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Monitoring and Controlling of Greenhouse

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Abstract: The potential for revolutionizing crop production practices has drawn significant attention to the monitoring and management of greenhouse settings. With the help of greenhouses, plants may grow in a controlled environment with the right amount of light, heat, humidity, and soil moisture. However, manual monitoring and intervention—which may be time-consuming, laLbor-intensive, and prone to human error are frequently used in traditional greenhouse management techniques. The design, implementation, and assessment of a greenhouse monitoring and controlling system built around the ESP32 controller are proposed in this research paper. In order to gather environmental data—such as temperature, humidity, soil moisture, and light intensity—that is essential for determining plant health and maximizing growth conditions, the system incorporates sensors. Farmers may remotely get real-time insights into their greenhouse operations by transmitting the acquired data to a cloud platform or central monitoring station using the ESP32's networking features. the incorporation of ESP32 controllers into greenhouse management is a noteworthy technical development that has the potential to completely transform current agricultural methods. ESP32-based systems give farmers a strong tool for maximizing agricultural productivity while reducing resource inputs and environmental effects by providing real-time monitoring and precise control of environmental conditions.

Keywords: ESP32, greenhouse, sensors

I. INTRODUCTION

Advances in technology have brought about a dramatic shift in the agricultural industry in recent years, with the goals of maximizing crop yields, reducing resource usage, and lessening environmental effects. The use of Internet of Things (IoT) devices in agriculture has surfaced as a potentially effective means of improving agricultural management procedures, among other developments. It has long been known that one of the most important factors in promoting the growth and development of plants and flowers is the regulated environment that greenhouses provide. With the world's population continuing to rise and the problems caused by climate change and dwindling arable land, it is more crucial than ever to maximize agricultural production while utilizing the fewest resources possible. Given this, greenhouse farming stands out as a viable option that provides exact control over environmental parameters to produce the best circumstances possible for plant development. By acting as protective buildings, greenhouses help plants and flowers survive harsh weather, including high temperatures, wind, and precipitation. This allows for year-round cultivation and an extension of the growing season. The temperature, humidity, light intensity, and carbon dioxide levels may all be adjusted in a greenhouse setting to best suit the needs of various plant species, cultivars, and development phases. Reducing the effect of climatic variations on crop yields is one of the main benefits of greenhouse-controlled settings. In contrast to open-field agriculture, which exposes plants to the whims of the environment, greenhouses offer a consistent and reliable climate that reduces stress on plants and encourages robust development. For fragile crops like flowers, which are vulnerable to harm from temperature fluctuations and unfavorable weather, this stability is especially helpful. Additionally, greenhouses provide defense against pests, illnesses, and weeds that invade the area, which lessens the need for chemical pesticides and herbicides. Management of integrated pests (IPM) In greenhouses, methods may be applied more successfully, making use of cultural practices and biological control agents to keep pest populations under control while causing the least amount of ecological disturbance. The ability of greenhouse-controlled conditions to maximize resource consumption and raise crop productivity is another important feature. Researchers have developed novel methods for precise and efficient monitoring and control of greenhouse settings by utilizing the various controller. The design, implementation, and assessment of a greenhouse monitoring and controlling system built around the ESP32 controller are examined in this research study. In order to gather environmental data—such as temperature, humidity, soil moisture, and light intensity that is essential for determining plant health and maximizing growth conditions, the system incorporates sensors. Through its ability to interface with actuators like fans, heaters, and irrigation systems, the controller facilitates accurate control of greenhouse conditions, ensuring ideal growth conditions and optimizing crop yields. By providing a thorough description of the controller based greenhouse monitoring and controlling system, including its design, functionality, and performance assessment, this work adds to the body of information already in existence. It also talks about how this technology can affect resource conservation, food security, and sustainable agriculture.

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II. LITERATURE REVIEW

The communication modes of environmental monitoring system basically have the following kinds: wireless communication based on Bluetooth [1], Zigbee protocol [2], Internet [3,5], GSM[4]. The mode of short distance wired data communication has several short comings, such as poor expansibility, short transmission range, instable system, etc [3].

