AN IMPROVED SMART INDOOR PLANT IRRIGATION SYSTEM BASED ON IIOT AND BLYNK APPLICATION

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ABSTRACT

Increasing technological innovations have been applied to a variety of daily life activities, including agriculture. Plant care is improved by the use of modern technological applications, such as a systematic irrigation approach, which helps to prolong plant life. Various studies have been presented to address the challenges of indoor plant care. However, there are currently no ideal solutions for caring for and prolonging the life of plants. Numerous problems have been reported relevant to the subject of indoor plant care, one of which is the intense thirst for plant soil, which causes a variety of problems, including cutting the roots of plants, especially when the soil is covered with clay, reducing the plant's capacity to conduct the basic processes required to preserve its life. Finally, if the thirst continues, the plant withers and dies. Furthermore, overwatering suffocates the roots, halts respiration, and eventually kills the plants. Unwanted soil fungus also thrives in constantly wet conditions. As a result, the goal of this study is to design and create an automated irrigation system based on the Industrial Internet of Things (IIoT) that can irrigate plants. The suggested system is divided into three stages. First, test the soil sensor's operation. Second, use the AskSensor IoT platform to monitor soil moisture. Third, send irrigation method information via Blynk apps. The findings of this paper demonstrated that the proposed system is superior to other related systems in several ways.

Keywords: *Industrial Internet Of Things, Smart Irrigation System, Asksensor, Blynk Apps, Indoor Plant Care.*

1. INTRODUCTION

The physical world is getting computerised, and everything is becoming connected. An explosion of smart devices and technology has enabled humans to communicate in real-time, anywhere and at any time. The Internet of Things (IoT) trend has given rise to a sub-segment of the IoT market known as the industrial Internet of Things (IIoT) or Industry 4.0. Industry 4.0, often known as I4.0, is the fourth Industrial Revolution emphasising interconnection, real-time data, autonomy, automation, and, machine learning [1]–[3],

Numerous of medical studies on the relationship between human health and indoor plants have been undertaken over the last decades, and the results of almost all of them found that they have many health benefits from both physical and psychological aspects when these indoor plants are properly cared for [4], [5]. As a result, researchers have been interested in growing and caring for indoor plants, especially as IIoT technology improves.

Indoor plant owners face numerous challenges. These challenges occur due to lack of time to monitor and care for their plants, as well as a lack of experience caring for plants. According to a study published by [6],the intense thirst for plant soil causes a variety of problems, including cutting the roots of plants, especially when the soil is covered with clay, reducing the plant's capacity to conduct the basic processes required to preserve its life. Finally, if the thirst is prolonged, the plant withers and ends up dying [6], [7]. Furthermore, overwatering the plants suffocates the roots, stops respiration, and eventually kills them. Also, unwanted soil fungus grows in consistently wet environments [7], [8], [9].

Therefore, the main goal of this paper is to monitor the condition of indoor plants as well as soil moisture sensing to estimate the extent to which indoor plants need the remote irrigation via Blynk application that has different watering methods. The proposed system can complete the irrigation process with a single press of a button, saving time and effort while also providing for the implementation of many IIoT capabilities. The proposed system differs from the others arreard the state of the arts by adding a camera to monitor the condition of indoor plants.

The proposed system's objective is to utilize a sensor to monitor the level of moisture in plant soil, as well as a camera to capture photos of plants and to use remote irrigation. When the soil moisture sensor reading falls below the threshold value, the proposed system sends a message to indoor plant owners informing them to water the plant using an application that includes three watering methods (Irrigation Now, Systematic Irrigation, and Scheduled Irrigation). Based on the idea of the proposed study, we can outline the main contributions of the suggested system as described below.

i. Developing an automatic irrigation system.
ii. Providing three methods for controlling irrigation.
iii. Providing an online camera to monitor the plant.
iv. Avoid low or excessive watering.
v. Helping the plant owner to monitor their plants remotely.
vi. Keeping the plant healthy and alive for an extended period of time.

The rest of this paper is organized as follows. Firstly, in Section 2, a critical analysis of the IoT-based irrigation system has been presented. Then, the proposed method is given in Section 3. Experimental results are described in Section 4 to demonstrate the effectiveness of the proposed method. Finally, this paper is concluded in Section 5.

