IoT-Integrated Multi-Sensor Plant Monitoring and Automated Tank-Based Smart Home Gardening System

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Abstract. Through the use of smart sensors to monitor and regulate plant conditions, smart home gardening management systems can maximize resource utilisation and minimize human intervention. This study offers a new system that remotely controls the water supply to ensure optimal plant growth without the need for personal presence. The system uses the Blynk IoT platform to monitor soil moisture and water levels. A Raspberry Pi is used in conjunction with several sensors, such as a soil moisture sensor and a DHT11 sensor for temperature and humidity readings. The technology activates a motor to provide water to the plants automatically when the soil moisture level falls below a certain threshold. Users can remotely monitor and manage the system from their cell phones thanks to integration with the Blynk platform. The suggested method is an affordable and effective way to garden in your home, and it's simply customizable to fit the requirements of different users.

1 Introduction

IoT applications that have the potential to save consumers time and effort while simultaneously enhancing the health and well-being of houseplants are smart home plant care systems. But many of the current systems have drawbacks, including excessive cost, difficult installation, and inadequate monitoring and control features. In this work, a unique smart home plant care system—light levels, temperature, humidity, and soil moisture—is proposed. It is inexpensive, simple to install, and offers comprehensive monitoring and control of all essential environmental parameters impacting plant growth. The system makes use of a Raspberry Pi microcomputer and many inexpensive sensors to gather environmental data in real time for the plant. Actuators are then controlled by the system to guarantee that the plant's requirements are satisfied. Additionally, the system has an intuitive user interface that enables customers to remotely monitor and manage their plants from any location in the globe. Compared to current smart home plant care systems, the suggested system has a

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number of benefits, including affordability, usability, comprehensiveness, customizability, and scalability.

Researchers have been really interested in creating smart home apps and systems. They commonly use the Arduino platform and Raspberry Pi for these projects. Author from reference [1] created a user interface (UI) to monitor changes using smart devices. They utilized a Wi-Fi module, enabling users to receive notifications via email and control the component through the graphical user interface (GUI).[2] They made a smart irrigation system using Arduino Uno, but the interface wasn't clear—possibly because it wasn't connected to any network. They collect readings and manually water the plant when the moisture level is low. It's a simple and cost-effective IoT project designed to conserve water usage. In their project, the author from reference [3] has created multiple sensors and actuators connected via Zigbee communication. It's accompanied by control software, allowing the storage and real-time availability of monitoring data on a web portal. Additionally, they've integrated three-day weather forecasts into the control and monitoring units. This unit determines when to irrigate based on the data received from sensor readings and weather predictions. To reduce expenses and effectively meet the functional needs, sensors and actuators were employed.[3] Atmel's microcontroller, model 328, was utilized to capture sensor signals and manage actuator outputs.[4] A GSM Module is integrated to send the user an SMS containing details about temperature, water, and light. In instances where plants don't receive sufficient natural light, artificial lighting is used to support plant growth. The table below compares all the smart home applications mentioned earlier, pinpointing the main drawbacks or limitations of each system.

After considering the current analysis and examining the table 1, the main limitations and disadvantages of the earlier approaches can be summarized as follows:

1. Preferentially using the Arduino platform over other platforms is advantageous due to its cost-effectiveness and user-friendly programming interface.

2. The majority of techniques were designed specifically for local use. Therefore, it's crucial to contemplate the adoption of remote sensing technologies, such as Bluetooth for short-range systems or Wi-Fi and cloud-based systems for global remote control

3. By incorporating machine learning algorithms or AI-driven predictive models, the system's autonomous irrigation decisions could be significantly improved. However, innovation seems restricted as most projects rely on similar techniques.

4. Past researchers often haven't clearly outlined the necessary costs for developing smart applications. To ascertain whether the approach is cost-effective, it's important to explicitly state the related expenses.

Table 1. The comparison between some developed Smart Irrigation System

Ref. No.	Year	Controller	Interface	Controlled Application	Limitation
[1]	2017	Raspberry Pi	Email	Light, Soil Moisture, Humidity& Temp, Motor	The absence of a DHT11 sensor limits a thorough evaluation of temperature and humidity levels, essential for accurate environmental adjustments.
[2]	2021	Arduino	Not Stated	Soil moisture, LCD, Relay	The system only focused on local use and didn't consider remote sensing technology.

