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Structuring an Automated Greenhouse Monitoring System

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Abstract - Agriculture in India is mostly traditional and is deficient in the use of new technology. Approximately 55 percent of the Indian populace is involved in agriculture and related activities, which account for just 15 percent of GDP. Consequently, it is imperative for stakeholders to abandon traditional agricultural techniques and modernize the sector via technological advancements. This initiative focuses on enhancing existing farming methods via the use of contemporary technology to achieve improved yields. This project presents a concept of a smart greenhouse using IoT, employing Node MCU for communication and Blynk as the server. The built Android application displays numerous metrics like as temperature and soil moisture, and it can also handle the automation system via an intuitive user interface. It can manage not only a single greenhouse but also several greenhouses using a single application. This initiative enables farmers to automate agricultural operations, minimizing the need for extensive human oversight.

Key Words: *Smart greenhouse, IOT, Node MCU, Blynk, android application.*

INTRODUCTION

A greenhouse is a confined enclosure designed to shield plants from external influences, including weather conditions and pollutants. It provides a sustainable and effective cultivation of plants year-round. Fundamental elements influencing plant development include sunshine, soil moisture, temperature, and humidity. A multitude of scholars have engaged in the study of water sprinkling and irrigation systems. They selected several techniques to assess the soil moisture status. An article on the automated water delivery system for urban residential areas indicated that this system can efficiently manage water resources. The requisite physical variables are difficult to regulate manually inside a greenhouse, necessitating the implementation of an automated system [5]. Numerous intelligent irrigation systems have been developed using Evapotranspiration (ET), thermal imaging, capacitive techniques, neutron scattering, and gypsum blocks as technology for moisture detection. Capacitive sensors, although immediate, are expensive and need frequent calibration due to variations in temperature and soil type [2] [3]. G. Parameswaran et al. presented a "Arduino-based smart irrigation system utilizing the Internet of Things" [11]. Kim et al. presented a study on the regulation of irrigation using a distributed wireless sensor network [7]. K.S. Nemali and colleagues. Proposed irrigation systems that are automated using volumetric water data [9]. Chandankumar Sahu et al. suggested a system titled “A Low Cost Smart Irrigation Control System,” whereby sensors are integrated with the ESP8266, and the data is processed by the ATMEGA-318 microcontroller on the ARDUINO-UNO development board [8]. Wi-Fi, in conjunction with IoT, is an emerging technology that facilitates access to various data from distant locations.

This work presents a system that acquires three parameters from sensors and activates actuators when the actual values exceed the threshold values, while also storing these values in a cloud database for remote access at any time. This research elucidates the automated regulation of climatic conditions inside the greenhouse. Various seasonal crops may be cultivated exclusively under certain circumstances. Onions, garlic, shallots, and similar crops are winter cultivars that need chilly temperatures for optimal development. Cucumbers, melons, and similar crops are summer cultivars that need moderate to warm climatic conditions.

The prototype we used consists of moisture sensors, temperature and humidity sensors, an Arduino Uno, and water pipes for supplying water from a tank regulated by DC motors. Moisture sensors (YL 69) are positioned next to the roots, while the temperature and humidity sensor (LM35) is situated at a further distance to monitor temperature and humidity for result analysis. If the temperature and humidity exceed the reference values, the cooling fan will be activated to keep them under the threshold levels.

The current method [6] involves manual monitoring of agricultural field characteristics, and the use of GSM technology will need more time to get the desired results. of address this issue, we have presented a more systematic and automated approach of monitoring crops by regulating several factors inside the greenhouse. The Internet of Things is considered the third wave of

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information technology after the Internet and mobile communication networks, characterized by enhanced sensing and measurement, more interoperability, and increased intelligence.

LITERATURE SURVEY

Recent advancements in this field have resulted in the emergence and rapid proliferation of transformative and disruptive technologies. Presented below are many research articles and publications pertaining to the greenhouse monitoring project. The study [1] presents a greenhouse monitoring system developed to fulfill the requirements for remote monitoring and management of the greenhouse. This system comprises front-end data collecting, data processing, data transmission, and data receiving. The system is an IoT architecture based on a B/S structure, using the CC2530 as the central processor unit. ZigBee technology is used in wireless communication.

The suggested IoT architecture in the study [2] enables both autonomous management of greenhouse operating conditions and remote control by the owner over the Internet. The owner may monitor and document the development of the crops inside the greenhouse throughout the planting time using switched Ethernet and WiFi.

The document [3] presents an embedded system that includes sensors, an ADC, a PIC 16f877a microprocessor, and actuators. When any climatic parameter exceeds a safety threshold, the sensors detect the change, and the microcontroller interprets this data from its input ports and displays it on the LCD.

The document [4] proposes the cultivation of vegetables and fruits inside spaceships or designated habitation modules for long-term space missions. The wireless sensor network (WSN) in this project consists of autonomous, flexible polymeric nodes outfitted with humidity, temperature, and illuminance sensors, along with nanostructured flexible devices designed for the detection of gases such as CO_2 and NO_x.