Table 1: Comparison of various technologies

Technology	Zigbee	Wi-Fi	GSM
Range	1-100+	1-100	wide
Source metrics	Reliability, Cost, power	Speed, Flexible	Cost
Application	Monitor & control	web, email	Data X^er

In the study article [1], the amplified data from the sensing node is supplied to the ADC, which then feeds it to the microcontroller. After that, this is linked to the Zigbee module, which sends the data to the other Zigbee module. It gathers the information, shows it on the host computer via Lab View, and creates a control sequence that allows the control room to wirelessly adjust the green house's parameters. Another wireless sensor that has grown significantly in recent years is GSM. Based on data packet switching, GSM's Short Message Service is a value-added service. Users don't need to set up another network because the GSM network has excellent network capabilities and can be routed and connected throughout the nation. Users can save money on costly network construction and maintenance expenses while also benefiting from increased network coverage. The quantity of its users is also unrestricted. The GSM network is a powerful platform for monitoring equipment communication and sending data remotely; it's a crucial component of wireless remote monitoring systems.[3]. A wireless sensor network (WSN) is made up of geographically dispersed autonomous sensors that work together to cooperatively transfer data from the sensors to a primary site over the network in order to monitor physical or environmental factors like temperature, sound, vibration, pressure, mobility, or pollution. In a separate study [3], the field monitoring system can concurrently transfer real-time environmental data from the wireless sensor networks in the greenhouse to the PC over the RS-232 interface and sample it using the Lab View virtual instrument platform. The field monitoring system and the Internet are connected by the information distribution system, which also sends the collected data to the WEB data server [3].

III. METHODOLOGY

A block schematic of the suggested surveillance setup. It is primarily composed of actuators (such as a valve, water pump, fan, and servomotor), sensors (such as capacitive soil moisture, relative humidity, air temperature, light intensity, CO2, and ultrasonic), and LCDs (liquid crystal display,which allows the measured data to be seen). Various factors within the greenhouse were controlled and monitored by an inexpensive microprocessor, the Arduino Mega 2560. Temperature, light, humidity, CO2 concentration, soil moisture, and water level (WL) were the factors that were being measured. The control process is summarized in the following steps:

1) Step 1: Initialization, defining, loading reference parameters based on the experimental thresholds.
2) Step 2: Measurements of the actual parameters.
3) Step 3: Comparison of the parameters (measured versus references) for each sensor.
4) Step 4: Sending a signal to the actuators by activating the corresponding relays: water pump: start filling the tank; valve: start watering and irrigation of the plants; servomotor: open windows for fresh air; fan: turn on air ventilation; LED: turn on the light.

Most sensor networks require careful manual installation and configuration to assure that software components are properly associated with the physical instruments that they represent.

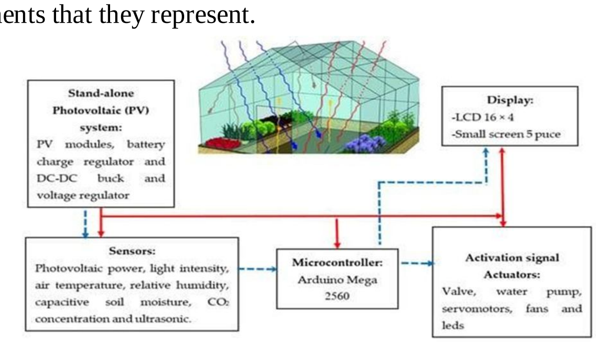

Fig 1: System Architecture

A. Steps Involved

Gather a large and diverse dataset of images containing healthy crops and crops with various diseases. Assemble a sizable and varied collection of photos showing both healthy and sick crops. Every image in this dataset has to be tagged with the appropriate ailment or state of health. This process is known as labeling the dataset. In order to accomplish the study's objective, we built a real greenhouse system with fully grown plants, as well as automation to check and record the water's pH level, light, temperature, and humidity—all of which are connected to ThingSpeak. In order to verify the SMART Greenhouse monitoring system's functionality, dependability, and usefulness, it underwent testing and assessment in accordance with ISO 9126 evaluation standards. The respondents, who ranged in experience from novice plant owners to experts in hydroponic gardening, were able to test and assess the prototype as well as the mobile application to monitor the parameters, yielding descriptive results for both the pH level (7.77), light (83), water temperature (27.94 degrees Celsius), greenhouse temperature (27 degrees Celsius), and humidity (75%). With a mean average of 4.06 for both software and hardware, the descriptive result is Very Good, indicating the utility and recommendation of the produced technology. Due to low agricultural conditions, land scarcity, and climate change, the SMART