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Ref. No.	Year	Controller	Interface	Controlled Application	Limitation
[3]	2014	Arduino	Created own portal. (iRain)	Light, temp, humidity, Soil moisture, Motor pump	The required cost is not clear
[4]	2017	Arduino	SMS using the GSM module	Fan, Light, Motor, soil Moisture, temperature	The cost details are unclear. It's essential to clearly specify the associated expenses.

2 Control unit and Blynk network

The Raspberry Pi, a low-cost, high-performance computer that is perfect for a variety of applications, including smart gardening systems, is the control unit that we used in our system. Because of its many advantages, the Raspberry Pi is a great choice to operate a smart gardening system. It is reasonably priced, packs a lot of computing power, and offers a lot of networking choices. Internet connectivity is one of the most crucial aspects of the Raspberry Pi for usage in a smart gardening system. This enables Raspberry Pi to establish a connection with the cloud-based Blynk server, a platform that lets users design and control the user interfaces of their Internet of Things devices. Both Ethernet and Wi-Fi are viable options for establishing internet connectivity on the Raspberry Pi. We have utilized the Raspberry Pi's integrated Wi-Fi capability in our smart gardening system. Open the Network menu on the Raspberry Pi and choose your Wi-Fi network to connect the Raspberry Pi to Wi-Fi. After entering your Wi-Fi network's password, click Connect.

The Raspberry Pi can transmit and receive data and communicate with the Blynk server once it is connected to the internet. The Raspberry Pi sends information about the current temperature, humidity, soil moisture content, and water tank level to the Blynk server via its internet connection. When the water tank is low or the temperature or humidity falls outside of a predetermined range, send notifications to the Blynk interface. On the other hand, the Blynk interface sends out notifications when the water tank is low or when the temperature or humidity falls outside of a predetermined range. It also displays the current temperature, humidity, soil moisture level, and water tank level. All things considered, the Raspberry Pi and Blynk interface work well together to create intelligent gardening systems.

The Blynk interface offers an intuitive user interface for system control and data display, while the Raspberry Pi provides the necessary computing power and connectivity.

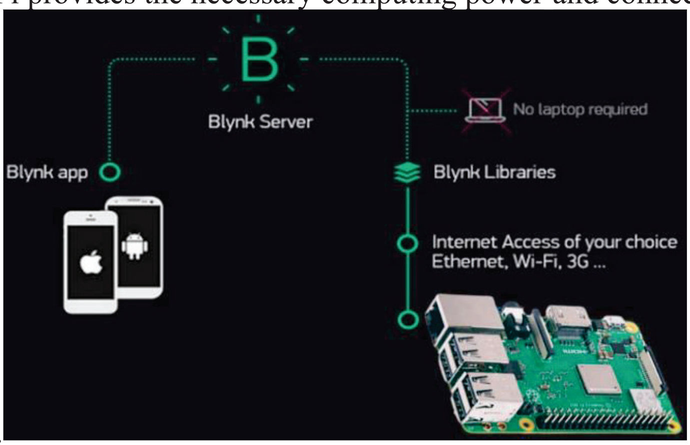

Fig.1. Blynk connection with Raspberry

3 Block diagram

This block diagram represents a system that collects data from soil moisture, temperature, humidity, and water level sensors, processes this data on a Raspberry Pi, and uses the Blynk platform to provide remote monitoring and control of a water pump via a relay.