The paper [5] discusses the monitoring of various parameters in greenhouse controls, including humidity, nutrient solution levels, pH, electrical conductivity, temperature, UV light intensity, CO_2 levels, mist, and the quantity of insecticides or pesticides, through diverse sensors to facilitate knowledge acquisition and enable early fault detection and diagnosis. A decision support system (DSS) functions as the primary operating system that regulates and synchronizes all actions.

The study [6] discusses greenhouses, which are climate-controlled edifices with walls and a roof specifically designed for the off-season cultivation of plants. The sensors used in this context are the YL69 moisture sensor and the DHT11. The Raspberry Pi 3 autonomously regulates many parameters by activating the corresponding actuators based on the collected data. The recorded values are preserved in a cloud database, and the results are shown on a website.

The study [7] proposes the implementation of a smart farming system using low-power Bluetooth and Low Power Wide Area Network (LPWAN) communication modules, alongside the existing cable communication network used in the current farm. The system employs monitoring and control features using the MQ Telemetry Transport (MQTT) communication protocol, therefore augmenting the potential for agricultural IoT development.

In the study [8], the author used the architecture of the Internet of Things (IoT) to create a comprehensive remote monitoring system based on Agricultural IoT, aimed at enhancing energy efficiency, dependability, safety, and customer experience. The low-cost single-chip STM32F103 series will be used for the network transmission layer to provide comprehensive gateway equipment.

The document [9] outlines a greenhouse monitoring system using ZigBee and GPRS technologies. The system incorporates wireless sensor network technology and GPRS technology for data collecting, wireless transfer, remote communication, and monitoring. The system employs GPRS technology to transmit data to the Internet, using Visual Studio software to provide a human-computer interaction interface with ASP.NET.

In reference [10], a wireless sensor network was established by deploying wireless sensor nodes equipped with sensors in a greenhouse. The suggested system includes a sensor node to monitor various parameters and regulate a device with corresponding sensors. Wi-Fi and GSM technologies provide communication between the sensor node and the gateway, contingent upon distance. A graphical user interface panel is developed using LabView to oversee and regulate the components and devices of the sensor node.

PROPOSED SYSTEM

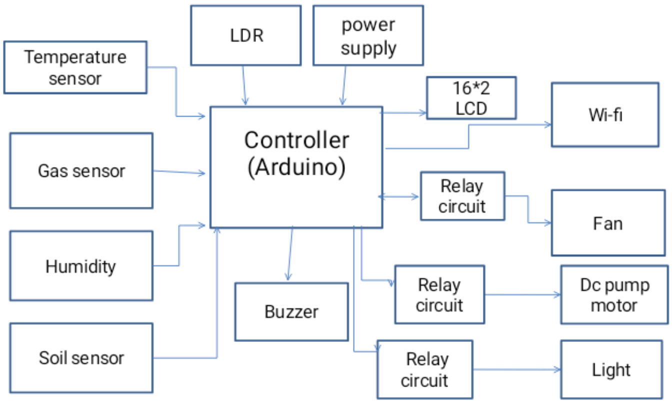

Fig-1: Block diagram

The sensor data is collected and sent to the server, where it is filtered and translated into a user-readable format before being provided to the Android application (UI). Additionally, it may notify the user if conditions cannot be maintained and check for faults. The data to be preserved is reviewed at regular intervals based on the chosen crop. The automation system is equipped with many sensors to monitor temperature, humidity, and soil moisture levels. The sensors incessantly gather data from the greenhouse and relay it to the control unit. The control unit verifies the incoming data, and if it exceeds or falls below the predetermined threshold value, it transmits signals to actuators to execute designated duties. The actuating component encompasses activating the cooling fan, motor, etc. The suggested system manages not only a single greenhouse but also several greenhouses via the use of a server. Various greenhouses may be configured for the cultivation of different crops. A user interface will be available to configure parameter values for various crops, switch between crops, and execute several manual procedures.

IMPLEMENTATION

Hardware Implementation

The greenhouse is constructed with gate sheet that absorbs incoming solar energy and prevents its exit, so maintaining warmth inside the structure. The many sensors and corresponding actuators are situated inside the greenhouse. The temperature and humidity sensor is positioned in the greenhouse to assess the temperature. The cooling fan is linked to the sensor, which receives the input and compares it to the temperature threshold value. If it exceeds the threshold, it transmits the signal via the relay module to activate the cooling fan. The temperature and humidity sensor is positioned in the greenhouse to detect humidity. The servo motor is linked to imitate the window's opening and shutting; the sensor detects the input and compares it to the humidity threshold value. If it exceeds the threshold, it transmits the signal via the relay module to activate the servo motor. The Soil Moisture sensor is embedded in the soil to quantify its moisture content. The servo motor is linked to imitate the window's opening and shutting, wherein the sensor detects the input and compares it to the humidity threshold value. If it exceeds the threshold, it transmits the signal via the relay module to activate the servo motor. The PIR sensor detects heat radiation, since animals and humans release more heat than plants, making it suitable for intruder detection and alerting the end user. The sensor measures the input and contrasts the value with the radiation threshold. If it exceeds the threshold, the signal is sent via the server, which then notifies the user.

