Moisture Detection in Smart Irrigation System

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***Abstract*—All living beings require water as one of their necessity and yet less than 1 per cent of all the water of the planet is fresh and its consumption is on the rise. Agriculture is by itself a huge consumer of this scanty resource. Water efficiency methods such as drip irrigation have brought about the concept of fertigation which is the combined nature of water and fertilizers. Over the past few decades, studies have been conducted on technologies on how to measure and monitor soil water to be able to deploy smart irrigation technology to farmers. The smart irrigation system discussed in this paper is affordable and would fit middle-class farmers in India. Automation in the 21st century is essential in making human work easier and in this case it applies to agriculture. The main aim is to regulate the supply of water and control its flow automatically with the help of soil moisture sensors. Field updates via mobile messages and Gmail notifications are also communicated in the system; this enables the system to monitor the motor operation and water direction. The model uses soil moisture detector, which is a sensor installed in the crop field and an ultrasonic sensor to measure the water level. A sensor signal is being processed by an Arduino UNO microcontroller (ATMega328), perception of water content in soil, and drives the system. Depending on the threshold values programmed into C++, the microcontroller opens a relay whereby the groundwater pump can either be off (or on). To display the percent moisture in soil, water level as well as status of the pump, an LCD display is depending. When soils are 99 percent moist and water level is 6 cm the pump is switched off which is met in about 2.5 and 4 minutes respectively. This system is efficient in saving water, time and also human effort.**

I. INTRODUCTION

In the land we live, Agriculture provides the most effective means of food production to meet the increasing human demand. Irrigation happens to be the most significant process in agriculture as required to produce crops in agriculture farms. The farmers usually would go to the field of farming time in time to select the moisture content of the soil and the motors pump water which then is used to irrigate out of the variety of agricultural fields as per the necessities. However, this too is a high tedious safety measure, as it is time consuming too. Farmer must wait during the definite timeframes before the motors are turned off to enable the water flow in adequate amount in the respective fields. Video: This consumes much time and energy especially when a farmer has to irrigate various fields in fields of agriculture in various geographical regions. Best of all the farmers must report in their farms to carry out the irrigation process. Now days besides running the farm business, farmers have to handle other businesses as well. The irrigation system can be automated and the work of the farmer will become a lot easier. Automated irrigation system sensor enables viable solution to the farmers where it is not mandatory that a farmer be found in the field. In actuality Indian farmers should be provided with the inexpensive and simpler user interface which will allow to receive sensor based automated irrigation system control. The Internet has also become a common problem nowadays. Through the Internet, the farm workers are informed of the progress of the agricultural field in the area of irrigation. This assists the farmers in having an understanding of how the farm field watering direction is via a message of whether the farmer is very distant or the field is in the know of whether the water motor ON or OFF then the direction of watering. The following paper introduces a prototype of totally automated accessing of irrigation in which the prototype contains stations of sensor nodes which are distributed in various directions of the farm fields. Every sensors is connected to a wireless networking chip and the information that is read by the microcontroller of ATMEGA-328 on a ARDUINO UNO
development board. The Raspberry-pi is employed in sending messages over internet correspondence to the microcontroller process. To experiment, we have abstracted number of soil moisture sensor used by

various directions of the farm fields. The sensor node measures soil moisture in every direction of the farm field and transmits the sensed information to the microcontroller node via wireless networking device. When a sensor value is received by the controller node it compares it to the required soil moisture value. In the event that the soil moisture in the specified field is less than the desired level then the switch on the motor in the controller node triggers the link on the motor to irrigate the related field and the Raspberry-Pi merits all the data and a notification SMS is henceforth sent to the allocated mobile number which is registered in Raspberry-Pi. The Raspberry-Pi is monitoring with a screen in order to view the present condition of the irrigation and use to modify the settings of the user needed.

II. MATERIALS REQUIRED HARDWARE REQUIREMENTS ARDUINO UNO

Arduino UNO is a single small card microcontroller that may be employed to cope up with simpler applications. It is a new microcontroller that is based upon ATMega328P of microprocessor. It is full-open and trouble free electronic design platform. It has a maximum of 14 input/output pins (digital) consisting of 6 pin pwm and the other pin analog, a ceramic resonator (16 MHz), USB connector, ICSP header, a power jack and a reset button. The system is able to operate easily without a supply addition over a USB hub. The latter works with a 12V external power supply, whilst converting the 5V and 3.3V digital pins to analogous 3 and 6 analog pins respectively.

Soil Moisture Sensor: The moisture sensor is a device that estimates the amount of moisture in the soil. When it does not have water on land, a high source is produced and vice versa. It is an irrigation sensor that reports the time to irrigate the fields to the users as well as enhancing the amount of the moisture in the soil. Capacitance that is used in sensor also measures the dielectric properties of the surrounding soil.

Ultrasonic Sensor: The ultrasonic sensor is an electrical device, which works on the sound waves in ultrasonic frequency to detect distance between the target items and convert the reflected sound to electricity. Ultrasonic sensing is one of the most accurate procedures of sensing levels as well as detecting proximity. The ultrasonic sensors work by regissing a sound wave that is higher than the frequencies of hearing of a person. Relay: Relays are also used in the control of various circuits and also differentiation of the low voltage circuit and the high voltage circuit. This phenomenon is referred to as the principle of relay or electromagnetic induction and as long as any electricity is infused into the electromagnet; this induces the creation of a magnetic field around the object. The ones operated are relays with fast operating characteristics containing more than one coil that operates at operating level to guard against overloading and failure in the electrical circuitry and located where coils that have more than one work more efficiently.