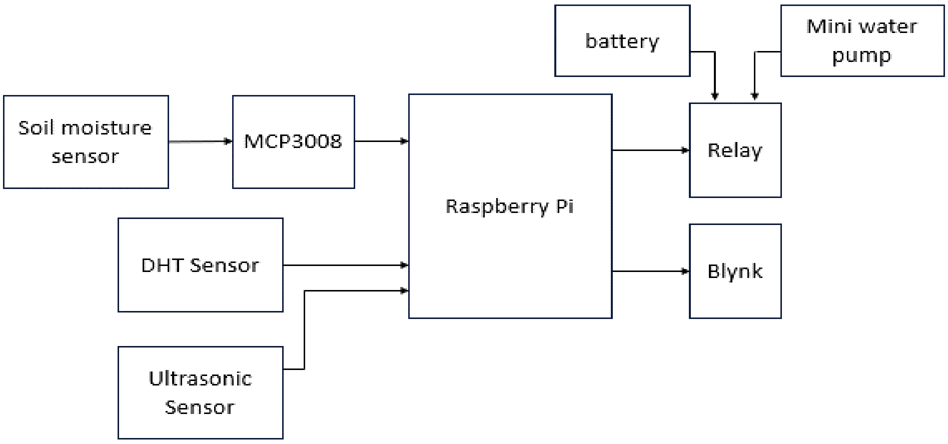

Fig. 2. Block Diagram of the proposed model

4 Smart home gardening systems and their control circuits

This section presents the developed four applications of the smart home. These applications are shown in Figure. The definitions, the components, and the control circuits for each application and system are discussed in detail in the following subsections.

4.1 Determining the soil moisture

The aim of this system is to determine the soil moisture content using soil moisture sensor. In this case one soil moisture sensor is used and MCP3008 an analog to digital converter is used, see Table 2.

Working: The raspberry Pi sends a signal to the MCP3008 to start the conversion process. The MCP3008 samples the voltage from the soil moisture sensor and converts it to a digital signal. Then it sends the digital signal to the Raspberry Pi. The Raspberry Pi reads the digital signal from the MCP3008 and converts it to a percentage. The percentage represents the amount of moisture in the soil.

4.2 Determining the humidity and Temperature of the surrounding

The aim of this system is to determine the humidity and temperature of the surrounding using temperature sensor. In this case we have used DHT11 sensor, see Table 3.

Working: The DHT11 sensor is used to determine the humidity and temperature of the environment. The Raspberry Pi reads the digital signals from the DHT11 sensor and then uses the calibrated coefficients stored in the DHT11 sensor to calculate the humidity and temperature.

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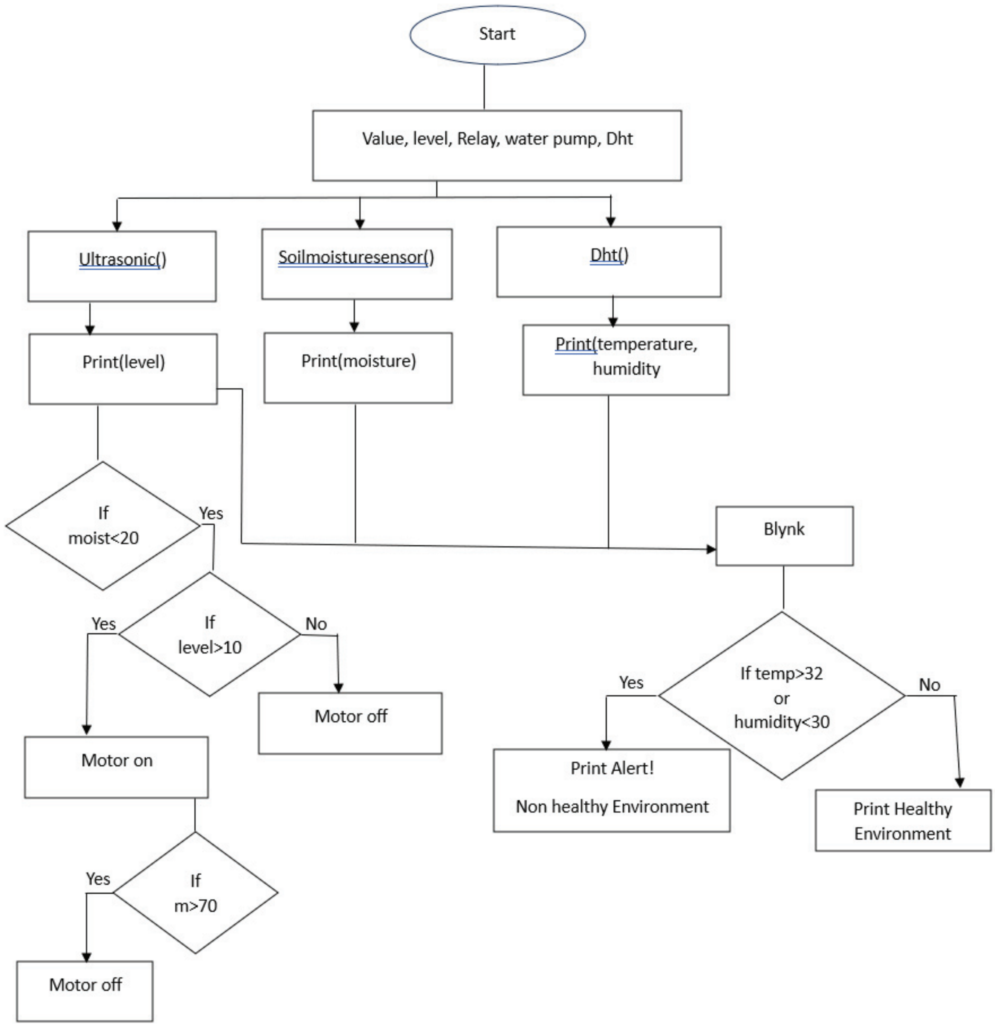

