DESIGN AND IMPLEMENTATION OF AUTOMATIC IRRIGATION SYSTEM USING SOIL MOISTURE SENSOR

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Abstract-This research presented a unique architecture based on the Internet of Things (IoT) and ARM for managing soil moisture and irrigation. The framework's goal is to reduce manual fieldwork and move data to a cloud server that can be accessed via an online application. The suggested plan offers benefits in terms of lower expenses, limiting water waste, and lessening physical interference. It also promotes irrigation that requires little upkeep and is ecologically friendly. Temperature, humidity, and sound sensors are paired with an ARM single-board computer, also known as the Raspberry relay module is positioned to control the water flow. The values collected by the sensor are saved on the cloud server, and the web application provides the required values and recommendations. When soil moisture levels are low and ground temperatures are high, the irrigation system automatically activates, allowing for email notification to the user. The model displayed anticipated effects at different levels of humidity.

Keywords: IOT system, soil moisture, ARM, raspberry.

1. INTRODUCTION

Crop development is significantly influenced by the climate and the soil. Soil irrigation is the essential strategy for increasing agricultural productivity with a dependable, economical use of water because monsoon rains are unpredictable and confusing for farmers. With limited water, agriculture was a significant challenge. To support traditional watering methods, a range of methods have been created with cutting-edge technology to reduce crop damage, prevent sparse, needless agricultural irrigation, and increase crop value.

In this study, we propose an ARM and IoT (Internet of Things) based soil moisture surveillance system that can automatically collect, view, and preserve geographical data such as ambient temperature, humidity, and soil wetness as well as soil salinity. Depending on the temperature and soil permeability of each area and property, the soil moisture monitoring system will achieve the goal of conserving water and energy. Simultaneously, it is frequently possible to stop cultivated land from silting up and losing soil. As a result, new, cutting-edge technology develops around the product's affordability and price, making an efficient watering system.

Keeping the aforementioned statement in mind, the advancement of this device is dependent on the integration of new advances in wireless sensor and ARM-based embedded device technologies into a single board. The mainstay of the system under presentation is the ARM (Acorn RISC Machine) along with a little portion of a silicon chip that uses less power. The ARM platform is especially well-suited for embedded systems that are capable of performing fundamental SCM (Single chip Micyoco) functions. The right pins are also used to connect the serial pin to the number of sensors and the GPIO. Additionally, memory space and algorithms will be improved by adding extra RAM and ROM. The ARM is the ideal method to complete the system because of all these benefits [1].

The Internet of Things (IoT) is defined as the network of physical computers communicating with each other. IoT frameworks were frequently utilized in computer communications and data and information interactions. The main purpose is to give the user a practical, error-free solution. The Internet of Things makes it possible to modify, keep an eye on, and discourage regular actions.

The automated regulation of irrigation is the system's main focus. The automated part is handled with Python programming [2].The gadget consists of soil humidity sensors that measure and regulate soil temperature, humidity, and levels, indicating changes in the surrounding environment. Utilizing a 5V power source, the Raspberry Pi thoroughly monitors the entire apparatus. Python web framework is used by a cloud service to understand the framework's IoT capabilities. There are currently a number of automated irrigation systems on the market. To monitor plant growth, numerous researchers have devised irrigation systems that require an amazing and expensive computer [3].

An effective technique uses an intelligent soil moisture monitoring system to reduce waste of water supplies, power, and productive water utilization. The main advantage of the method is that irrigation can be easily tracked and handled at anytime, anywhere on the Internet. As a result, the ARM and IoT systems are quite versatile when it comes to providing the best options for soil management, pleasant drainage, and water preservation.

2. METHODOLOGY

In order to make clear the main points of this work, a review of existing soil monitoring systems is included in this section, with a focus on environmental sensors, automated systems, and the Internet of Things. The goal of Gondchawar et al.'s study on IoT-based smart agriculture [4] is to make agriculture smart using IoT and automation technologies. It includes intelligent warehouse management with smart power and smart irrigation that is centered on trustworthy real-time data sets. It regulates the preservation of humidity, the preservation of temperature, and the detection of theft. An intelligent gadget performs all tasks, utilizing a microprocessor, Raspberry Pi interface sensors, ZigBee modules, actuators, and a camera.

