Journal of Information & Optimization Sciences
ISSN 0252-2667 (Print), ISSN 2169-0103 (Online)
Vol. 45 (2024), No. 2, pp. 571–579
DOI : 10.47974/JIOS-1595

An intelligent greenhouse monitoring and control system employing Internet of Things

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Abstract

IoT-based intelligent greenhouse monitoring and control system has been designed to optimize agricultural processes. The proposed system employs a network of sensors to collect real-time data on environmental parameters such as temperature, humidity and soil moisture within the greenhouse. Leveraging Internet of Things (IoT) technology, the collected data is transmitted to a centralized platform accessible by farmers. Through this platform, users can remotely monitor and control the greenhouse conditions, ensuring optimal growth conditions for plants. Automated actuators enable precise adjustments, such as irrigation and ventilation, contributing to resource efficiency and sustainable farming practices. This innovative solution enhances crop yield, reduces resource wastage, and empowers farmers

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with actionable insights for informed decision-making, marking a significant advancement in modern agriculture

Subject Classification: *93-XX, 94-XX.*

Keywords: *Arduino, NodeMCU (ESP8266), Real time monitoring, Relay module, Microcontroller, Electrical systems.*

1. Introduction

A greenhouse is an arrangement for the refinement of plants in a controlled environment, providing an optimal climate for growth. Typically made of transparent materials like glass or plastic, greenhouses trap sunlight to create a warmer atmosphere, allowing plants to thrive outside their natural seasons. This controlled environment enables extended growing seasons, improved crop yields, and protection from adverse weather conditions [1]. Greenhouses play a crucial role in modern agriculture, horticulture, and plant research, contributing to sustainable food production and environmental conservation. However, the current limitations in greenhouse plant control necessitate manual operation using various documents due to the lack of remote accessibility [2]. To optimize plant growth, continuous monitoring and management of critical factors like temperature, moisture and soil humidity are essential [3]. This study introduces a greenhouse management system based on the Internet of Things (IoT) to address these challenges. The system enables the

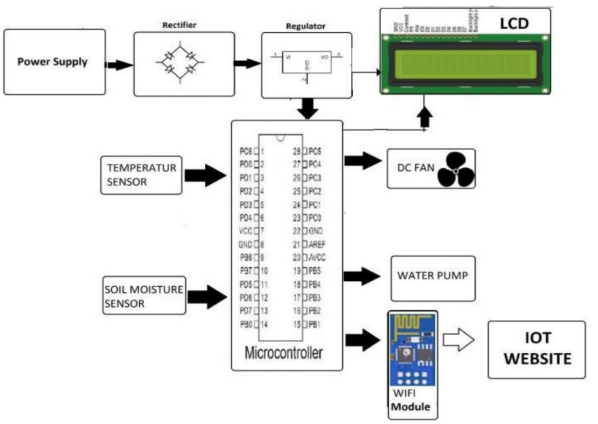


Figure 1

Model Block Diagram of Circuit

detection of visible conditions such as humidity, soil moisture, and temperature. All environmental data is seamlessly transmitted to BLYNK, an online platform that can be accessed remotely, ensuring efficient and convenient greenhouse facility management. Block diagram of system is shown in Figure 1.

2. Methodology

For the establishment of a dependable greenhouse monitoring infrastructure, it is imperative to employ parameters such as temperature, humidity, and soil moisture to achieve optimal design for a diverse range of plant species. The continuous surveillance of all greenhouse variables is facilitated through the integration of a humidity and temperature sensor (DHT11) along with a soil moisture sensor. A pivotal component of the envisaged system is the Node MCU, responsible for the storage of data derived from the aforementioned sensors. The deployment of a BLYNK mobile application on smartphones offers a seamless interface for monitoring and controlling greenhouse information. Within the proposed framework, the initial phase involves the DHT11 sensor undertaking the measurement and quantification of the persistent values of temperature and humidity, subsequently transmitting this data to the Node MCU. These real-time values will now be compared to pre-set threshold values by Node MCU. a Soil Moisture Sensor (DHT11), a Humidity Sensor (DHT11), and a Temperature Sensor (DHT11) are connected to a NODE MCU Esp8266, and there is a BLYNK App that controls a DC Fan and DC Motor (Pump). Node MCU will provide the signal to turn on the fan and the soil moisture sensor will follow the same process. Threshold value will be determined by temperature and humidity. If the threshold value exceeds, the electronic gadgets are automatically turned ON, which keeps up the required air inside the greenhouse. In addition, that allows us to maintain dampness and temperature in the closed greenhouse. This sensor provides data to the BLYNK App for the customer to view. It is Node MCU that is at the core of this framework and takes responsibility for the entire cycle The Node MCU turns on the engine when the soil moisture sensor does not detect any dampness in the soil and indicates this on the LED status. This framework uses a 16X2 LCD screen to display the status of all activities such as motor on or off, temperature and moisture with the BLYNK application, an alert message is also provided when the status changes, and flow chart of the complete process in shown in Figure 2.