Fig. 3. Flowchart of Smart Home Gardening System

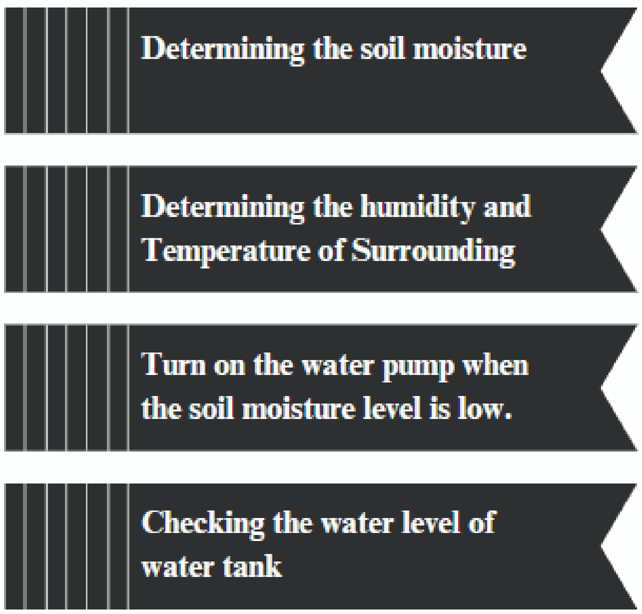

Fig. 4. The four developed smart home applications in this paper.

Table 2. System characteristics.

Component	Definition	Technical specification
Soil Moisture Sensor	An instrument that gauges the water content of the soil is called a soil moisture sensor. This kind of sensor is used to track the amount of water in the soil in horticulture, agriculture, and other fields.	Voltage: 3.3V - 5V Current: 20mA Measurement range: 0-100% Output: Analog voltage (0-5V) Size: 30mm x 10mm x 5mm
MCP3008	An eight-channel analog-to-digital converter (ADC) is the MCP3008. An integrated circuit (IC) of this kind transforms analogue signals into digital signals.	Voltage: 2.7V - 5.5V Current: 1.5mA Number of channels: 8 Resolution: 10 bits Output: SPI

