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Automated Irrigation System

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ABSTRACT
Smart Garden is a technology for monitoring the surroundings of plants. It monitors the level of water in the soil, the heat and humidity of the air, and watered your plants automatically based on sensor data. To fetch the data provided by the sensor from a distant place, the Thing Speak applications are used. Notification service may also be implemented with the aid of the Thing Speak app. This paper focuses on an automated irrigation system that is used to detect soil moisture for efficient use of water for irrigation. Today it is the task of promoting plant development to enhance its growth and reduce costs resulting in the flexible concept of using an automatic irrigation system to continue to help better manage water and human resources. This function is as important as the need for the hour, which is to convert the direct irrigation into automatic irrigation that will use a soil moisture sensor, and which will combine with the dankness of the soil leading to the on / off pumping of the motor.

KEYWORDS
Automated irrigation system; Internet of Things (IoT); irrigation; moisture detection; smart agriculture; smart sensors

1. INTRODUCTION

Irrigation, the artificial distribution of moisture in soil using various mechanisms such as tubes, pumps, and sprays, plays a vital role in regions with irregular rainfall patterns or recurring droughts. While conventional smart irrigation systems operate on predefined schedules, our focus here is to tackle a specific challenge: the inefficient use of water resources in conventional irrigation practices.

Traditional smart irrigation systems rely on timers and schedules, often failing to adapt to changing conditions. Even upgraded systems equipped with rain sensors may fall short of optimal resource utilization as they do not consider the real-time moisture levels in the soil. This oversight is significant because soil moisture content, the amount of water held within a specific soil sample, profoundly influences groundwater recharge and soil chemistry. Furthermore, it directly impacts water conservation.

Consider this alarming fact: over 4 billion people worldwide face water scarcity for more than 30 days each year. It is against this scenario that we introduce the Automated Irrigation System. Our system goes beyond conventional approaches by continuously monitoring soil moisture levels and intelligently controlling the irrigation process. This technology offers a promising solution to mitigate water wastage while effectively irrigating both large and small land areas.

In the following sections, we will dive into the technical details of our system and discuss how it efficiently manages water resources by checking soil moisture content and controlling water supply accordingly. Ultimately, our aim is to contribute to a more sustainable and water-efficient approach to irrigation, aligning with global efforts to address water scarcity issues.

2. LITERATURE REVIEW

The spectra of global water scarcity cast a long shadow on the future of food security. Agriculture, the thirsty behemoth of resource consumption, stands at a crossroads. Clinging to traditional irrigation methods is akin to dancing on the precipice of disaster. But a revolution is brewing, powered by ingenuity and technology. At the vanguard stands the smart irrigation system, wielding the scalpel of precision and the wisdom of the Internet of Things (IoT) to rewrite the narrative of water management in agriculture.

This review delves deep into the fertile ground of research on smart irrigation systems, meticulously dissecting their components, capabilities, and transformative potential. We begin by acknowledging the stark reality: irrigation is the lifeline of agriculture, especially during the summer's fiery breath. Yet, traditional methods leave us gasping for efficiency, drowning in waste [1]- [2]. The need for intelligent solutions that not only quench the thirst of crops but also conserve this precious resource becomes an undeniable imperative.

Enter the sensor-based smart irrigation system, an oracle with eyes that pierce beyond the surface. They delve into the secrets of the soil, meticulously measuring moisture, temperature, and a chorus of environmental parameters with laser-like precision [3], [4], [5], [7], [16], [17]. Microcontrollers like the AtMega328 act as their interpreters, deciphering data, and orchestrating irrigation only when the soil whispers for it, eliminating the wasteful deluge of the past [1], [4], [10]. Some systems, like wise stewards of the land, extend their reach to pH sensors, optimizing fertilizer use based on the soil's unique chemistry, ensuring every drop nourishes and does not pollute [17].

IoT platforms like Thing Speak weave a shimmering web of connectivity, transforming these systems into digital oracles in the palms of farmers' hands. Remote monitoring and control of irrigation schedules become a reality, accessible even on smartphones, empowering farmers to manage their fields from the comfort of their homes [5], [20]. Real-time data and weather forecasts become their guiding lights, allowing them to adjust water delivery with the agility of a dancer responding to the sky's ever-changing symphony [8], [9], [15].

