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IoT Based Greenhouse Monitoring and Controlling System

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Abstract: *The increasing demand for sustainable agricultural practices has led to the development of smart technologies for efficient resource management. This paper presents an IoT-based Greenhouse Monitoring and Controlling System, designed to create an optimal environment for plant growth by automating key processes within a greenhouse. The system utilizes a network of sensors and actuators to monitor critical parameters such as temperature, humidity, soil moisture, and light intensity in real time. These sensors are connected to a central microcontroller that processes the data and triggers the necessary control actions, such as activating irrigation systems, regulating ventilation, or adjusting lighting, based on predefined thresholds .The IoT platform enables remote access and real-time data visualization through a cloudbased dashboard, allowing farmers and agronomists to monitor and control greenhouse conditions from any location. Alerts are generated when environmental conditions deviate from optimal ranges, ensuring timely intervention. The system is energy-efficient, scalable, and designed for ease of use, which promotes sustainable agricultural practices and higher crop yields*

Keywords: Arduino, sensors, automation, IoT, smart greenhouse, and wireless monitoring

I. INTRODUCTION

This greenhouse automation system monitors and controls environmental conditions to ensure optimal plant growth.It uses sensors for light intensity, soil moisture, and humidity to gather real-time data.Based on these readings, the system automatically manages lighting, irrigation, and ventilation via relays controlling the motor and lights.The temperature, humidity, and soil moisture levels are displayed on an LCD for easy monitoring.This automation reduces manual intervention, ensuring efficient plant care and resource management.

Agriculture is one of the many industries being revolutionized by automation in the current era of technological developments. Traditional farming practices are time-consuming and laborintensive since they frequently call for continual human intervention. However, a novel approach that improves productivity, minimizes human labor, and maximizes resource use is offered by the combination of IoT and intelligent automation systems in agriculture. Because they provide a controlled climate that is ideal for plant growth, greenhouses are essential to guaranteeing the availability of food all year round. However, it can be difficult to manually manage different climate settings. By automating the monitoring and management of environmental parameters including temperature, humidity, soil moisture, and light intensity, a smart greenhouse system solves these problems. This system uses IoT to improve agricultural practices by enabling remote control, data analysis, and real-time monitoring

II. METHODOLOGY

The sensors placed at various points in the greenhouse collect environmental data. This data is sampled at regular intervals and sent to a central controller or microcontroller unit Microcontroller: The microcontroller acts as the primary device for data collection and processing. Data Sampling and Communication: The microcontroller interfaces with the sensors and uses communication protocols to send the data to a central server or cloud platform. The collected data is sent either to a local edge device or directly to a cloud server.

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Data Filtering and Processing: Raw data from sensors may require pre-processing before it is transmitted or used. Decision-Making: The system uses predefined thresholds (e.g., temperature between 20-30°C, humidity between 60-80%) for controlling the actuators. If the measured data exceeds these thresholds, corresponding actions are triggered. Mobile Application/Web Interface: Users can monitor real-time data, receive alerts, and control the system remotely through a mobile app or a web-based interface. Threshold Alerts: Users can set custom thresholds for temperature, humidity, soil moisture, etc. The system will send notifications (via SMS, email, or app alerts) when the values exceed the set limits. If the temperature exceeds the threshold, the fan or ventilation system is turned on. If soil moisture is below the required level, the irrigation system is activated. If CO_2 levels are too low, the system can activate the CO_2 dispenser. Automated lighting can be controlled based on time of day or light sensor readings.

III. LITERATURE REVIEW

People began to propose stringent standards for the quality of agricultural products as their lives rapidly improved. A greenhouse is a building that may modify the environment for plant growth and set the climate to the best circumstances for plant growth, meeting the needs of plants year-round and shielding them from the effects of soil or climate. However, rather than relying solely on the greenhouse to preserve heat, it is essential to precisely and thoroughly record the crop growing environment in real time in order to achieve extremely high crop yields and good quality. 1] Liu Xia, Luo Wenhui, and Su Toxin's "Greenhouse Monitoring System Design Based on MSP430 and King View" concludes the Chinese Association of Automation's Youth Academic Annual Conference. 2017 (YAC), pp. 111–114.