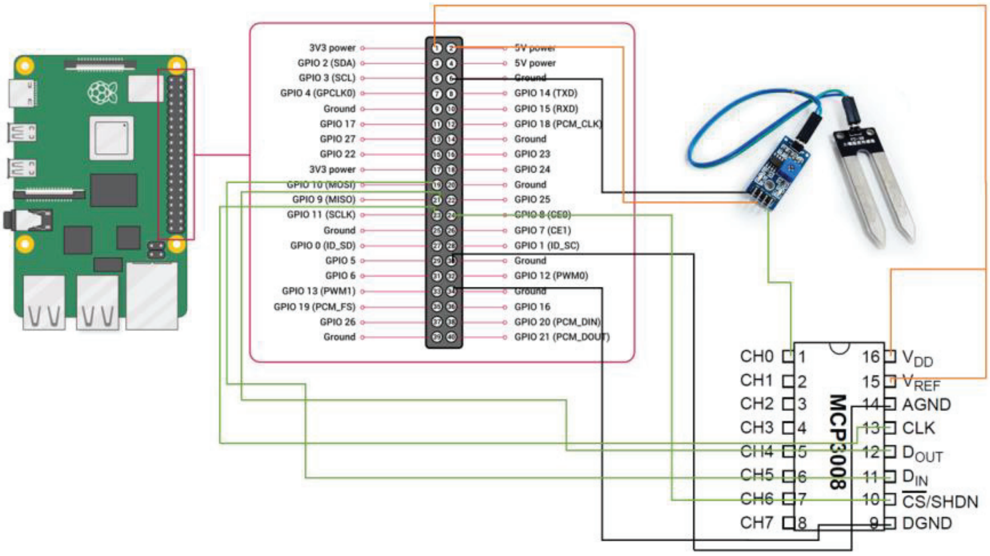

Fig. 5. Soil Moisture Sensor Circuit Diagram

Table 3. System characteristics.

Component	Definition	Technical specification
DHT11	A thermistor is used to measure temperature, and a capacitive humidity detecting element is used in the DHT11 digital humidity and temperature sensor. This inexpensive, user-friendly sensor is frequently utilised in both commercial and hobbyist projects.	Voltage: 3.3V - 5V Current: 2.5mA Temperature range: 0-50°C ±2°C Humidity range: 20-80% ±5% Sampling rate: 1Hz Output: Digital signal (single-wire serial interface) Size: 15mm x 15mm x 5mm

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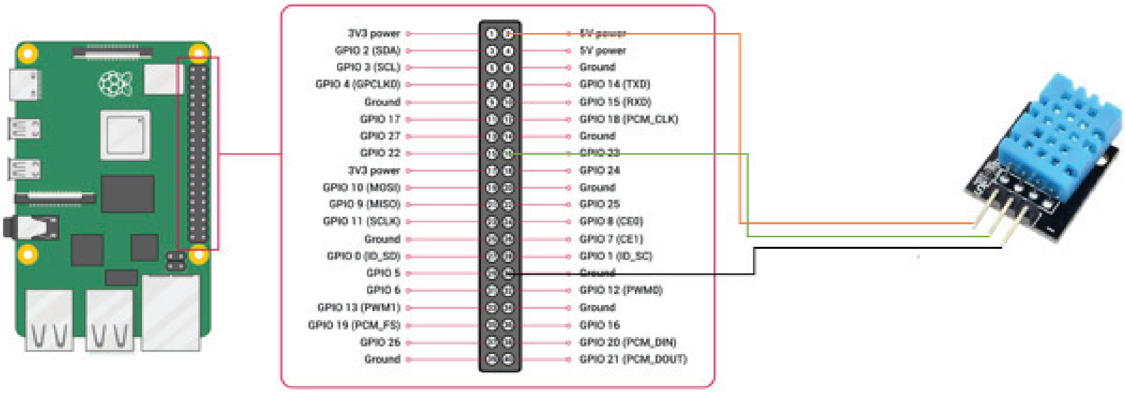

Fig. 6. DHT sensor circuit

4.3 Checking the water level of the water tank

The aim of this system is to check the water level of the tank. In this case we use ultrasonic sensor, see Table 4.

Table 4. System characteristics.

Component	Definition	Technical specification
Ultrasonic Sensor	An ultrasonic sensor is a component that measures an object's distance using ultrasonic sound waves. This kind of sensor finds usage in many different fields, including robots, parking assistance systems, and distance-measuring apparatuses.	Voltage: 5V Current: 15mA Measuring range: 2cm - 400cm Accuracy: 3mm Measuring angle: <15° Output: Digital signal (pulse width) Size: 45mm x 20mm x 15mm