2. LITERATURE REVIEW

As shown in a study presented by reference [10] , the authors developed a solution that will contribute to smart agriculture by utilizing automated and IoT innovations. The proposed system is based on Raspberry Pi automation, which increases crop productivity. IoT provides numerous applications for agricultural growth as well as decision support when required. The main goal of the study is to improve agriculture production while using less irrigation. Framers lose a lot of time and consume more than the required quantity of water when watering plants. Therefore, this study developed a method that will efficiently manage the watering system with less complexity to minimize the loss. This system operates using data from sensors that collect information such as moisture content, humidity, and soil temperature. The idea of the proposed system is to allow for smart farming and use a smart watering system for farming, which helps to save water.

While reference [11] demonstrated a smart irrigation system that took into account water scarcity in specific areas. Excessive watering will also have a negative impact on the plant. As a result, soil fertility and crop productivity would suffer. Therefore, this system was designed with an autonomous sprinkler that will distribute water to all crops efficiently and without water waste. This technique is based on data collected, such as soil temperature, humidity, and meteorological conditions. The temperature sensor and moisture sensor will be used to collect this data. The Raspberry Pi serves as the planned system's heart. When the moisture content or temperature changes, the sensors automatically send signals to the raspberry pi, which alerts the sprinklers and performs automatic watering. This paper primarily demonstrates the need for an automatic watering system for optimal irrigation, as well as the building of an automated sprinkler using the Raspberry Pi.

Other study presented in 2018 [12], the authors propose a solution that will boost water efficiency and reduce energy use. Presenting smart irrigation with solar panel electricity will reduce energy consumption. The proposed system is created using devices such as Arduino, Raspberry Pi, cameras, and other technologies. Using Arduino and Raspberry Pi, this study looked at how to make the best use of energy from solar panels and waste less water.

In 2018, Kahin Akram Hassan et al. proposed research demonstrating the significance of indoor monitoring and controlled climatic environments for active plant growth. The Internet of Things and Azure are utilized for this controlled indoor monitoring [13]. Reference [5] provided a good study in which the authors suggested a system that assists plant growth and hydroponics (fish growth) at the same time. This method demonstrates the significance of nutrients in fish excrement. An IoT-based model is created, with the Arduino serving as the system's brain. The main advantage is that it allows users to regulate the cost of plant growth while also improving food quality.

Traditional tunnel farms around the world use drip irrigation or spray irrigation technologies, which are superior than traditional flooding methods. Various irrigation technologies give varying levels of water consumption and energy

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competency [14]. Surface irrigation and level irrigation systems use little water and energy, while subirrigation, overhead irrigation, and sprinkler irrigation methods use little to no water and energy. The energy efficiency of sprinkler and drip irrigation methods is comparable, however drip irrigation is more water efficient than sprinkler irrigation [15].

The quantity of land irrigated in the United States is roughly the same as it was 10 years ago, but the essential thing is that the amount of water utilised for this purpose is far less than it was previously. They raise an abundance of fruits, vegetables, nuts, and whole grains to meet the needs of their residents all year. Since 2013, two types of conventional irrigation systems have been deployed in the United States [16] .The first is employed in gravity systems, which account for 35 to 42% of irrigation systems in the United States. It floods water from its source to a crop area using land-forming devices such as canals, streams, basins, and furrows. Furrow system regulated flooding systems and uncontrolled flooding systems are two examples. Pressure systems employ the second type of irrigation technology. Water is pumped through tubes or pipes in pressure systems, and irrigation is accomplished using an applicator such as a sprinkler or perforated pipe.

Three important challenges affecting China's development have been agriculture, landscape, and farmers [17] . Agricultural transformation is the solution to these flaws. Though this shift will be difficult and time-consuming, incorporating cloud computing and the Internet of Things to their agribusiness will assist them in resolving the problem. However, cloud computing, IoT, and SOA technologies are assisting in the creation of massive data sets involved in agricultural harvesting. Cloud computing is linked to IoT, and both can work together to improve agricultural production and solve issues related to agriculture, landscape, and farmers.

Various traditional methods have been devised and utilised regionally in India over the past decades to meet the needs of their people in a sustainable manner. In India, there are three irrigation methods: diversion canals, small-scale water bodies such as tanks to store rainwater, and wells to collect groundwater. These methods are applicable to both local and large-scale applications. As India's population grows so will the demand for water for numerous purposes such as irrigation, residential, hydroelectricity, industrial, mining, and regeneration. However, India possesses the world's largest irrigated acreage, yet it accounts for just around 40% of planted land [18] . One of the main reasons for this low irrigated land is the widespread use of traditional irrigation technologies, which results in a poor water use efficiency of approximately 35-40% [19].