The benefits of smart irrigation systems ripple far beyond the mere trickle of water saved. Some systems, like multifaceted jewels, incorporate nutrient delivery and pest control, fostering a holistic approach to sustainable agriculture, weaving a tapestry of healthy crops and flourishing ecosystems [6], [14]. And for those concerned about the sun's dwindling generosity, fret not! Solar panels can be harnessed to power larger systems, making them environmentally friendly and financially sustainable, a beacon of hope in the face of climate change [2].

However, like any nascent technology, smart irrigation systems face their own challenges. The initial cost can be a formidable barrier, particularly for small-scale farmers in developing countries, casting a long shadow on their dreams of adopting this technology [12]-[15]. Furthermore, the patchy quilt of rural internet connectivity threatens to shroud these systems in the darkness of inaccessibility, hindering their potential to revolutionize agriculture [19].

3. METHODOLOGY

3.1. Materials/Components

3.1.1 Soil Moisture Sensor:

The ground soil moisture sensor is one sort of sensor utilized in this model to determine the volumetric content of water inside the ground soil. Drying and sample weighing are essential because the straight gravimetric dimension of soil moisture must be eliminated [16]-[20]. Other soil rules like electrical resistance, dielectric constant, neutron interaction, and moisture content replacement are used to estimate the volumetric water content indirectly.
This sensor uses the drying method which is very common to measure soil moisture. The equation is as follows:

S = soil moisture content
M = weight of the soil before drying
M' = weight of the soil after drying
W = weight of the soil moisture

$$W = M - M' \quad (1)$$
$$S = ((M - M') / M) * 100$$

Substituting from equation (1), we get equation (2):
$$S = (W / M) * 100 \quad (2)$$

The mapping levels for this sensor are as follows:

1. Value >= 1000: sensor is disconnected
2. Value between 600 - 1000: Soil is dry
3. Value between 370 - 600: Soil is humid
4. Value < 370: Sensor is in water

3.1.2 Arduino UNO:

It is an open-source platform that makes it very simple to use by using very[21] minimal hardware and software. It can translate inputs like light from a sensor [22]-[26], a finger on a button, or a social media post into outputs like turning on an LCD, starting a motor, or publishing anything online.

3.1.3 Servo Motor:

It is an actuator that rotates and that enables accurate angular position control. It is made up of a motor and a sensor that provides feedback on the position. A servo drive is also required to complete the system. The feedback sensor is used to precisely control the motor's rotational position.

With all the due considerations like the weight of the flap, angular acceleration, etc., the torque required for the task will be calculated.

3.2. Architecture

The system architecture (figure 1) depicts a simple connection of various components in the automated irrigation system.

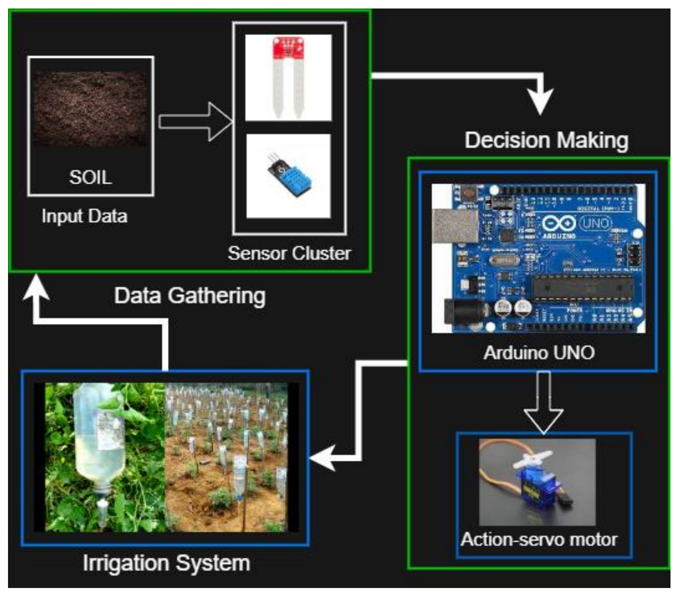

Fig. 1. System Architecture of the proposed automated irrigation system

3.3. Theory

In this research project, a sophisticated system of hardware components was assembled, which included the microcontroller, a precision-engineered soil moisture sensor, a responsive servo motor, and a plastic bottle fitted with a precisely crafted lid featuring a small aperture. Acting as the system's orchestrator, the Arduino UNO played a major role in overseeing all interconnected devices. The experimental setup featured a potted plant placed beneath the poised plastic bottle, with the servo motor's articulate arm connected to the bottle's lid, enabling controlled lid manipulation. The intricate web of electrical connections between the Arduino UNO, soil moisture sensor, and other vital components was seamlessly facilitated by jumper cables.