A greenhouse monitoring system module based on MSP430 and CC2530 has been proposed by the authors. In order to monitor the greenhouse in real time and provide favorable circumstances for crop growth, they have combined the module with host computer configuration software. The system gathers data about the greenhouse's lighting intensity, CO2 concentration, and air temperature and humidity. Through configuration software, the host computer simulates this information, transmits the data wirelessly, and displays it appropriately. They have linked a CC330 wireless module to an MSP430 control module. The host computer setup software is linked to this module. They have collected and analyzed the environmental parameters using the SCM control module. The data is seen, managed, and stored on the host computer. interact with the wireless module. 2] "Design and Implementation of Modern Greenhouse Remote Monitoring System Based On the Android System" by Li Xiaofeng, Qin Linlin, Lu Linjian, and Wu Gang, 34th Chinese Control Conference (CCC), 2015, pp. 5742-5746 The local monitoring module, server module, and Android client module are the foundations of the greenhouse monitoring system module that the authors have suggested. Because each module is largely independent, system maintenance is made easier, and new features can be added as needed. The local monitoring module was utilized by the authors to control the device and collect data. Distributed CAN buses are used for this. Sensors have been attached by the authors to the input module, which simultaneously gathers outdoor meteorological and indoor microclimate environment parameters. This information is forwarded to A PCI CAN adapter is used to link the monitoring computer to the CAN bus. Through the CAN bus, the output module gets a control signal from the local monitor system. To store user, status, and log table data, the writers chose the MySQL database server. The Android client sends an HTTP request to the Apache server, and the client receives the server script's response. The video of the greenhouse was recorded by the authors using H.264 on a streaming media server and sent via RTSP. The VLC multimedia player is used to play the video after it is received by the Android server. Real time data display, device status viewing, device control, parameter setting, and user registration and login are all made possible via the authors' Android client.

IV. EXISTING AND PROPOSED SYSTEM

The existing greenhouse monitoring and controlling systems are typically manual or semi-automated. In many traditional greenhouses, parameters such as temperature, humidity, soil moisture, and light intensity are monitored manually by staff. Controlling these factors, like turning on fans, heaters, or irrigation systems, is also done manually or through basic time-based systems. This approach is labor-intensive, prone to human error, and lacks real-time responsiveness. Moreover, these systems do not offer remote monitoring, data logging, or intelligent control, making it

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difficult to maintain optimal growing conditions consistently or scale operations effectively. In contrast, the proposed IoT-based greenhouse monitoring and controlling system utilizes modern technology to automate and optimize the entire process. Smart sensors are deployed throughout the greenhouse to continuously collect real-time data on critical environmental conditions such as temperature, humidity, soil moisture, light intensity, and carbon dioxide levels. This data is sent to a central microcontroller or edge device (like an Arduino, Raspberry Pi, or ESP32), which processes the information and uploads it to a cloud-based platform. From there, users can access a user-friendly dashboard through a smartphone or computer, enabling them to monitor the greenhouse remotely, view historical trends, and receive instant alerts when conditions deviate from ideal levels. Additionally, the system can automatically activate devices like irrigation pumps, exhaust fans, or grow lights based on predefined rules or AI algorithms. This smart automation ensures better resource efficiency, improves crop yield, reduces manual labor, and allows for data-driven decision-making. Overall, the IoT-based system represents a significant upgrade over traditional methods by offering scalability, efficiency, and precision in greenhouse management.