The design and implementation of ZigBee technology based on the CC2530 chip is an established agricultural greenhouse technology. Its main purpose is to monitor the climate [5]. The gadget makes use of power and smart greenhouse observation.

This technology benefits both science and healthy seedlings. Reference [6] describes how soil moisture sensors, temperature and humidity sensors, capacitive detectors, and an enhanced watering system monitor the plant field. Data for the maintenance of the server database is encrypted using JSON format and wireless transmission from sensors to the site server. MySQL script PHP script data irrigation device automation is kept in this folder. The annual average energy consumption for a water demand study with a single motor pump is 2 Ah per d The description above just touches on a few of the several approaches that have been put out for monitoring and irrigating soil moisture systems, particularly those that involve wireless sensing, the Internet of Things, ARM, and cloud-related technologies.

However, the majority of these techniques are costly and challenging to remotely operate. In order to remotely convey pertinent recommendations to the web application and gather data from a self-sufficient device, the problem of remote soil monitoring with difficulty avoidance must be solved autonomously.

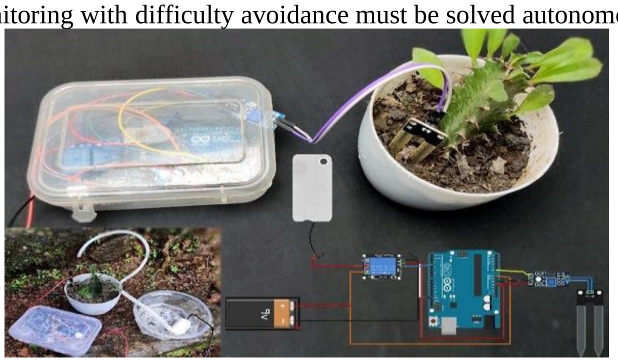

Fig. 2.1 Automatic Irrigation System

3. COMPONENTS OF AUTOMATIC IRRIGATION SYSTEM

3.1 Hardware Element

The solar-powered automatic check gate regulates the water flow to the field and is electronically connected to soil moisture sensors positioned within the basin. The gate opens and closes on its own accordance with on scheduled data from a soil moisture sensor to operate an irrigation event in real time.

The experimental field's water supply channel inlet is home to the check gate, which is composed of an iron-framed aluminum sheet with a thickness of 7.4 mm. Water leaks from the sides of the aluminum sheet were stopped with rubber gaskets. The gate's aperture is 30 centimeters high. The gate was intended to operate in both fully open and closed modes. The gate's exact specs are displayed. To measure the height of the gate when it opens and closes, a metal plate is positioned just beneath the ultrasonic sensor, creating an obstruction. When an item is detected by ultrasonic sensing elements, they release brief, high-frequency sound pulses at regular intervals.

Reflected back to the detector as echo signals, and the detector calculates the difference between the signal's emission and reception time in order to reach the target. The sound pulse struck the metal plate, creating an obstruction, and then returned to the sensor, allowing the distance of the plate to be computed. The gate can be opened or closed by the system up to 20 and 50 cm from the ultrasonic sensor, respectively. There are three buttons on the control box.

3.2 Software Element

Croplytics, created by Aspartic and tailored to our research requirements, is the software utilized in the automation study. It has a mobile and web interface that allows users to access it from any location. It consists of an interface that provides real-time soil moisture status, the position of the sensor on Google Maps, and gate configuration for ON and OFF based on a predetermined threshold value of soil moisture. By putting the global positioning system (GPS) of the sensor into users can find the sensor with ease across a wide area of the field. The languages C and C++ are used to write the program code. The GSM module is used to store the soil moisture data on a dedicated server at three-minute intervals. That being said, the duration can be altered to suit specific requirements. A shorter time interval results in greater power usage. Through mobile apps or the internet, the inbuilt GSM module makes it possible to access system information at any time and from any location. To access the system data, a user must have a login and password.