The Arduino UNO's programming aided it as it monitored soil moisture levels, springing into action when the sensor signaled dryness surpassing a predetermined threshold [27]-[30]. It initiated a response, prompting the servo motor to execute a precise 90-degree rotation, unveiling the bottle's aperture, and allowing a gentle drip of water to irrigate the plant's ecosystem.

When the soil reached an optimal moisture level, the Arduino UNO commanded the servo motor to restore the lid to its closed position.

Throughout the research, data was collected and logged provided by the soil moisture sensor, including moisture levels and timestamped records of irrigation initiation and cessation.

3.4. Circuit Diagram

Figure 2 shows the circuit diagram of the assembly.

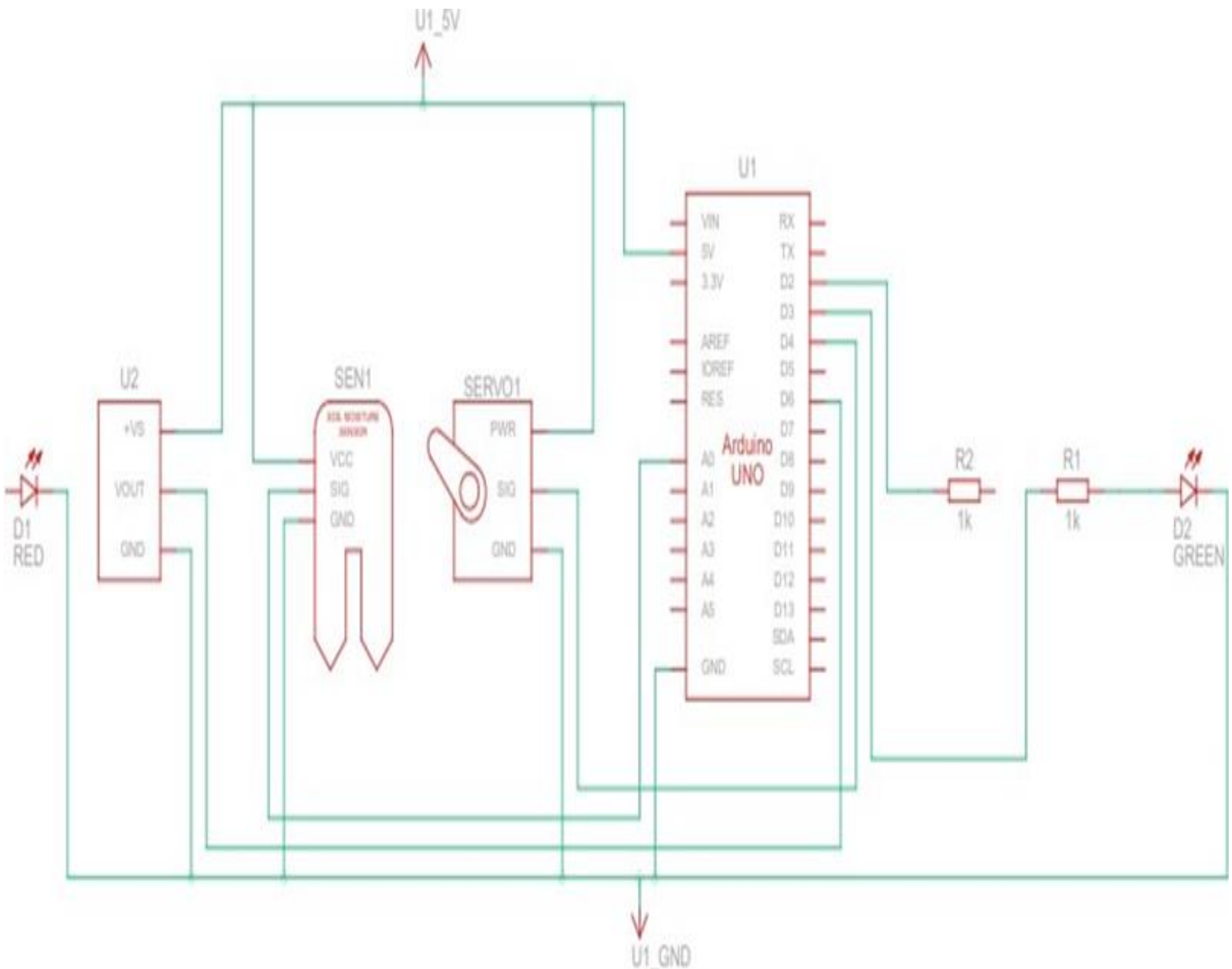

Fig. 2. Circuit diagram of the assembly

The major parts and connections that enable automated watering based on soil moisture levels are displayed in the circuit diagram. An Arduino UNO serves as the irrigation system's main controller, processing data. The Soil Moisture Sensor, which oversees supplying crucial soil moisture data, is the key part. Its VOUT output connects to the Analogue Input on the Arduino, enabling precise soil moisture monitoring. A servomotor is used to regulate irrigation, and its control signal is connected to Arduino Digital Pin D4. By controlling the servo motor's motion through this link, the Arduino can precisely manage the water supply to the plants. To support voltage division or pull-up/down operations and ensure signal stability and correct conditioning, the circuit includes two 1k resistors, R1 and R2. To ensure appropriate operation and data interchange, the circuit uses Ground Connections (GND) to create a single reference point for all components. The circuit runs on a 5V power source. Two LEDs are also included in the circuit: D1 (Red) and D2 (Green). When the soil is dry, D1 illuminates, acting as a signal to start the watering process. When the soil is sufficiently moist, however, D2 illuminates, indicating that irrigation is not necessary.

4. RESULTS AND DISCUSSIONS

This miniature pseudo model of an automated plant irrigation system is tested in two different soils. The moist soil is wetter than the dry dirt. When the soil is dry, the soil moisture sensor and humidity sensor will detect the moisture level and compare it with the fed data and recognise the dryness and then turn the servo motor by a 90-degree allowing the irrigation system to work. Once the soil is wet and moist, the soil moisture sensor and humidity sensor will detect the moisture level and compare it with the fed data and once it recognises the moisture it will turn the servo motor back by a 90-degree closing the irrigation system. In essence when the soil is dry will the pump start operating, since that soil requires more water for healthy crop development, and when the soil is moist, the pump will not function because the soil does not require any water owing to the presence of water, therefore this project will conserve water during irrigation and reduce human efforts.

4.1. System Setup

Figure 3 and figure 4 shows the Photographic representation when the soil is dry and wet respectively.

Fig. 3. Photographic representation when the soil is dry.

Fig. 4. Photographic representation when the soil is wet.

4.2. Monitor Readings and Graphs

Table 1. shows the Readings obtained from the serial monitor measuring various parameters. Figure 5, figure 6, figure 7 and figure 8 shows the graphical representation of humidity, temperature, heat index, moisture level respectively.

Table 1. Readings obtained from the serial monitor measuring various parameters.

Time Stamp	Humidity	Temperature	Heat Index	Moisture Level
18:37:28	4352	371.5	-3468453	1
18:37:36	4480	448.1	-6535652	0
18:37:38	4480	435.4	-6016655.5	0
18:36:44	4467.2	409.8	-4998574.5	0
18:37:01	4428.8	396.8	-4443545	1
18:37:03	4416	384.2	-3992917.75	1
18:37:20	4390	384	-3933380.5	1

