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Crop-Optimized Greenhouse Control System

Vijo M. Joy[1], Pearly Jacob[1], Benjamin Sebastian[2], Arjun K Prasanth[2], Ashwin Krishna P S[2], Ashwin P S[2], Alwin Antony[2]

[1]Assistant Professor, Dept. of Electronics, Aquinas College, Edakochi, Cochi, Kerala, India

[2]UG Student, Dept. of Electronics, Aquinas College, Edakochi, Cochi, Kerala, India

ABSTRACT: **G**reenhouses serves as a controlled environment for cultivating plants that succeed under regulated climatic conditions. This study aims to modernize greenhouse operations through automated monitoring of key variables such as temperature, light, humidity, and soil pH, through selection switches. Our setup utilizes a microcontroller alongside temperature, humidity, light, and pH sensors. Regular monitoring allows for data transmission over the internet to agricultural experts or farmers, enabling periodic inspection and continuous communication. System assembly and performance testing yielded excellent results, insisting the efficiency of the proposed system. Greenhouse system represents a central solution in modern agriculture, offering precise control over environmental variables to optimize crop growth. This leads to the implementation of Arduino-based greenhouse automation, modify internal weather conditions as per the requirements of various crops. Moreover, we introduce a novel approach to crop selection via switches, facilitating seamless customization of the growing environment for various plant species. Through a combination of hardware setup, software development, and real-world experimentation, this work provides detailed insights into the design, implementation, and potential impact of Arduino-based greenhouse automation.

KEYWORDS: Sensors, Internet of Things, Greenhouse, Atmega 328, Crops

I.INTRODUCTION

A greenhouse serves as a closed structure designed to shield plants from external elements such as weather conditions and pollutants, fostering sustainable and consistent plant development year-round. Cultivating crops is a rewarding endeavor for farmers, signifying the creation of new life. However, it entails various farm activities and ongoing maintenance to ensure a bountiful and healthy yield. Greenhouses, framed structures utilized for cultivating fruits, vegetables, flowers, and other plants requiring specific temperature and humidity conditions, harness solar radiation during the day to warm the plants, soil, and structure. The internal greenhouse environment significantly influences plant quality, underscoring the importance of managing parameters like temperature, light, and humidity. This project employs Arduino technology to automate greenhouse parameter monitoring, facilitating enhanced plant growth. The Internet of Things (IoT) is an emerging technology that includes a network of interconnected devices equipped with electronics, software, sensors, and connectivity, facilitating communication and data exchange. This technology holds the promise of revolutionizing various aspects of our lives, from nurturing a more connected society to enabling smarter cities and enhancing industrial efficiency. Similarly, in the realm of agriculture, researchers are increasingly exploring the application of IoT to advance farming practices. Given the essential to address challenges such as climate change, extreme weather events, and environmental impacts, integrating IoT into the agriculture and farming sectors becomes essential to meet the growing demand for food [1][2].

Greenhouse Automation System offers a technical solution for rural farmers by automating the monitoring and control of greenhouse environments, reducing the need for direct human supervision. This paper reviews various studies and proposes a system to address the limitations of current monitoring systems, with a focus on a versatile architecture applicable to diverse automation applications. As urbanization expands and land availability diminishes, there is increasing demand for greenhouses reserved for crop cultivation. Leveraging technological advancements, we can remotely control and monitor multiple greenhouses via IoT from a central location, enhancing efficiency and productivity. Also, when a specific crop is chosen through the switches, the Arduino microcontroller regulates the environmental conditions by turning on or off various actuators like heaters, fans, water pumps, and lights. This guarantees that the greenhouse sustains the perfect growth conditions customized to the selected crop, fostering robust plant growth and maximizing output. This method allows growers to effectively handle different crop varieties within the same greenhouse area, improving resource efficiency and productivity while reducing the need for manual involvement. Greenhouse farming represents a strategy aimed at boosting crop, vegetable, and fruit yields.

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Traditionally, farmers have had two options for controlling greenhouse environmental parameters: manual monitoring or adopting automated inspection mechanisms. However, manual monitoring comes with drawbacks such as production losses, energy inefficiencies, and high labor costs, rendering it less effective. On the other hand, IoT through smart greenhouse systems embedded with intelligent sensors offers a more efficient and proactive approach to climate control [3] [4].