Gutiérrez et al. [20] created and attempted to deploy a mechanized irrigation system to conserve water. They employed a wireless network of sensors to save nearly 90% of the water used in traditional irrigation systems. In the same year, Kumar et al. [14] published a comparable approach, while Parameswaran and Sivaprasath [15] and Rawal [21] later developed a few sensor-based alternatives. Nelson employed sensor data such as temperature and soil moisture, as well as WSAN, in 2015 to automate the watering process and reduce water consumption. Saab et al. [17] attempted and succeeded with an on-field study of a smart phone irrigation setup. He explored and tested the use in Mediterranean conditions, which resulted in a 25% reduction in water consumption. Saqib et al., 2020[22] recently added to these contributions by proposing a network system for the HC12 module to extend communication range

3. METHODOLOGY AND IMPLEMENTATION

In this section, we will discuss the proposed system's design and the way of implementing it. The suggested system has three components: hardware, software, and application interfaces. These components make the system integrated and easy for plant owners to deal. Demo and real-photos of the proposed system's functioning, as well as flowcharts, have been included to help clarify the project's work as much as feasible.

3.1. Flowchart of the proposed system scenario.

A flowchart approach for an autonomous irrigation system with a surveillance camera is shown in Figure 1. It shows how the whole proposed system works, including the system (hardware and software) and the people who will use it (plant owners).

3.2. System Implementation

Figures 2 and 3 represent the proposed automated irrigation system; figure 2 shows the system when the plant needs water (dry soil), while figure 3 shows the system when the plant does not require water (wet soil).

The proposed automated irrigation system depicted in Figures 2 and 3 is made up of five steps, which are as below.

Step 1: Plants are dry and need water.
Step 2: A text message will be sent to the plant owner's phone informing him or her that the plant is dry and needs to be irrigated.

Step 3: The plant owner's needs to open the Blynk app.
Step 4: The proposed system's application has three irrigation methods (Irrigation Now, Systematic Irrigation, and Scheduled Irrigation). The first method, "Irrigation Now," allows the plant's owner to irrigate the plant directly without the presence of the irrigation sensor. While the second method, "Systematic irrigation," the suggested system irrigates the plant based on sensor orders. Finally, scheduled irrigation occurs when the plant's owner irrigates the plant at a predetermined time. i.e. (two times a day).
Step 5: After the irrigation process, the plant owner will receive a notification from the proposed system telling the owner that the plant is irrigated