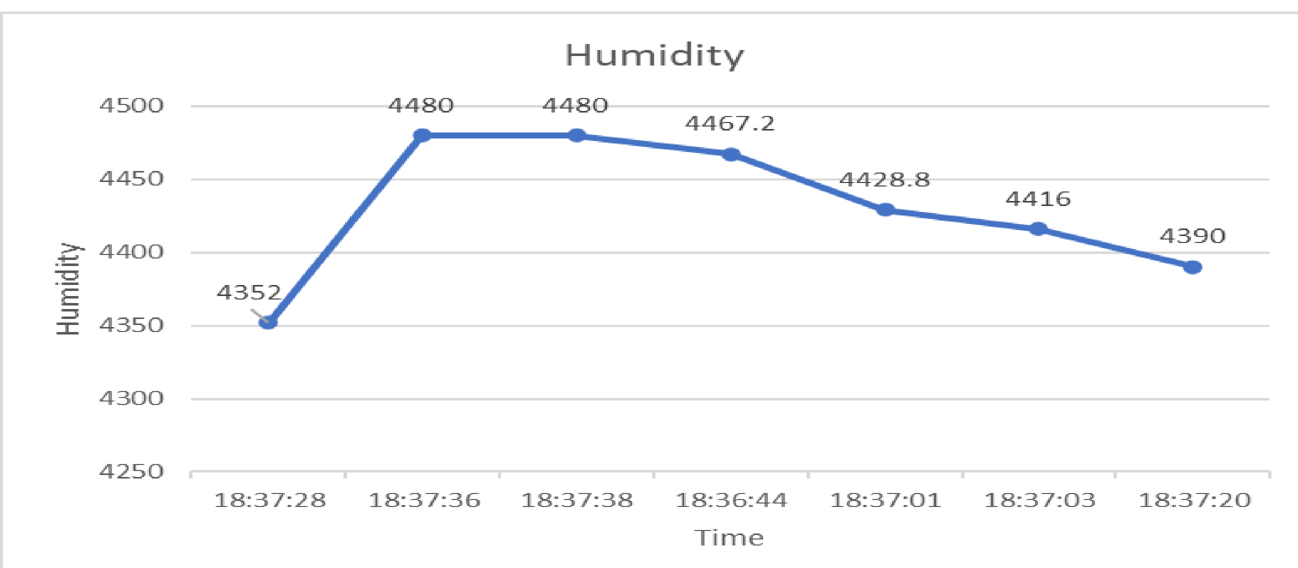

Fig. 5. Photographic representation when the soil is wet.