Aisha Yahaya etal.,[5] presented the utilization of sensor-based environmental monitoring to enhanced agricultural practices. Intelligent greenhouses represent a significant stride toward modernizing agriculture, prompting numerous researchers to explore ways to optimize greenhouse conditions. One such endeavor involves the introduction of a wireless monitoring and control system by Kulkarni et al.,[6] employing IOT to collect and display data on an LCD interface. Similar methodologies have been proposed by Ibrahim et al. [7], who have devised remote monitoring and control schemes aimed at ensuring the effective operation of greenhouses. These efforts underscore the growing interest and investment in leveraging IoT technology to enhance agricultural productivity and sustainability.

II. SYSTEM MODEL AND ASSUMPTIONS

A greenhouse typically consists of a roof and walls made of glass or plastic, allowing it to harness solar radiation from the sun to warm the interior, including plants and soil. This structure creates a controlled environment that shields and nurtures plants. While water is crucial for gardening, many gardeners rely on manual systems for plant care within greenhouses, which can be inefficient and diminish productivity. To address this challenge, automating greenhouse control is proposed. The primary objective of this project is to automate greenhouse management using efficient sensors for temperature, moisture, light, and pH levels. Leveraging advanced sensors and IoT technology, data from the greenhouse are collected, processed, analysed, and relayed to farmers via their mobile phones or personal computers, along with relevant instructions [8-9]. The block diagram depicting the proposed system is presented in Figure 1.

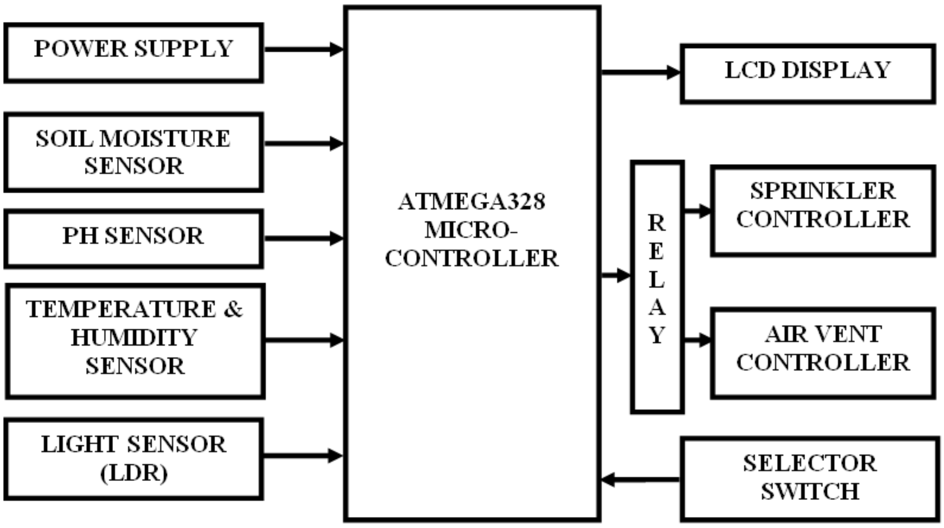

Fig. 1 Block diagram of proposed greenhouse control system

Sensor Module: This module consists of temperature and humidity sensors, an LDR (Light Dependent Resistor) sensor, PH Sensor and a soil moisture sensor.
Arduino Microcontroller: The Arduino serves as the central processing unit of the automation system.
Actuator Module: This module consists of water pumps that control irrigation within the greenhouse.

III. RESULT AND DISCUSSION

The proposed greenhouse management system represents a comprehensive automation solution harnessing cutting-edge technology. This system will continuously monitor crucial parameters such as light intensity, temperature, soil pH, and moisture levels while efficiently controlling them. At the heart of the system lies the Arduino microcontroller, acting as the central processing unit. It continuously assesses data from various sensors, both analog and digital, ensuring their accuracy and determining if any corrective measures are needed. Upon detecting the need for action, the system promptly alerts authorized users via IoT messaging. The Arduino unit regulates the water pump based on readings from

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the soil moisture sensor, activating it when moisture levels dip below the required threshold. Circuit diagram of proposed system is shown in Figure 2.