3.3 Capacitance based soil moisture sensor

The dielectric constants of soil and water are the basis for the operation of the capacitance-based soil moisture sensor. Unlike resistance type sensors, it is resistant to corrosion since the electrodes do not come into direct contact with the soil. The positive plate, negative plate, and space between the plates make up the three primary parts of the capacitance sensor. Plates referred to as dielectrics. The water molecules included in the soil mass can be identified thanks to the significant difference in the dielectric constants of soil and water. A 555 time-based circuit that generates a voltage proportionate to the capacitor implanted in the soil was used to assess the capacitance of the sensor. An analogue to digital converter (ADC) transforms the measured voltage into a digital number. The ground There is an inverse relationship between voltage and moisture content—that is, the greater the voltage, the lower the moisture content. Because it is inexpensive, uses little energy, and has a decent degree of precision, this kind of capacitor-based soil moisture sensor is frequently seen in automated and intelligent irrigation systems.

The sensor is made out of a circuit box, solar panel, and PVC tubing. A low voltage microcontroller can work with the capacitive soil moisture sensor V1.2 since it operates at a low voltage of 3.3 to 5 V. Three-pin sensor interfaces are supported. The output of the sensor is an analog kind that worked with an analog to digital converter (ADC) on an Arduino Nano. The control box has a 5 V solar panel on top and an inbuilt 3.7 V Li-Ion battery for continuous power. A microcontroller, a LoRa module (for wireless communication), and a solar charger module with a 3.7 V, 8800 mAh Li-Ion rechargeable battery make up the circuit box.

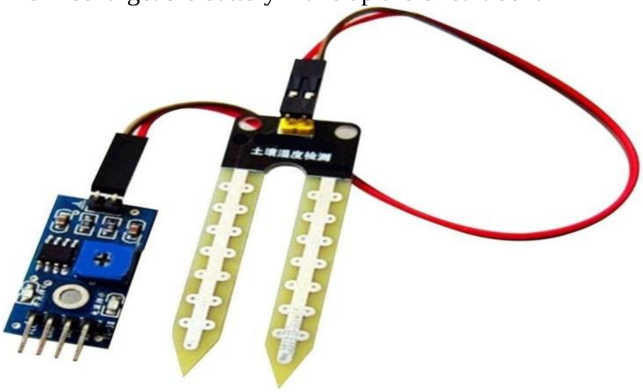

Fig. 3.1 Soil Moisture Sensor

3.4 Wireless Communication Network

The ability of an IoT device to communicate with other devices in order to transport and exchange data is one of its primary and crucial features. Wireless communications is the main method used by IoT devices to connect with additional electronics. Infrared (IR), radio frequency (RF), and satellite data transmission over the air without a physical wire connection is referred to as a wireless communication network. Depending on geographical coverage, power consumption, and memory, Internet of Things devices can be connected via both internet and non-internet protocols. Within a certain range, the non-internet protocol uses less power and requires less memory. Various protocols for networks are available based on their intended application, including Bluetooth, Wi-Fi, ZigBee, HTTP, and Long-Range Wide Area Network (LoRaWAN).

A wireless communication network was created in this study between the soil moisture sensors, gateway, cloud server, and automatic check gate. A gateway is a channel that connects two dissimilar networks that use distinct transmission protocols. It can function both one-way and two-way according to the data's direction of flow. Before transferring the data to the cloud network, it interprets the sensor data and converts it to a format that works.

The gateway was powered by an AC 6 A adaptor and placed 100 meters away from the soil moisture sensors. The global system for mobile (GSM) module, buck converter, LoRa module, and microcontroller make up the gateway. The LoRa module provided the gateway with soil moisture data every three minutes. Between intervals, the system entered sleep mode to save power usage. Additionally, the information is kept to the specialized cloud server and used GSM to connect to the gate. Depending on crop condition and need, users could program the automatic check gate to open and close at predetermined maximum and minimum soil moisture levels.

4. EXPERMENT LAYOUT

The experimental basin plan measures 60 m × 14 m and has a slope of 0.0005 m/m. Three soil moisture sensors with capacitance bases were positioned at 37.5 cm, 25%, 50%, and 75% of the field length (Sensor number 1), 7.5 cm (Sensor number 3), and 15 cm (Sensor number 2), in relation to the soil depth. A solar-powered automatic check gate that was positioned in a water supply channel at the field's inlet controlled the inflow and outflow of water into the basin layout. To monitor the flow rate, an ultrasonic flow meter (Model Unidata 6526E) was installed at the inlet.