V. BLOCK DIAGRAM

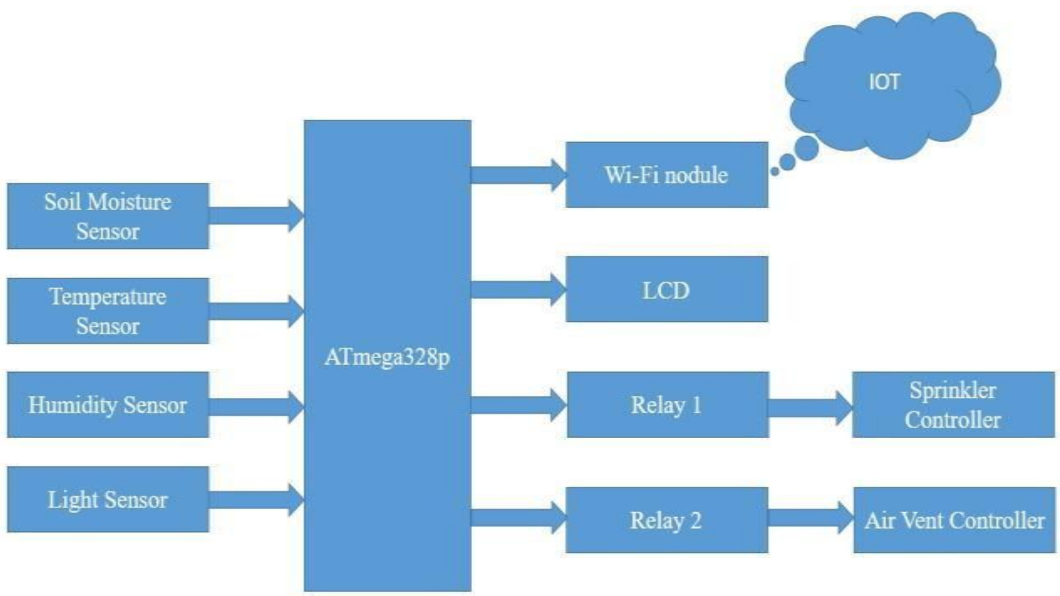

Figure 1: Block Diagram

VI. WORKING

The working of an IoT-based greenhouse monitoring and controlling system involves the integration of smart sensors, microcontrollers, connectivity modules, and cloud platforms to automate and optimize the environment within a greenhouse. Sensors placed throughout the greenhouse continuously measure key environmental parameters such as temperature, humidity, soil moisture, light intensity, and carbon dioxide levels. These sensors are connected to a microcontroller unit (such as Arduino, ESP32, or Raspberry Pi), which collects the data and processes it. The microcontroller then sends the data to a cloud server using communication technologies like Wi-Fi, GSM, or LoRa. The data is stored and visualized on an IoT dashboard or mobile application, allowing users to monitor the greenhouse environment in real time from any location. Based on the sensor readings, the system can automatically control actuators such as water pumps, exhaust fans, heaters, and artificial lights to maintain optimal growing conditions. For example, if the temperature rises above a certain threshold, the system can turn on a fan to cool down the greenhouse. Additionally, users receive instant alerts or notifications if any parameter goes beyond the acceptable range. This smart system ensures efficient use of resources, reduces manual intervention, and helps maintain ideal conditions for plant growth throughout the year.

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VII. COMPONENTS

Arduino UNO: The open source Arduino microcontroller board, created by Arduino.cc, is based on the Microchip ATmega328P microprocessor. A number of expansion boards and other circuits can be interfaced to the board's digital and analog input/output pins. The vehicle's movement is managed by a microcontroller that receives the embedded C program.

Dht11 sensor: The DHT11 sensor measures temperature and humidity between 0 and 50°C and between 20 and 90% humidity. By tracking changes in the climate and providing real-time data to the microcontroller for any necessary adjustments, this guarantees that plants develop in the best possible conditions.

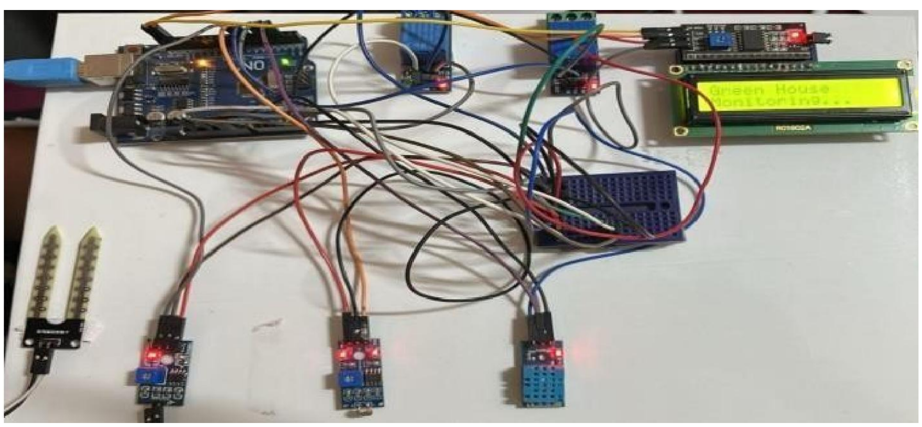
Soil Moisture Sensor : By measuring the soil's water content, the Soil Moisture Sensor makes sure that irrigation is done as efficiently as possible. In order to keep plants from being overwatered or dehydrated, the sensor transmits signals to the microcontroller, which in turn turns on or off the water pump as needed.

LDR Sensor: By continuously measuring the amount of ambient light, the Light Sensor (LDR) makes sure that artificial lighting is only turned on when there is not enough natural light. This promotes energy efficiency and the maintenance of ideal light conditions for plant growth.

Wifi Module: China's Espressif Systems, based in Shanghai, produces the ESP8266, a low-cost Wi-Fi microprocessor with full TCP/IP stack and microcontroller functionality. Western manufacturers first became aware of the chip in August 2014 when third-party producer Ai-Thinker produced the ESP-01 module. Using Hayes-style commands, this tiny gadget enables microcontrollers to establish basic TCP/IP connections and connect to a Wi-Fi network. But at the time, there wasn't much information available in English about the chip and the orders it could understand. Many hackers were drawn to investigate the module, chip, and software on it because of its extremely low cost and the fact that it had very few external components, which indicated that it could eventually be very inexpensive in scale.