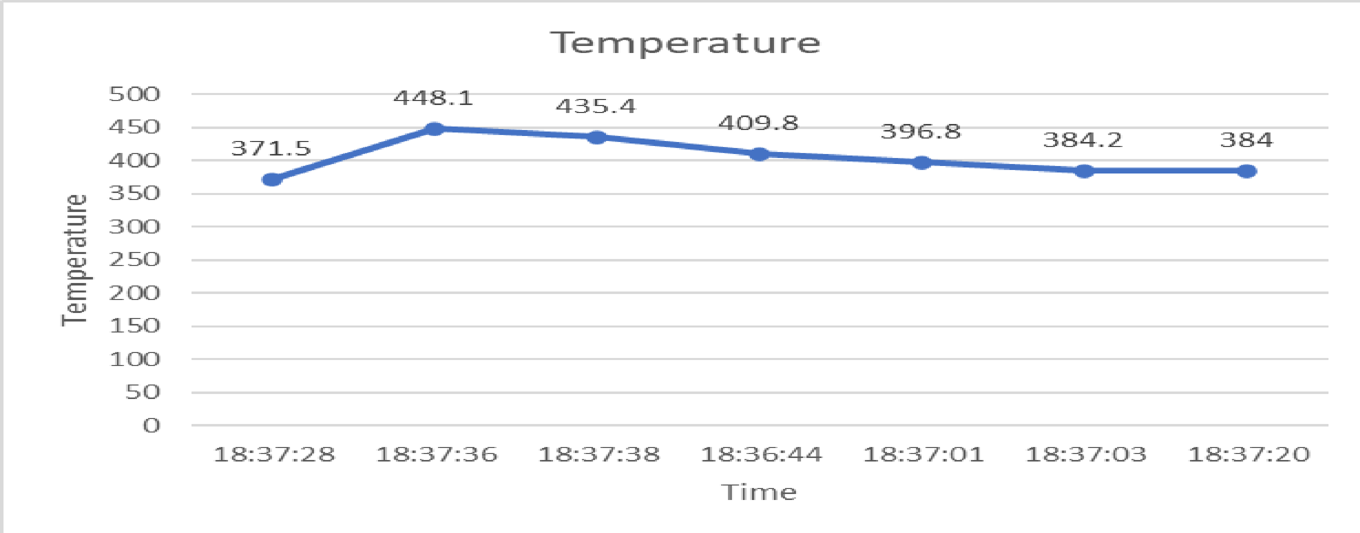

Fig. 6. Graphical representation of Temperature readings

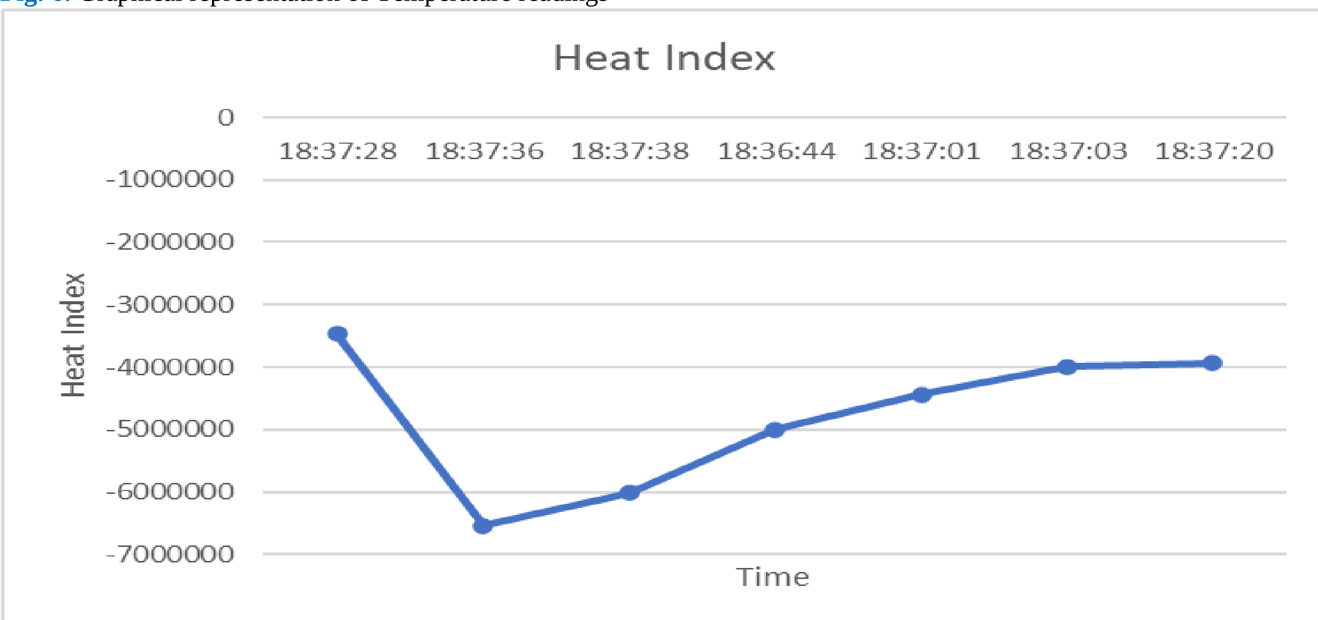

Fig. 7. Graphical representation of Heat readings