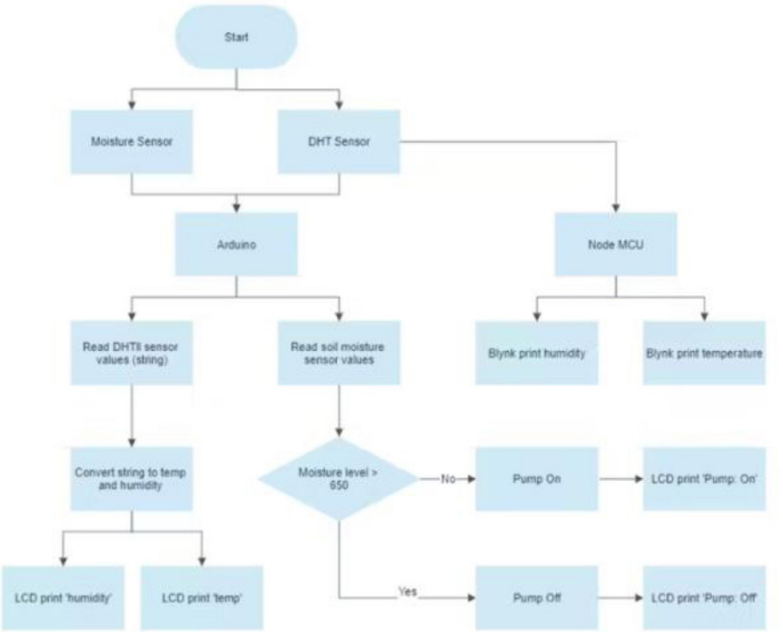


Figure 2

Flow Chart of circuit

Plant growth and health are directly affected by analyzing and predicting greenhouse parameters. Statistical modelling, machine learning, and data analysis are all incorporated into this process that makes this system more efficient and robust.

3. System Architecture

The primary objective of this design is to showcase the conceptualization and execution of a vibrant sensor apparatus devised for the supervision and regulation of environmental conditions within greenhouse terrains. With a temperature sensor and humidity sensor, a TV display module, a 12v DC charger, and a pump, the hothouse control system is energized by an Atmega328 Arduino UNO microcontroller. In response to elevated temperatures, DC fans are activated, and conversely, when temperatures decline, the fans deactivate. Water position is sensed by soil humidity detector, as the position decreases, pumps turn on. This will make it easier to control and cover the system, complete connection is elaborated in Figure 3.

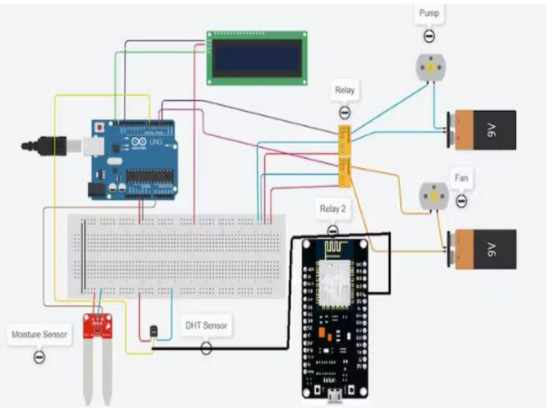


Figure 3

Circuit Diagram of proposed system

3.1 *Arduino Uno*

Microcontroller board for prototyping, featuring ease of use, open-source, and compatibility with various sensors and actuators [3],[4].

3.2 *Node MCU*

ESP8266-based open-source IoT platform, combining Wi-Fi connectivity with ease of programming for versatile applications [5].

3.3 *Node MCU Temperature and Humidity Sensor (DHT11)*

A temperature sensor measures ambient temperature, converting it into an electrical signal for monitoring or control applications in various systems. Humidity Sensor: A humidity sensor measures moisture levels in the air, crucial for applications like climate control and environmental monitoring [6].

3.4 *Soil and Moisture Sensor*

The soil humidity sensor serves the purpose of assessing the moisture content within the soil it occupies. Comprising two probes to facilitate the passage of current through the soil, the sensor gauges the resistance encountered in acquiring the humidity level. In the presence of additional water, it induces enhanced soil conductivity, resulting in lower electrical

resistance, whereas dry soil translates to delicate resistance and, consequently, reduced electrical conductivity [7].