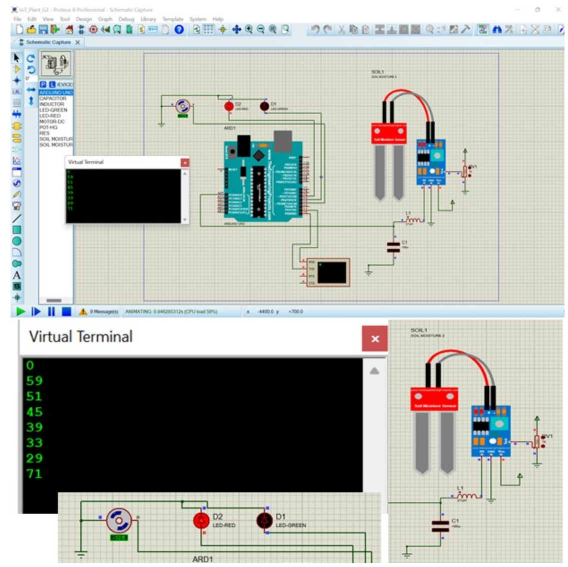

Fig. 2. The Design Automatic Irrigation System For Dry Soil

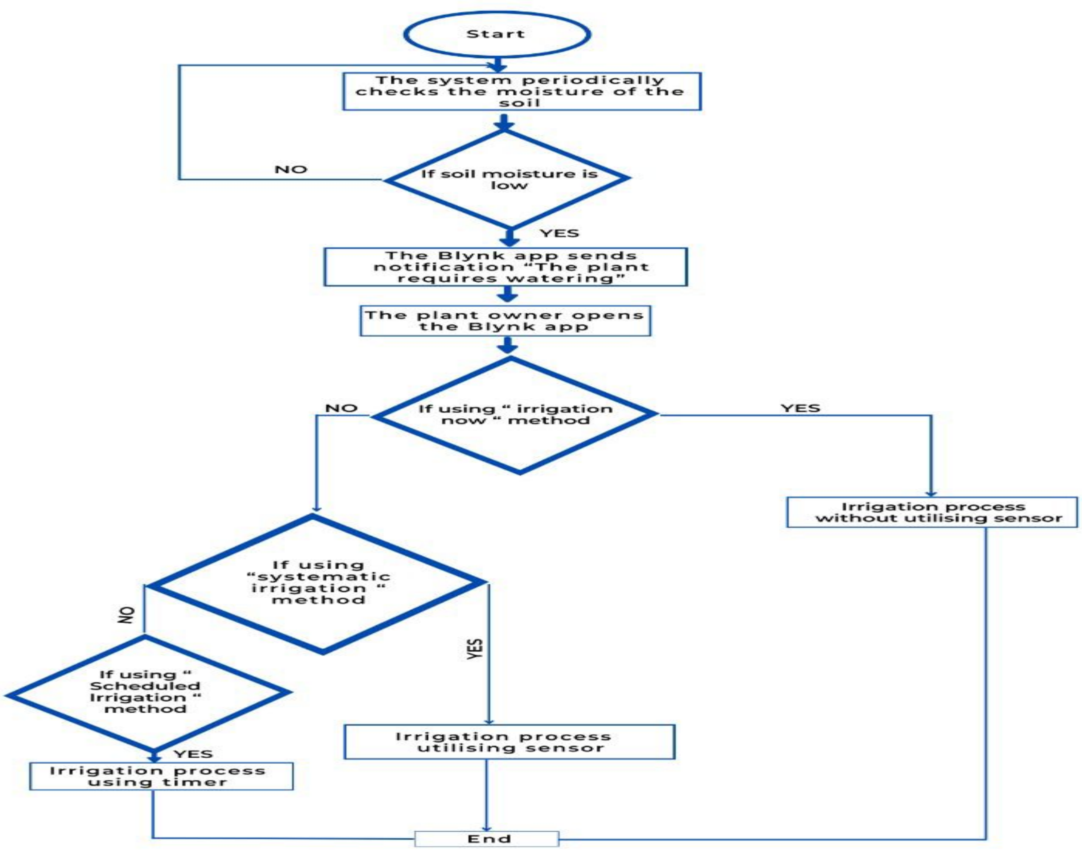

Fig. 1. The Procedures And Steps Of The Proposed System

The moisture sensor in Figure 2 above reads the soil moisture level. A reading level of less than 500 indicates that the soil is dry. So, the system that was made sends a message to the plant owner through an application connected to the Internet of Things by giving the plant owner the three methods to irrigate the plant.

The proposed system will repeat the procedure of reading the moisture sensor every 100 seconds. As shown in Figure 3, the soil sensor reading is activated once more to assess the soil's water saturation. When the soil reaches a threshold of the moisture level, the pump will stop pumping water. For more understanding, Figure 4 depicts a demo of the proposed irrigation system while Figure 5 presents the real use of the system.

The proposed system appeared in figures 4 and 5 were conducted to determine whether or not the system is working properly. The test was conducted utilizing the black box method. The testing process consists of three phases. *First,* testing the functionality of soil sensor. *Second,* monitor the soil moisture utilizing AskSensor IoT paltform. *Third,* send information about the irrigation method through Blynk apps. The mentioned three phases have been illustrated based on three functions each of those function determined with a different color (Green, Blue and Orange).

The first function, testing the functionality of the soil sensor (green color), is responsible for the following tasks.

i. Having a sensor that measures soil moisture connected to the ESP8366 controller.
ii. The soil moisture sensor is inserted into the soil to determine how much water is present in the plant soil. The mentioned sensor is responsible for sensing soil moisture content and collecting an analog input signal to be processed by the microcontroller.
iii. The output signal is sent by the ESP8366 controller to the relay.
iv. After receiving commands from the ESP8366 controller, the relay activates the solenoid's valve and watering in the amount required, and then the solenoid's valve is dis-activated when the relay if off.
v. The camera is connected to the ESP8366 controller to monitor the plant's casing.
vi.

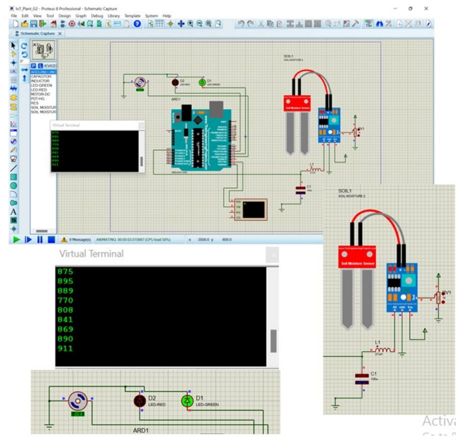

Fig. 3. The Design Automatic Irrigation System For Wet Soil.