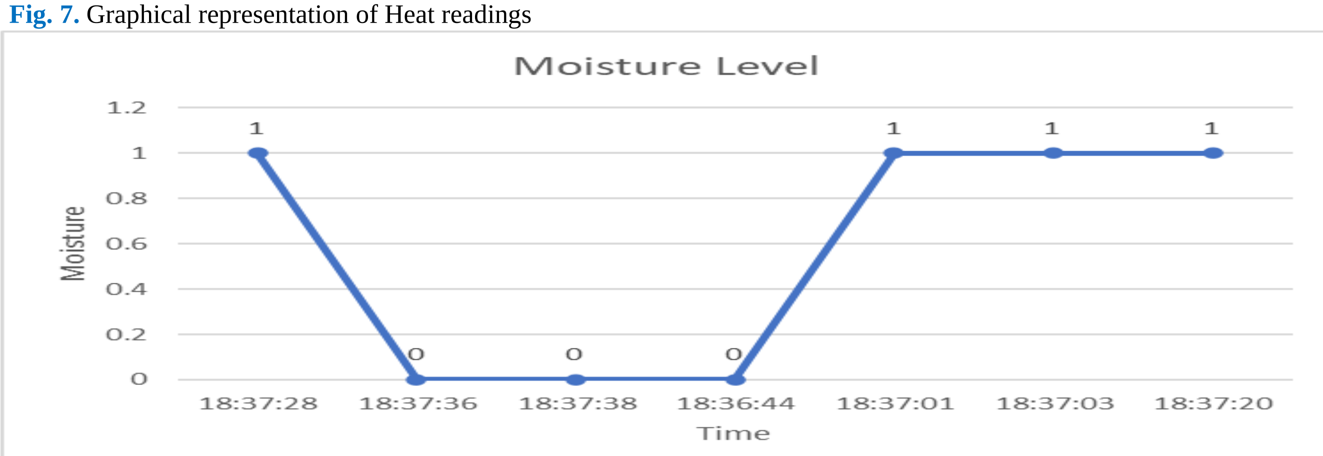

Fig. 8. Graphical representation of Moisture readings

4.3. COMPARATIVE STUDY OF SIMILAR WORKS

Table. 2. Shows the Comparative study of similar works.