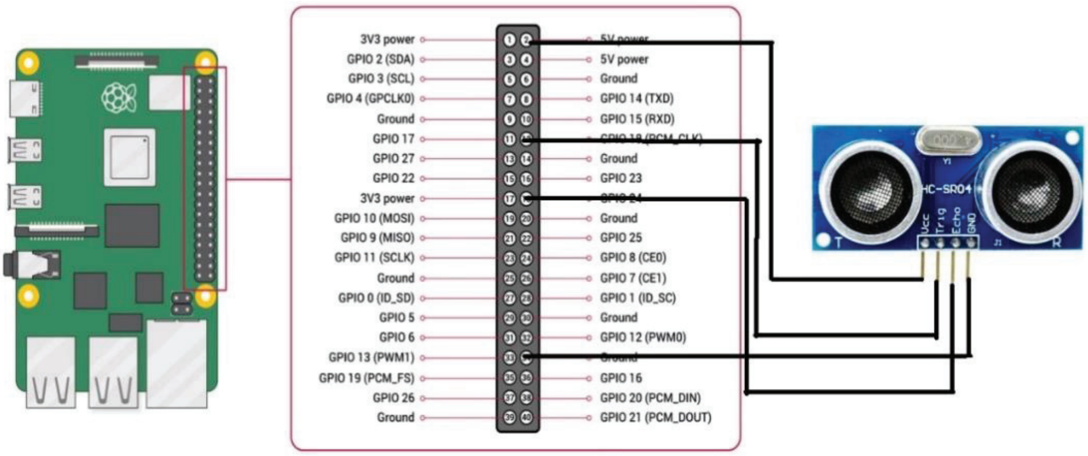

Fig. 7. Ultrasonic sensor circuit

Working: This system's ultrasonic sensor measures the time it takes for an ultrasonic pulse to return after emitting one. The speed of sound can be used to compute distance. We can then deduct the distance from the tank's overall depth to find the water level.

4.4 Turn on the water pump when the soil moisture level is low.

The aim of this system is to on the water pump with the help of relay whenever the moisture level is low and turn it off when the moisture level is sufficient or the water level of water tank is not sufficient. In this case we use relay, mini water pump and 9V battery, see Table 5.

Table 5. System characteristics.

Component	Definition	Technical specification
Relay	An electromechanical switch is called a relay. It's a switch type that responds to an electric current. Numerous applications, including automation systems, lighting control, and motor control, require relays.	Voltage: 5V Current: 10mA Switching current: 10A Switching voltage: 250V AC Size: 25mm x 15mm x 10mm
Mini Water Pump	A mini water pump is a tiny device that moves water. People often use it in small projects they enjoy and in businesses too.	Voltage: 3V - 6V Current: 0.5A - 1A Flow rate: 100-200 L/H Head: 2-3 meters Size: 30mm x 20mm x 10mm

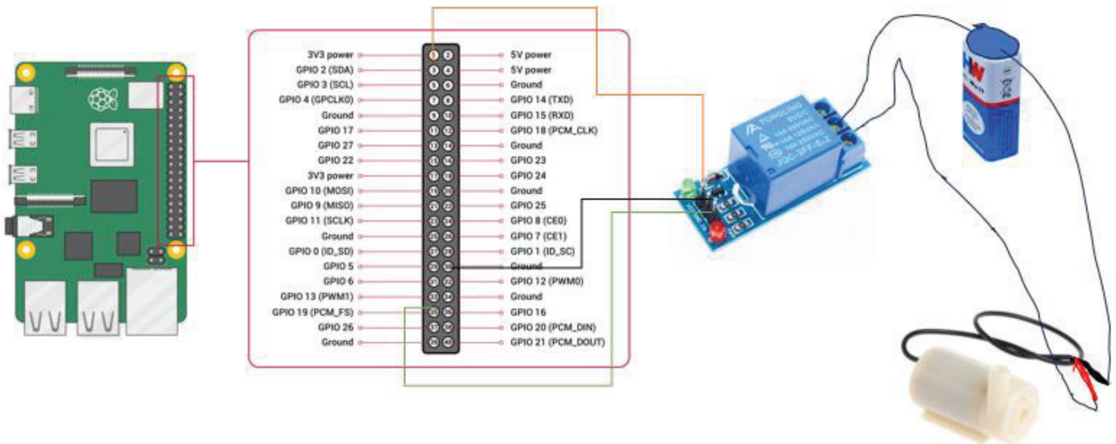

Fig. 8. Connections of relay, mini water pump and battery for watering of plant

Working: The Raspberry Pi sends a signal to the relay to turn on the water pump. The relay then closes the load contacts, allowing current to flow through the water pump.