Hardware Communicating with Server

Figure 3 illustrates the interaction between the hardware and the server. It examines the apps operating on the hardware device and elucidates the manner in which the application interacts with or accesses the resources (database) housed in the Blynk cloud server, as well as how the server interfaces with programs operated on the hardware device. Figure 3.10 illustrates the architecture of the hardware application and its communication with programs operating on the server interface, specifically about database read and write operations. The figure illustrates the need for hardware programs to use or access the database. The server will be prompted to authenticate input data from the device by juxtaposing it with pre-existing data in the user database or to relay the device GPIO status from that specific database, however access will ultimately be authorized by the primary application. Access to the database for the sub-application is contingent upon authorization from the main application. This design is necessary to prevent database overwriting by multiple files and to avoid write rejections due to the database potentially being in an unclosed state if accessed by another program simultaneously.

Software Implementation

The picture below elucidates the structure of the code; nevertheless, this depiction does not constitute the algorithm or flowchart of the code executed on the ESP-2866, however it will certainly aid in comprehending the logic of our code. The library files, including servo.h, ESP8266WiFi.h, BlynkSimpleEsp8266.h, and DHT.h, indicate that servo.h is used for controlling multiple servos. The library efficiently utilizes timers, enabling the control of 12 servos with a single timer. ESP8266WiFi.h facilitates the connection of the ESP8266 module to a Wi-Fi network for data transmission and reception. BlynkSimpleEsp8266.h is used to setup the NodeMCU with the Blynk platform. In the configuration phase, we provide the SSID and password to connect to the Wi-Fi, since the ESP2866 has an integrated HTTP module that supports GET and POST methods. GET is used to get data from a designated resource, whereas POST is utilized to transmit data to a server for the creation or modification of a resource. The authentication key and password are thereafter initialized to access the server for data transmission and reception. During the configuration phase, the pins are designated for input and output and labeled appropriately. If the connection is active inside the loop segment of the code, the functions to read the sensor are executed. The input data is concurrently sent to the server via Blynk, where it is compared with the threshold values. Corresponding values are then assigned to the actuators; otherwise, the Node MCU attempts to reconnect to the server, verify data alterations, and execute designated actions.

RESULTS

The greenhouses were built and the seeds were sown in the greenhouse. Tomato plant was selected for the demonstration. The figures 4 and 5 shows the growth stages of tomato plant.

Fig-4: Day 1 and day 15 of tomato plant

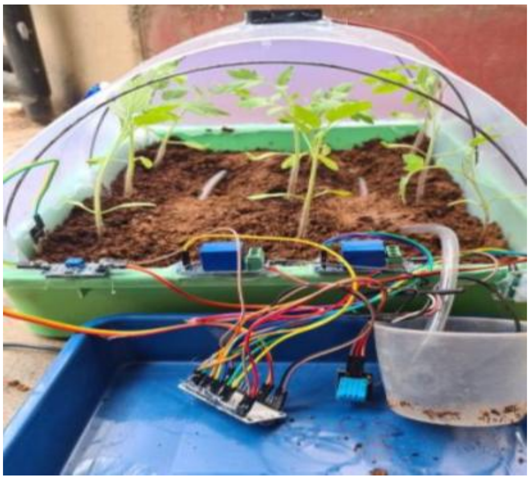

Fig-5: Day 30 of tomato plant

Tabel-1: Recordings of various parameters of tomato plant

Date	Temperature	Humidity	Soil Moisture
2023/04/10	27	76	454
2023/04/11	25	79	569
2023/04/12	28	76	613

2023/04/13	25	78	435
2023/04/14	27	76	454
2023/04/15	25	76	569
2023/04/16	28	79	613
2023/04/17	25	76	510
2023/04/18	30	78	481
2023/04/19	30	78	530
2023/04/20	27	79	586
2023/04/21	29	80	569
2023/04/22	27	76	613
2023/04/23	30	79	510
2023/04/24	30	76	481
2023/04/25	30	78	481
2023/04/26	27	76	530
2023/04/27	29	76	586
2023/04/28	27	79	481
2023/04/29	29	76	568
2023/04/30	27	78	435

CONCLUSION

Agriculture is seeing a heightened need for the use of automation, computing technology, and control systems. Engineering students must comprehend, define, and develop computer-controlled apparatus. The device may be remotely configured over the internet, allowing for almost instantaneous visibility of program or parameter changes. A control system was developed and coded for data management and acquisition. The system prototype functioned in accordance with the requirements and was pretty satisfactory.

The created method is appropriate for both large-scale agribusiness and small agricultural farms. The system alleviates the burden of physical labor. It mitigates the danger of human mistakes in maintaining a greenhouse under certain environmental conditions.

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