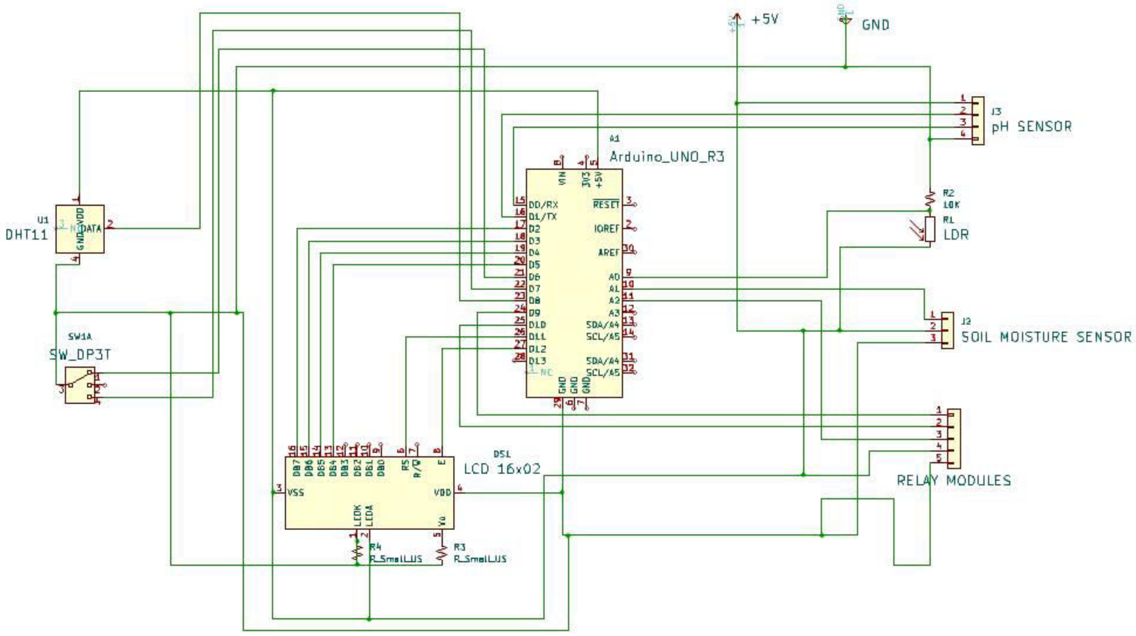

Fig. 2 Circuit diagram of proposed system

Additionally, a temperature sensor integrated with the Arduino monitors greenhouse temperature, triggering a fan to moderate high temperatures as needed. Furthermore, a pH sensor gauges soil pH levels, while an LDR measures light intensity within the greenhouse. If light levels decrease, the system automatically activates a connected bulb to maintain optimal lighting conditions. By integrating these components and functionalities, presented system effectively modify the weather conditions inside the greenhouse to suit the specific requirements of different crops, optimizing plant growth and maximizing yield. Specific crop is chosen through the selector switches, the Arduino microcontroller regulates the environmental conditions by turning on or off various actuators like heaters, fans, water pumps, and lights. This guarantees that the greenhouse sustains the perfect growth conditions customized to the selected crop, fostering robust plant growth and maximizing output. Also, it is possible to wireless control and monitoring through internet of things.

This adaptive control system guarantees that the greenhouse environment is finely adjusted to provide the specific requirements of the chosen crop, promoting ideal growth conditions. Moreover, Arduino sustains a continuous feedback loop, consistently evaluating sensor data and implementing essential modifications to adapt to shifting factors like external weather patterns and seasonal changes. The outcome is a seamlessly integrated system that not only optimizes greenhouse functions but also enhances both the quantity and quality of crops harvested. Table 1shows some crops and its required parameter.

Table 1: Crops and its Required Parameter

Crop	Temperature (^{o}C)	Humidity (%)	Soil Moisture (%)	pH Scale
Okra	29.5 – 33.0	50-70	60-80	6.0-6.8
Tomato	29.0 – 31.0	60-70	70-80	6.0-7.0
Cow Pea	29.5 – 33.5	60.-80	60.-70	5.0-6.5

Advantages of the proposed system are, 10-12% increase in yield depending upon the type of greenhouse, type of crop, environmental control facilities, Reliability of crop will increases, Expands the growing season and Minimize external

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threats to the crop. It can be used for small and large scale farming, controlled growing environment in research centres and Government biological nurseries.