The water pump then turns on and starts pumping water to the plants. When the Raspberry Pi sends a signal to the relay to turn off the water pump, the relay opens the load contacts and the water pump turns off.

5 Results

In this paper, we successfully developed a Smart home gardening system using Raspberry Pi, soil moisture sensor, dht11, water pump and ultrasonic sensor. The system is designed in order to water the plant irrespective of human presence without needing to put much effort and gives the user convenience to monitor plant through Blynk application while connected to internet.

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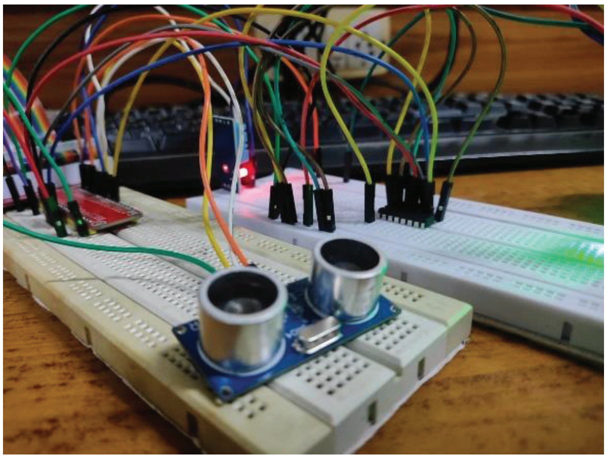

Fig. 9 (a). Hardware Implementation of the proposed model

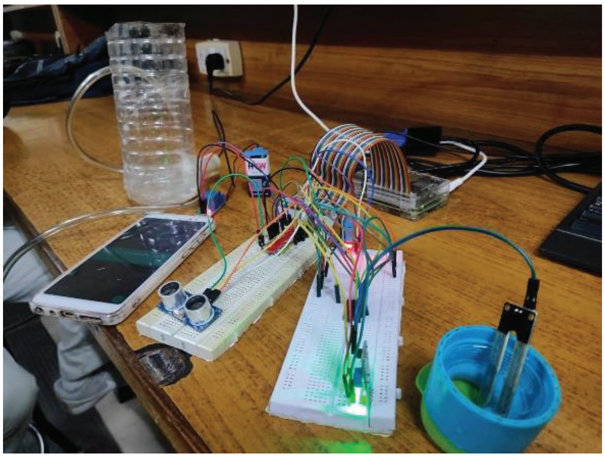

Fig. 9 (b). Hardware Implementation

Fig. 10. Blynk interface showing the values of each sensors

We tested the system in our homes with different kinds of plant like climbers, herbs etc. What we need to keep in mind is what moisture level the plant requires in order for proper growth and then we provide the effective solution accordingly. The system was able to accurately detect the moisture levels in the soil and activates the water pump automatically. Using dht11 sensor we can determine whether the temperature and humidity is favourable for the plant or not and tell the user whether its safe or not. The ultrasonic sensor is able to measure the water level of water tank and prevent the water pump from pumping when there is no water. During testing, we monitored the water usage of the Smart Home Gardening System and compared it to traditional manual watering.

6 Conclusion

In conclusion, the designed system represents a comprehensive and versatile solution for soil moisture monitoring and automated irrigation control. By integrating various sensors, including the soil moisture sensor, DHT sensor, and ultrasonic sensor, with the Raspberry Pi, we have created a platform capable of gathering crucial environmental data. This data is not only collected but also visualized and controlled remotely through the Blynk platform, offering convenient and real-time access to information and irrigation management. The system's ability to make data-driven decisions, such as controlling the mini water pump through the relay, empowers users to optimize water usage, making it a sustainable and efficient solution for agriculture or gardening applications. Additionally, the system's scalability allows for further enhancements, such as integration with weather forecasts or additional sensors, to refine irrigation strategies. Overall, this project demonstrates the potential of combining IoT technologies, sensor data, and automation to address critical challenges in agriculture and environmental monitoring. It serves as a foundation for future developments and innovations in the field of smart agriculture and automation.

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