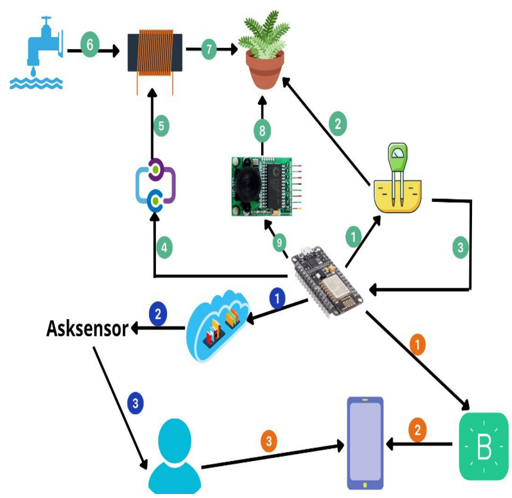

Fig. 4. A Demo Of The Proposed Irrigation System.

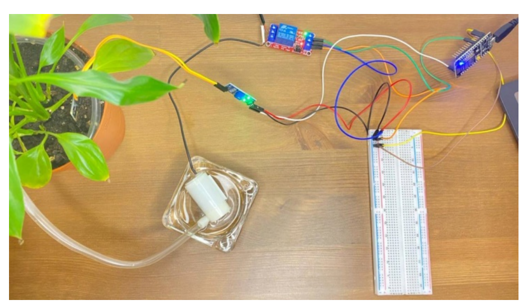

Fig. 5. The Real Use Of The Proposed Irrigation System.

The second phase (blue color) is responsible for monitoring soil moisture using AskSensor IoT platform.

i. The soil moisture level signal was successfully colleted by the ESP8366 controller from the soil moisture sensor. Then

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the ESP8366 controller sends notifications to plant owner via AskSensor platform through the WIFI access point.

ii. The plant owner can access the AskSensor platform via any browser using smartphones or computers.

iii. After logging in, plant owners can access the information on the AskSensor platform to monitor and observe the soil's moisture as a graph format.

The last function (Orange color) is responsible to control the entire application of the proposed system.

i. The ESP8366 controller is connected with the Blynk utilizing python code.

ii. Plant owners can use this application anytime and anywhere, in order to monitor their plants.

4. RESULT AND DESCUSSIONS

This section shows the results obtained through the use of the three phases of the proposed method. The results have been presented in three scenarios: First Scenario: testing the implementations of the irrigation system, Second Scenario: testing the soil moisture monitoring utilizing AskSensor platform, Last scenario: testing the notification utilizing Blynk application. The mentioned three phases

4.1. First Scenario: Testing the implementations of the irrigation system.

The proposed system is made up of a soil moisture sensor, a relay, an esp8266 board, a watering pipe, and a solenoid valve. The test parameters are based on the collected reading from the soil moisture sensor which falls in the threshold of 30%-40% range. If the sensor reading levels fall between these ranges, this indicates that the moisture level is low (dry soil), and the plants need to be irrigated, and the relay state is ON and the solenoid valve is activated and enables the watering pipe to open in order to deliver water to the plants. Table 1 shows the scenario of testing the implementations of the irrigation system.

4.2. Second Scenario: Testing the soil moisture monitoring utilizing AskSensor platfoem.

In this scenario, the test was conducted to get the result value of the soil moisture gathered by the soil sensor. In the proposed study, five different 200ml cups have been used to test the experimental results. The soil was put in each cup and then 100 ml of water was poured out onto the soil. To get the results, it has been used five experiments attempts. The first attempt was applied to test the state of the soil moisture, it is associated with the initial value of soil moisture, which is set at 0%. The outcomes of soil moisture sensor testing are presented in figure 6.

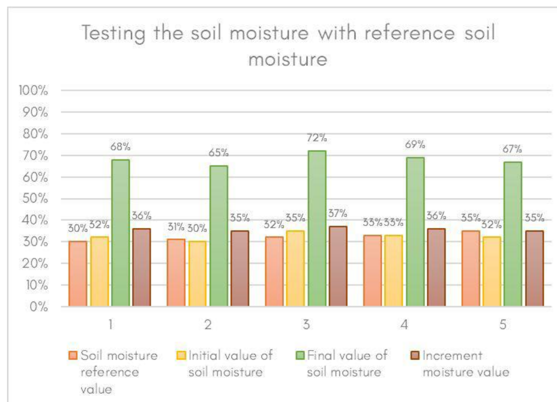

Fig. 6. The Outcomes Of Soil Moisture Sensor Testing

Equation 1 below illustrates the concept of calculating the average value of soil moisture, which is stated in figure 6 which varies from 50 % to 66 %.

$$A = \frac{FSM}{NT} \times 100\% \quad (1)$$

Where:

A = Average value of soil moisture, FSM = final value of soil moisture, and NT = number of testing.