4.1 Calibration of Soil Moisture Sensor

The sensors for soil moisture were calibrated prior to being positioned in the field. Thirteen soil samples, varying in moisture content from extremely dry to wet, were randomly taken concurrently with reading from a soil moisture sensor. The gravimetric method was used to calculate the moisture content of the soil. Following fresh weight measurement, samples were oven-dried for twenty-four hours at 105.

4.2 Soil Moisture Sensor Placement

Water flow reach, which is divided into head, mid, and end reach categories, and crop root zone depth were the two elements taken into consideration when placing the soil moisture sensor (SMS). The sensors' depth varies depending on the flow's reach and the crop's root zone depth. Wheat crops were intended to be grown in the system when it was designed.

4.3 Irrigation Management

The current soil moisture state determines how the check gate operates. When the predetermined threshold values of soil moisture sensor number 2 were achieved or exceeded, the check gate opened, indicating a 40%, 30%, or 20% soil moisture depletion of the field's capacity. The gate of verification was closed when the soil moisture content exceeded the corresponding soil moisture sensor's field capacity by 90%.

4.4 Irrigation System Performance

Irrigation performance indicators and the effectiveness of an automatic check gate in maintaining the field's pre-set water condition were used to evaluate the overall performance of the irrigation system. Irrigation performance was assessed using three well-known performance indicators: low quarter distribution efficiency, water requirement efficiency, and irrigation application efficiency.

5. RESULTS AND DISSCUSSION

Tests of the automatic irrigation system were conducted in bare soil with varying soil moisture threshold values. Three schedules of operations were observed in order to assess the system.

Three irrigation events were tracked in bare field conditions for every operating schedule. During each irrigation event, the gate was fully opened and closed when the threshold value.

It took the system 80 seconds to open the gate and 70 seconds to shut it entirely. The gate was successfully opened and closed automatically at each irrigation event check in accordance with the pre-set value of soil moisture reached or exceeded. When 40% of the soil moisture was removed in OS1 and OS2 as opposed to OS3, it was discovered that the irrigation performance indicators—irrigation application efficiency, distribution efficiency, and water requirement efficiency—were higher in those regions. It suggests that the effectiveness of surface irrigation was enhanced by the greater soil moisture deficit. All things considered, OS Out of the three operating schedules, 1 fared the best.

A solar photovoltaic module used sun energy to supply the system's power needs. Because it needed minimal maintenance and could still provide enough electricity even on overcast days, the system was very energy-efficient. Three days in a row of check gate operation required a completely charged battery. Free of charge in the event of cloud cover

CONCLUSION

In order to enable farmers or users to remotely handle the gate opening and closing with the least amount of manual intervention, an automatic check gate has been designed for the basin and connected to the Internet of Things via a wireless soil moisture sensor network utilizing GSM. A farmer may obtain the field's current moisture status remotely and can decide when to start and stop watering based on that fundamental real-time moisture status. In bare loamy soil, the system was effectively tested. Additionally, in an effort to improve irrigation application efficiency, the study tried to determine the best location and quantity of sensors in the field. After evaluating three possible operational schedules based on varying combinations of depth and duration along the flow, it was determined that a minimum of two soil moisture sensors are needed for the system to function effectively. One for the opening, which is 50% of the field's length and 15 cm deep, and another for shutting the system. When there is a greater soil moisture deficit, the sensor should be positioned at a depth of 37.5 cm and placed at a length of 25% from the inlet; when there is a lower moisture deficit, the sensor should be positioned at a depth of 7.5 cm and placed at a length of 75%. It stated that the soil moisture depletion determines where the sensor for system closure is located. The system's software and hardware have done well in a variety of situations. The automated check gate is extremely resilient to various weather circumstances (hot, rainy, and winter) with little upkeep. With little manual intervention, the web/mobile application assisted in remotely maintaining the appropriate level of soil moisture. With solar energy, the power usage was also sustainable. Automation lowers labor requirements, increases application efficiency noticeably, allows for remote access, and runs in real-time. Overall, the findings showed that the wireless sensors used in the automatic check gate have worked well, and the use of Internet of Things (IoT) based systems with wireless soil moisture based automatic basin irrigation system has greatly increased irrigation application efficiency. The findings offered hope for increasing irrigation efficiency through surface irrigation system automation.

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