VIII. RESULTS

Real-time environmental data, such as temperature, humidity, soil moisture, and light intensity, is available through the Greenhouse Monitoring System mobile app. The user-friendly interface uses graphical symbols to visually represent system status and shows sensor values. Through the app, customers can keep an eye on greenhouse conditions from a distance, guaranteeing ideal plant growth. It improves automation productivity and streamlines data interpretation with an intuitiveuser interface.



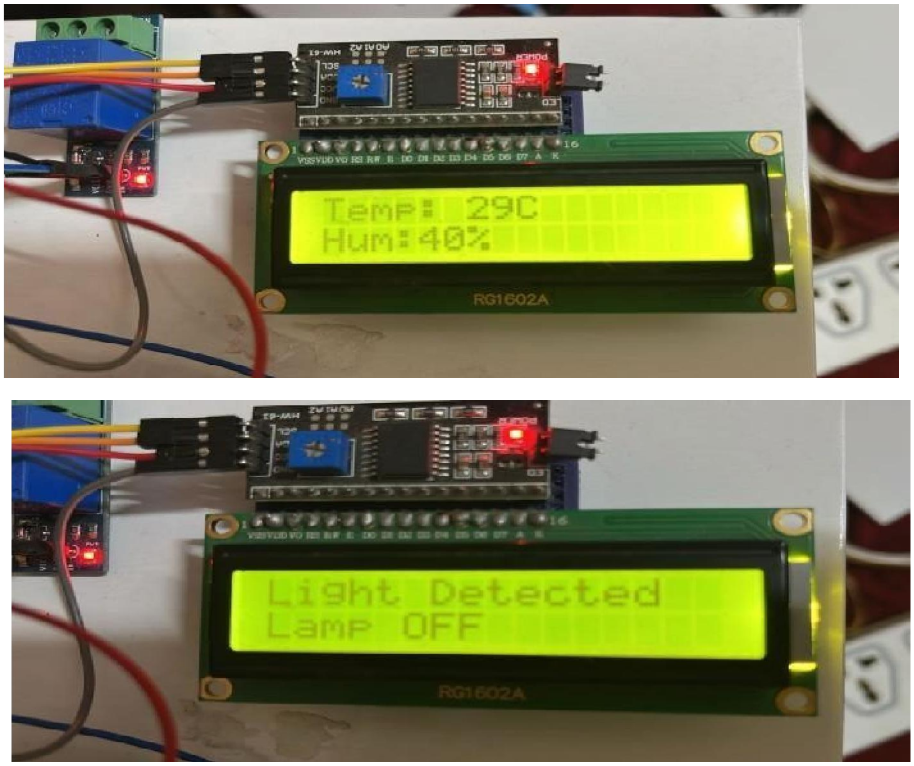


Figure 2: Output of the system

Figure 3: MobileApp view

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IX. CONCLUSION

The greenhouse control and monitoring system is meant to produces healthier crops with increased yields in minimum time. This project is very useful for small scale farmers and for hobbyists .We can easily grow plants in a greenhouse because we do not need to check parameter because the system does it automatically. This project can be used for small-scale farming such as small nurseries or indoor plantation at households for people who like to have small gardens at their homes .It can also be used for cultivation of special herbs used in medicines since they require very close monitoring of their eco-culture due to their sensitive nature. The Smart Greenhouse System offers a creative answer to contemporary farming problems. This technology minimizes human labor while guaranteeing ideal conditions for plant growth by combining automation and the Internet of Things. In addition to increasing productivity, remote monitoring and control of the greenhouse makes sustainable farming methods possible. Machine learning algorithms and AI driven analytics could be used in future developments to increase productivity and forecasting power.

X. STATEMENT

The IoT-based greenhouse monitoring and controlling system is designed to automate the process of maintaining optimal environmental conditions for plant growth using smart technology. This system leverages Internet of Things (IoT) devices, including various sensors and actuators, to monitor parameters such as temperature, humidity, soil moisture, light intensity, and CO_2 levels in real time. The collected data is processed by a microcontroller and transmitted to a cloud platform, where it can be accessed through a web or mobile application. Based on the data, the system can automatically control devices like irrigation systems, ventilation fans, heaters, and grow lights to create the most favorable conditions for crops. The primary goal of this system is to improve the efficiency and accuracy of greenhouse management while reducing manual labor and resource wastage. It enables farmers to remotely monitor and control their greenhouse environments, receive alerts for any abnormalities, and make informed decisions using real-time and historical data, ultimately leading to higher crop yields and more sustainable farming practices.

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