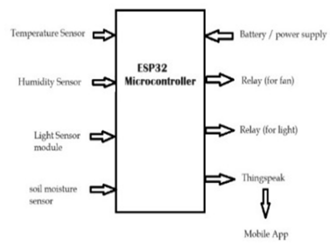

Fig 2: ESP32 controller

Greenhouse System for Hydroponic Garden is utilized as a substitute tool, solution, and innovative approach to address food shortages. The advocates strongly advise using solar energy to power the pump, improving the prototype wiring, using a high-end Arduino model to address more sensors and devices for a larger data collection arsenal, enclosing the device to ensure safety, and updating the mobile application with bug fixes and an electronic manual for the entire system. The microcontroller, actuators, relays, sensors, and other interface components make up the system model. Actuators that are employed include fans, lights, and soil moisture sensors. The goal of our suggested system is to create a microcontroller-based circuit that will track and record the natural environment's temperature, humidity, soil moisture content, and sunlight levels. These variables will be continuously changed and adjusted to maximize plant growth and yield. Effective control processes are carried out. We will define certain threshold levels for each climatic parameter based on the application. The microcontroller will use a relay to carry out the necessary action when any parameter level over a safety threshold and continue doing so until the strayed-out parameter is returned to its ideal level. The primary block. Naturally, the ESP32 controller is the central component of our system; other components consist of sensors, supply voltage, and relays. We have five sensors—temperature, light (LDR), soil moisture, humidity, and pH—as shown in the block diagram above. The micro controller requires 5 volts, which our power supply provides. Push buttons may be used to display variation graphs of different parameters through interrupts and to pick plants. save the data that is being watched, and utilize relays to turn on and off the linked devices in accordance with program instructions for control action. The graphs of different parameters for analysis and the real-time parameters are both displayed using graphical representation. The initial project goal of developing a microcontroller-based control system to maintain the ideal environmental parameters (soil moisture, temperature, and humidity) for plant development and welfare within a greenhouse was achieved when the final prototype design underwent successful testing. This hindered the prototype's analysis and efficacy, particularly with regard to the 12V fan that helps regulate humidity and temperature. Using appropriate software programs to create mathematical models for fan sizing could have been more advantageous. Through the integration of actuators such as irrigation systems, heaters, and fans, the Arduino-based system is capable of regulating the greenhouse's interior conditions to guarantee the best possible development for various plant species. Plant development is more constant and dependable as a result of this automation, which also lowers the possibility of human mistake and minimizes manual effort. Numerous benefits are offered by the Arduino-based greenhouse monitoring and management system, including higher crop yields, resource efficiency, remote accessibility, scalability, data-driven decision making, and cost effectiveness. Farmers may create optimal growing conditions, manage resource use, and ultimately boost greenhouse output by employing Arduino technology.

B. Mobile Applications and Alert SMS

To monitor the greenhouse's condition, a smartphone application was created. As a result, consumers may receive a straightforward SMS alert in the event that there was a systemic issue. One form of SMS message that a user may get is shown in the accompanying image (no Internet connection, for example).

IV. RESULTS

The greenhouse monitoring and control system was conducted and the system demonstrated accurate and reliable monitoring of temperature, humidity, light intensity, and soil moisture levels. The implemented control algorithms effectively regulated environmental conditions within predefined thresholds, ensuring optimal growth conditions for the cultivated plants. Remote monitoring capabilities enabled greenhouse operators to access real-time data and control settings from anywhere, thereby enhancing operational efficiency and convenience. Furthermore, the system's low-power consumption and energy-efficient design contribute to sustainability and cost-effectiveness in greenhouse operations.

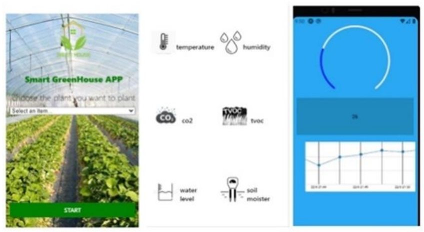

Fig 3: Designed App

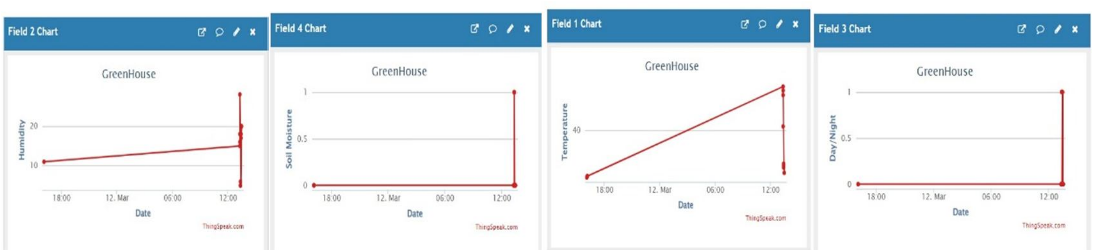

Fig 4: Results displayed on thingspeak platform

V. CONCLUSION

In conclusion, the incorporation of ESP32 controllers into greenhouse management is a noteworthy technical development that has the potential to completely transform current agricultural methods. ESP32-based systems give farmers a strong tool for maximizing agricultural productivity while reducing resource inputs and environmental effects by providing real-time monitoring and precise control of environmental conditions.

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