3.5 *BLYNK Application*

BLYNK App constitutes a versatile platform compatible with both iOS and Android, designed to oversee the remote control of Arduino and Raspberry Pi devices through internet connectivity. Conceived with a focus on the Internet of Things, it possesses the capability to govern a myriad of devices, present sensor data, store information, and execute various other functions. Within this framework, we orchestrate the manipulation of LEDs through the BLYNK App and Esp8266. The schematic elucidates the BLYNK app's functionality; upon detecting internet connectivity, it seamlessly transitions to the operational phase. Subsequently, when connected, it navigates to the Detectors (DHT11) for Temperature & Moisture and Soil Moisture Sensor. A Node MCU is initiated to scrutinize the sensor values, which are then elegantly showcased on an LCD screen within the BLYNK App. With BLYNK app mobile applications can be easily designed to connect smart things with smartphone. Programmers can choose user interface features like sliders, buttons, or gauges with BLYNK. Monitoring and control functions can be integrated with BLYNK [6] [7].

The BLYNK Server facilitates communication between smartphones and hardware, offering the option to utilize either the BLYNK Cloud or set

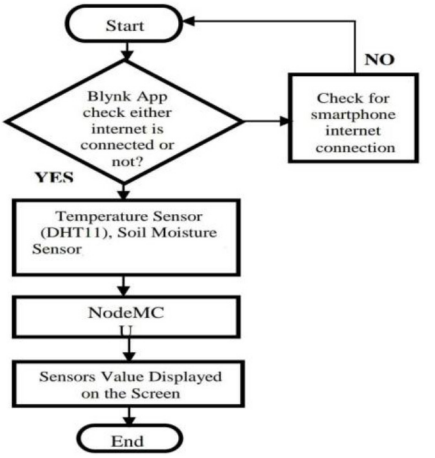


Figure 4

Flow Chart of BLYNK App

up a private server locally. Known for its effectiveness and reliability, this open-source platform can efficiently handle numerous devices and is deployable, even on a Raspberry Pi. Flowchart for working of BLYNK app is shown in Figure 4.

4. Result and Discussion

The greenhouse system efficiently measures and displays various environmental parameters such as humidity, temperature, soil moisture. The recorded values are accurately presented on an LCD screen integrated with the system. The interaction between the Node MCU Esp8266 Wi-Fi Module and diverse sensors occurs seamlessly, devoid of any interference. The accompanying Figure 5 illustrates a representative screen from the BLYNK application visible on the user's device, effectively portraying the greenhouse data. The BLYNK App impeccably exhibits the greenhouse values on the user's device, including the status of actuators like the Pump. The display indicates whether the device operates in auto or manual mode, accompanied by the corresponding status LEDs. The recorded value of soil moisture of greenhouse, temperature level of greenhouse,

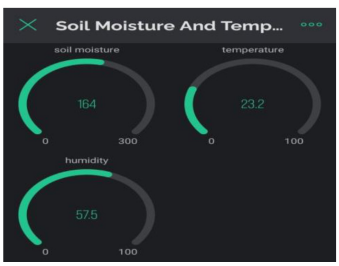


Figure 5

BLYNK Software Interface

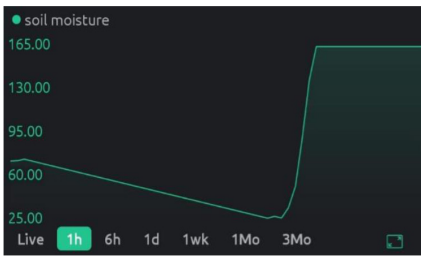


Figure 6

Soil Moisture of Greenhouse



Figure 7

Temperature level of Greenhouse

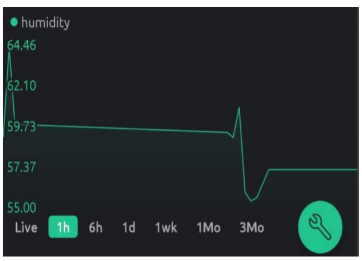


Figure 8

Humidity level of Greenhouse

and humidity level of greenhouse are displayed in Figure 6, Figure 7 and Figure 8 respectively. On the basis of recorded result, it can be concluded that system efficiently monitors and controls the environmental parameters.

5. Conclusion

Our successful implementation of the Greenhouse Automatic Monitoring and Controlling System integrates three sensors to assess Temperature, Humidity, and Soil Moisture, enhancing crop production. Leveraging cost-effective IoT databases, the system allows flexible threshold adjustments for optimal crop fertilization. Envisioned as a future multi-controller system, including a master and slave controllers, its objective is to concurrently automate numerous greenhouses, endowing farmers with a Smart Greenhouse tailored for climate-smart and nutrition-sensitive cultivation of crops. The system computes energy consumption, aiding growers in efficient resource utilization, while its core functions of monitoring, controlling, automating, and detecting anomalies contribute to environmental enhancement and resource conservation. This innovative solution reflects a holistic approach to modern agriculture, aligning with sustainability and efficiency goals, promising positive impacts on crop yields and resource utilization in a concise and impactful manner.

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