The formula (1) can be used to compute the average final value of the soil moisture or the average increment value of the soil moisture. The second treatment focuses on the soil moisture reference value range. As shown in the figure 7, the initial value of soil moisture for each experiment was between 30% and 35%. The ultimate moisture value ranged from 65 to 72 % based on five studies. The average final moisture value was estimated using formula (1), and the results showed 68.2%. The increment moisture value from each experiment could be estimated simply by subtracting the final value from the initial value of soil moisture. The average soil moisture increase value is 35.8 %.

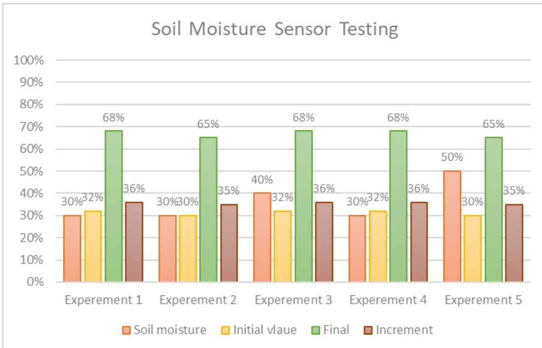

Fig. 7. The Findings Of The Soil Moisture Reference Value Range

4.3. Third Scenario: Testing the notification utilizing Blynk application.

The proposed system sends messages to the plant's owner in order to keep them notified of the irrigation procedure that was carried out utilizing the suggested methodology. Table 2 expresses the notifications appears utilizing the Blynk apps.

For additional information on how to use Blynk apps, which are an Internet of Things platform application that can be freely installed on smartphones and allows for the sending of notifications and information about the condition of the irrigation, including its activation or deactivation. The irrigation system, whether active or passive, must send data to the Blynk apps. The apps receive data from the microcontroller, process the data, and finally send a notification to the plant owner's smartphone. Plant owners, on the other hand, can search the Blynk Apps for notifications about the irrigation system and determine if it is enabled or not. Figure 8 (a and b) depicts the Blynk app user interface in the dry case of soil moisture, while Figure 9 shows the Blynk app user interface in the wet case of soil moisture.

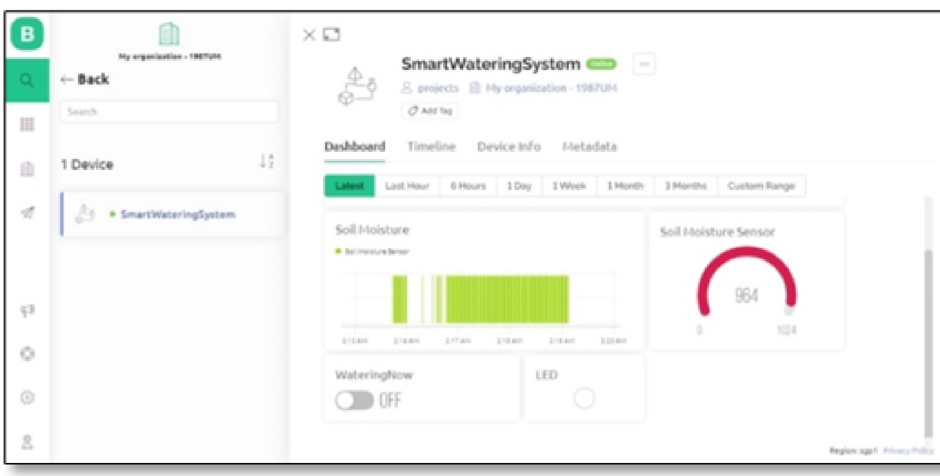

Fig. 8 (a) the Blynk app user interface in the dry case of soil moisture sensor

In the figure 8(a) above the red circle means that the plant needs watering and also it shows the bottoms of the three watering methods (Irrigation Now, Systematic Irrigation, and Scheduled Irrigation). Moreover the Figure 8(b) illustrates the chart result of the same case (dry case of soil moisture sensor).