Table. 2. Comparative study of similar works

S. No	Name of Author and Year	Year	Methodology	Limitations
1	Sivagami, A.; Hareeshv are, U.; Mahesh war, S.; Venkatac halapath y, V. S. K.	2018	This model considers several factors, like crop growth rate, temperature change, etc. It focuses on how carbon dioxide levels are fluctuating in the crop environment. The model sources water using drip irrigation.	This article does not use Wireless Multimedia Sensor Networks or GSM to analyse the chemical makeup of the soil and optimise fertiliser inputs.
2	José L. Chávez; Francis J. Pierce; Todd V. Elliott; Robert G. Evans	2010	They function by using a Single Board Computer (SBC) running Linux. To establish a wireless connection to a distant server, SBC is installed in the main control box and linked to a GPS unit, a sensor network radio, and an Ethernet radio.	Because this method uses cutting-edge technology like wireless sensor networks and SBC, it may be expensive to build and maintain. The security and dependability of the internet connection and the distant server may potentially present problems.
3	M. Rohith, R. Sainived hana and N. Sabiyath Fatima	2021	The paper is made up of several parts, including numerous sensors, an Arduino board, a power source, an LCD, a relay, and a motor.	The system will malfunction if one component fails. The system cannot process the irrigation system or deliver alerts when there is no power supply. The system requires rigorous maintenance. Monitoring must be done repeatedly.
4	Shreya Patil, Samarpeet Garad, Nikita Shitole, Soham Shirsat, Sahil Dalmia	2023	Detecting moisture levels using soil moisture sensor and using a servo motor to activate/deactivate the irrigation system in use.	Requires preinstalled irrigation system. No website/app created as of now to check status of these operations.

5. BENEFITS AND IMPACTS

The proposed irrigation system represents an ideal solution tailored specifically for small-scale agricultural operations and garden enthusiasts. This innovative system operates with remarkable efficiency, focusing on the judicious conservation of water resources through the intelligent utilization of automation technology. Its multifaceted benefits extend not only to resource-conscious individuals but also to those who lead busy lives and find it challenging to allocate substantial time to garden maintenance.

What sets this system apart is its capability to initiate irrigation based on real-time soil moisture levels, eliminating the need for constant monitoring and manual intervention. Essentially, it takes the guesswork out of watering plants. Users are only required to ensure that the designated bottle or container is adequately filled to the prescribed level. This user-friendly feature not only simplifies the gardening process but also contributes significantly to sustainable water management practices. In essence, this irrigation system harmoniously blends modern technology with eco-conscious gardening, making it an indispensable tool for both novices and experienced horticulturists alike.

6. CONCLUSION

In conclusion, the Automated Irrigation System's potential for improvement and growth bodes well for the development of agricultural practices that are both effective and sustainable in the future. This system can significantly contribute to alleviating water scarcity and improving agricultural output by incorporating cutting-edge technologies and addressing the changing needs of farmers and gardeners.

7. FUTURE SCOPE

Weather Integration: Integrating weather data can help irrigation become even more responsive. The system may preemptively modify irrigation schedules based on anticipated rainfall, temperature, and humidity by using meteorological forecasts, assuring effective water use.

Energy Efficiency: Improving the system's energy performance should be considered. This may entail powering the irrigation system with renewable energy sources, which might include solar panels, to lessen the system's environmental impact.

Smart Pest Management: Adding pest identification and management to the capabilities can assist safeguard crops even more. To detect and address pest infestations, integrating sensors and algorithms can be a useful addition.

Water Quality Monitoring: Including water quality monitoring can help to ensure plant health and stop soil deterioration. Insights for sustainable farming methods can be gained from sensors that measure the irrigation water's pollutants, salt, or pH levels.

Collaborative farming: Setting up a platform where several farmers may exchange information and ideas from their automated irrigation systems could result in more effective water use and crop management on a bigger scale.

Educational Outreach: Raising awareness and offering instructional materials about the advantages of automated irrigation systems can persuade more people to use this technology, assisting with efforts to practice sustainable agriculture and conserve water.

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