activities that uses the most water is agriculture. One of the most time-efficient farming chores, irrigation can be automated by using the proposed system to switch depending on the health of the plants, or sensor values. This helps to avoid crop damage by preventing overwatering or underwatering of the soil. Via Front End Structure, the farm owner can keep an eye on the procedure online. By doing this task, it will be possible to save water and motor power for later use by reducing their waste. By this experiment, it can be inferred that the usage of IOT and automation may significantly advance farming.

II. ADVANTAGES

- The system is inexpensive in terms of hardware components and power consumption.
- The system helps in saving of water and electricity. It can be applied in large agricultural areas.
- The system helps the labour problem when there are no workers to work with and eliminate manpower.
- The system can be switched to manual mode if required.
- It is convenient to all climatic conditions and all sorts of irrigation.
- Monitoring the levels of water source from remote places.

III. APPLICATIONS

Irrigation can be completed on farms, orchards, farms etc. It is effective for a variety of crops. This application is useful for monitoring the patient. Software applications developed for this system can be used for domestic tasks such as tank storage. The system is operated automatically and manually

- IoT Irrigation Control.
- Soil Nutrient Analysis.
- Smart Greenhouses.
- Precision Farming.
- Data Analytics.

IV. CONCLUSION

A system to track temperature, humidity, and soil moisture level was developed, and this project offers a chance to examine the current systems, their benefits and shortcomings. One of the activities that uses the most water is agriculture. The suggested system can be used to automate irrigation by turning the motor on or off based on the health of the plants, or sensor values. Which is one of the farming operations that uses the least amount of time and prevents soil from being over or underirrigated, preventing crop damage. Via an android app, the farm owner may keep an eye on the procedure online. Notwithstanding this project's limitations, it can be said that automation and the Internet of Things can significantly advance farming.

Plants are vital to our way of life because they support our ecological way of life. For them to live a healthy existence, it is essential to maintain their appropriate growth and a enough supply of water. In this study, an intelligent plant monitoring system that uses IoT and AI technology is created. Real-time measurements of three crucial factors, including the temperature, humidity, and wetness of the soil, are uploaded to a cloud server for additional analysis. In this work, two alternative machine learning models—ANN and SVM—were used. Two statistical measures, such as RMSE and MAE, are used to analyze machine learning models.

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