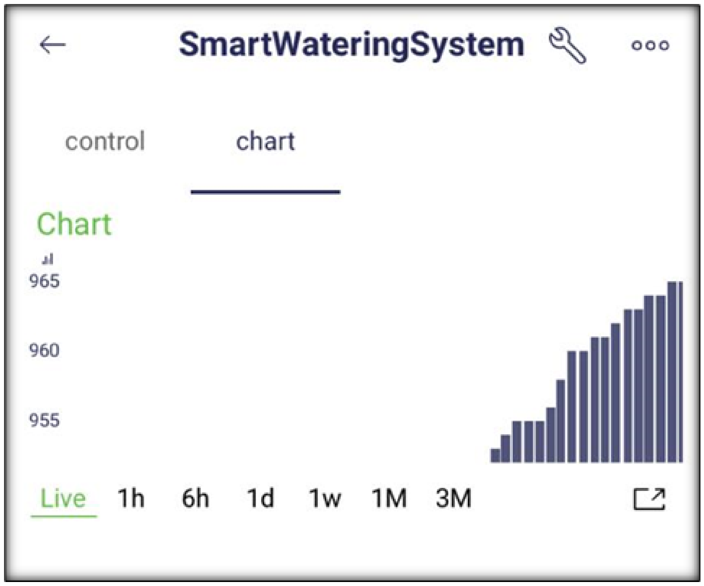

Fig. 8 (B) The Chart Of The Dry Case Of Soil Moisture Sens

Figures 9 (a and b) on the other side depict the the Blynk apps user interface in the wet case of soil moisture sensor.

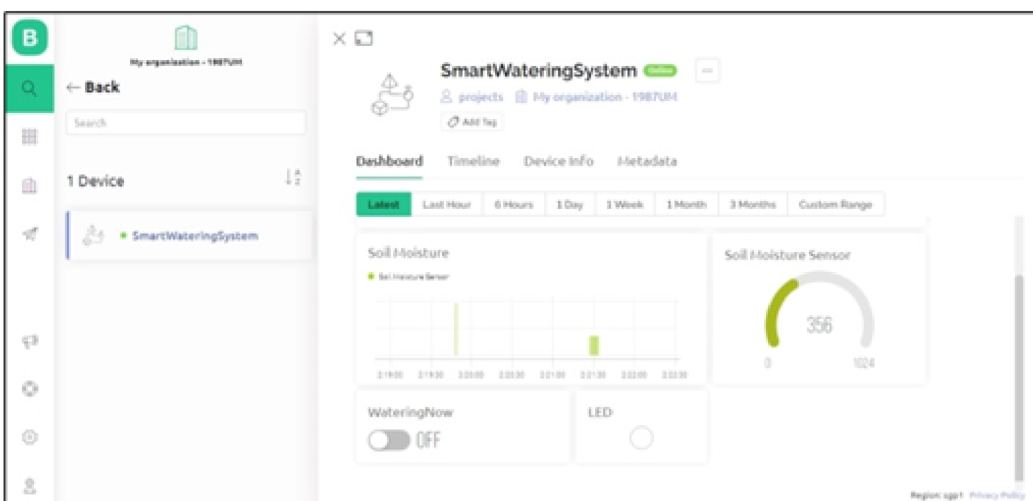

Fig. 9 (A) The The Blynk Apps User Interface In The Wet Case Of Soil Moisture Sensor