IV. CONCLUSION

This work established a comprehensive design for a fully automated greenhouse management system. Through experimental setup, it is evident that the system meets all requirements for greenhouse monitoring. The automated greenhouse monitor has the potential to increase plant yield significantly. This design offers automatic control over essential parameters such as light, pH, temperature, and humidity, effectively addressing critical conditions. By employing this model, crop efficiency can be consistently enhanced. Thus it can handle famine problem around the world up to a great extend. Additionally, the provision of remote access control to greenhouse parameters via IoT represents an advanced and highly beneficial feature for users. The proposed system can be improved by adding time bound administration of fertilizers, insecticides and pesticides. In addition, a speaking voice alarm could be used to make it more users friendly. In addition to the conditions that have been mentioned in this work, other conditions may be included such as shade and fire detection. Image processing schemes may be employed for adding these features.

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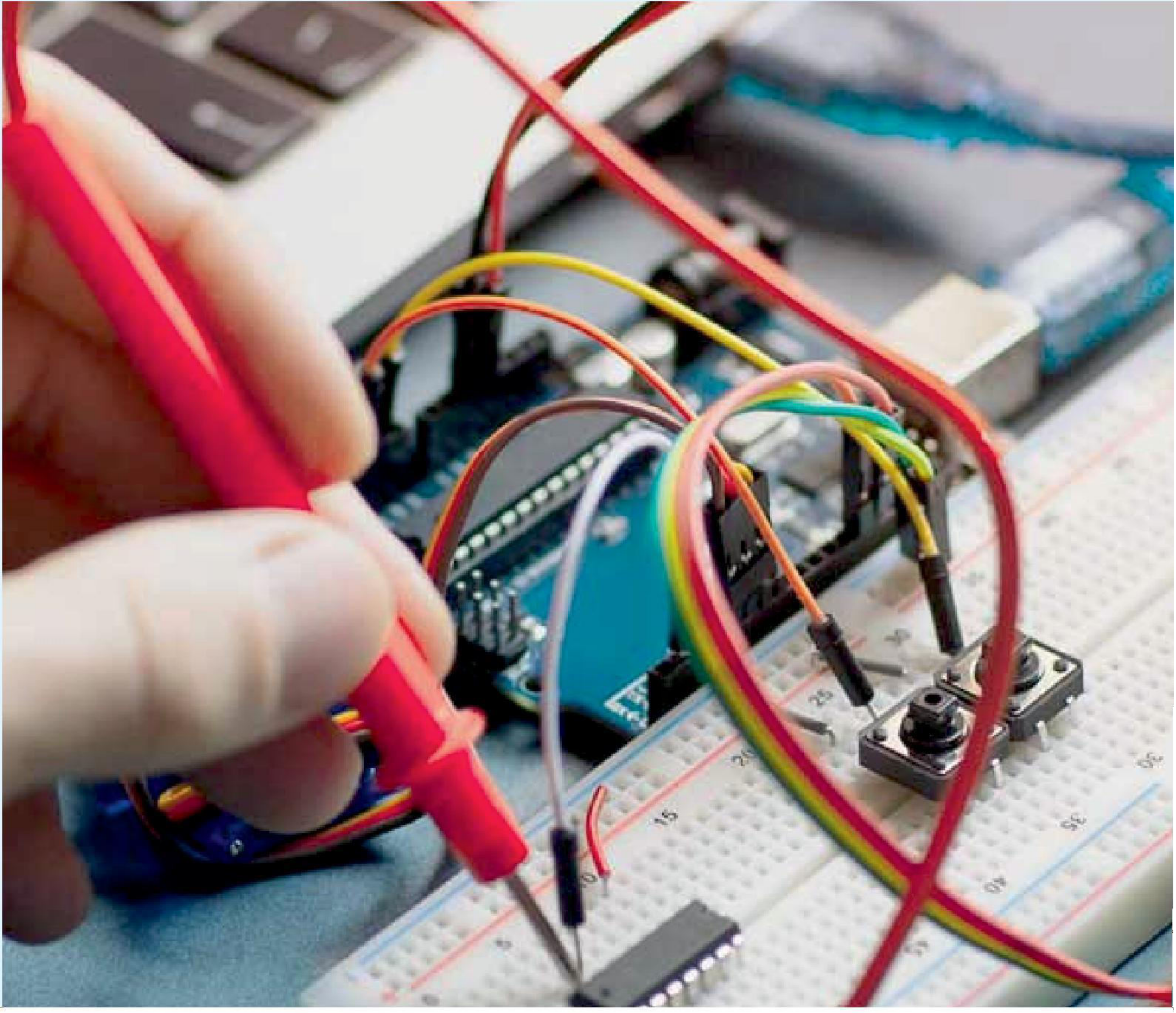

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