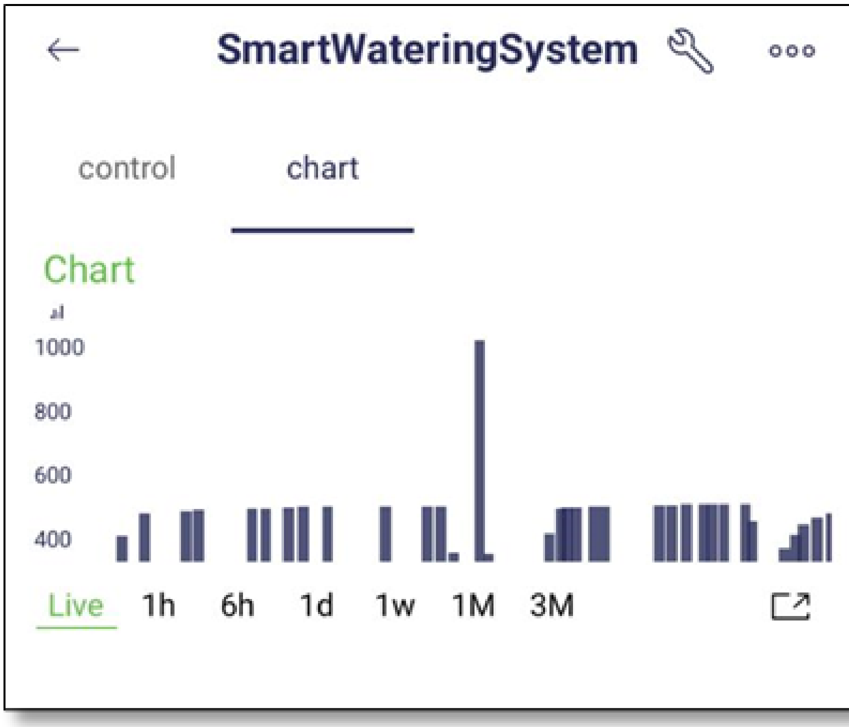

Fig. 9 (B) The Chart Of The Wet Case Of Soil Moisture Sensors

Table1: The Scenario Of Testing The Implementations Of The Irrigation System

Irrigation function test.	Soil moisture reading value	State of esp8266 board	State of relay	State of solenoid valve	State of watering pipe	Test results
1.	30 % - 40 %	ON	ON	Open	Watering	Positive result
2.	Above 40%	ON	OFF	Closed	No watering	Positive result

.

Table 2. The Notifications Appear Utilizing The Blynk Apps.

The detection value of the soil moisture	Irrigation devices	Notification situation via "Blynk apps"
30 % - 40 %	ON	Succeeded send the notification to plant owner smart telephone
Above 40 %	OFF	Succeeded send the notification to plant owner smart telephone

The results of the proposed paper fulfilled what was put forward in the contributions of the Introduction section. A good automated irrigation system has been established that has achieved reduced water waste and also achieved remote monitoring of the system. Also, the amount of irrigation was compatible with the amount of water required by the plants.

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5. BENCHMARKING

This section expresses a compression of the proposed study's characteristics with the state-of-the-art. Lots of studies related to automatic irrigation systems have been presented in the literature, and none of these studies have obtained optimal solutions. Some studies only illustrated the study using explicit applications, others created systems without the use of an online camera, and others did not use IOT technology. Moreover some existing studies didn't mention the network topology has been used to create the irrigation systems. The proposed system has solved the mentioned problems. Table 3 shows the main advantages and disadvantages of the current study and the proposed research.

Table 3. The Highlights And Drawbacks Of The Existing Study And The Proposed Research.

References	*Application*	Sensor	Network Standard	IOT	Camera
Microcontroller Based Automatic Plant Watering System [23]	×	✓	×	×	×
Solar Powered Smart Irrigation System [24]	×	✓	×	×	×
A Smart IoT Fuzzy Irrigation System [25]	×	✓	✓	✓	×
Smart Plant Watering System with Cloud Analysis and Plant Health Prediction [26]	×	✓	✓	✓	×
The proposed study	✓	✓	✓	✓	✓

6. CONCLUSION

According to the research objectives, the proposed automatic irrigation system connected with IoT platforms Blynk and AskSensor may perform the functions of indoor plant irrigation. The proposed system will reduce water consumption while also monitoring the irrigation process. One of the benefits of the proposed system is that it saves labour and time because the homeowner is not required to monitor and water the plant himself, as the system does this automatically, and the homeowner water anywhere, whether outside or inside, and when the plant needs water. Furthermore, one of the system's benefits is that it reduces the costs of irrigation vehicles. The system's disadvantage is its high cost; there are costs associated with the purchase, installation, and maintenance of automatic irrigation equipment. The soil moisture sensor sensed moisture in the soil and sent a signal to the esp8366 board. The sensor reading is interpreted by the microcontroller to automatically generate the watering function. When the device activates or deactivates the irrigation function, the suggested system sends a notification to the Blynk apps. The system has a monitoring capability that uses AskSensor to record the soil moisture value and graph the data. To perform real-time monitoring and alerting, the system needed to be connected to the internet. When the system isn't connected to the internet, it can't be monitored or send notifications, but the watering device still works. The starting value of soil moisture could be adjusted based on the amount of moisture required by the plants. This is accomplished by reprogramming the microcontroller. For this study, we set the baseline value of soil moisture to be between 30% and 40%. Based on the experimental setting, the testing findings of the AskSensor soil moisture monitoring system assessed the average final value of soil moisture to be 67 %. This means that the device could add an average of 36% more water to the soil in one watering cycle.

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