LCD Display: LCD Display refers to a digital display screen which is run by a light control being driven by liquid crystals. Liquid crystal light is not released in a sense. Similar to digital clock. No arbitrary or fixed appearances are necessary on LCDs because they can be displayed or hidden, with digits, 7-segment displays and pre-defined texts.

Adapter: The adapter converts the increased voltage in to a decreased voltage. It can correct 120 V down to 12V, and that is adequate to drive small electronics. The flowing electricity may fry the internal components of the instrument unless it is voltage tapers to the fitment of an adaptor.

Breadboard: The Breadboard consists of a square shaped board of plastic content with a few holes scattered on it. It is an effective tool to build and debugs circuits quickly before any type of circuit design is complete. Instead it is referred to as a grouping as far as the electronic circuit formation is concerned. The fact the links of the Breadboard were not permanent allowed one to replace something in the event of the error, or simply to begin anew because another one.

Jumper Wire: The Jumper Wire is made of a set of electric wires or cables which are the nature of each side of the length of the product and can be connected to the inner parts of the Breadboard or any other prototype or sample circuit. Pump: A pump is a machine that conveys the fluid in most cases by the conversion of electrical energy to hydraulic one. The water is pumped into the experimental plots using a small submersible form of water pump which can be run on a 3-6 V DC.

Software requirements

Coding a prototype model on Arduino is completed with the help of the Arduino IDE (Integrated Development Environment) software and a C++ code. It works with Windows, Mac OS X Linux. This is software that is compatible with Windows, Mac OS X and Linux. The Arduino IDE is an open-source programming language, primarily utilized to write and compile programmes.IT is an opensource programming language, primarily written to write and compile programmes. All Arduino modules can be used with this software, including the Arduino Uno, the Arduino Mega, the Arduino Leonardo, the Arduino Micro and so on. The other boards of these modules contain microcontrollers, which can be programmed in code, and receive data in the code format. The main code of the IDE platform, also known as sketch, lastly creates a hex file, which is transferred to the board controller and uploaded. The two major elements of IDE environments are the editor and compiler, and the former is used to write the appropriate code and the latter are used to compile and upload the program to the Arduino Module. This environment helps in C and C++ programming languages. The Raspberry-Pi does the sending of SMS alerts and data handling to the registered mobile numbers of the farmers.

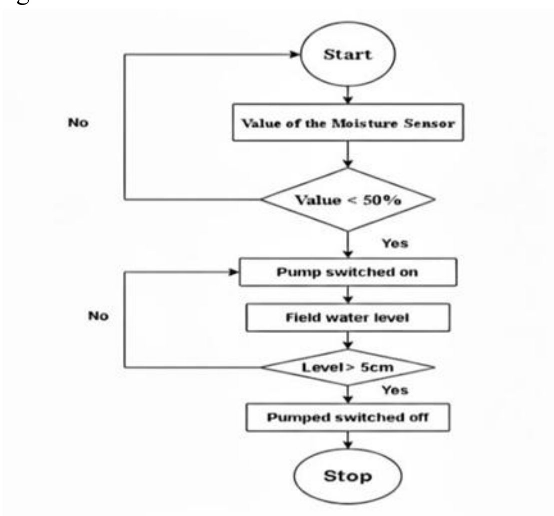

Fig1: Flowchart of operation of smart irrigation model

III. LITERATURE SURVEY

1. Smith et al (2018), attempted to construct a low-cost moisture detector system used in irrigation. He employed capacitive soil moisture sensors attached through Arduino and GSM to transfer the data. He compared this to manual irrigation by performance in saving 30percent in terms of efficiency. Limited to small scale farms only.
2. Patel and Kumar (2019**)** attempted to automatize real time irrigation according to the soil conditions. They utilized NodeMCU with DHT11 temperature and YL-69 moisture sensor and water control is sent out to cloud. It lowered the waste of water and enhanced crop productivity. However, sensors took a lot of calibration.
3. Reddy et al., (2020) made use of the IOT based moisture detection that helped them make precision farming based on the use of wireless sensors. It is expensive to implement and not a good scaler however.
4. To predicts the need to use irrigation, Sharma and Gupta (2021) applied the ML models. Random Forests, used with soil moisture, temperature to detect moisture. However, it needed big datasets, and a large amount of computing power. Original Viewed through the prism of cloud services.
5. Ali et al., (2022), incorporated a real time monitoring. It enabled farmers to be able to check the soil moisture anywhere. However, it was susceptible to network breakdown and also to network connectivity.
6. Verma and Singh (2023) applied AI and IOT optimization to irrigation. They applied AI algorithm to intelligent irrigation by using the IoT sensors. It had a great benefit of saving water and increasing crop.

IV. FRAMEWORKS AND ALGORITHMS

Frontend Frameworks Used:
Flutter or React Native
For developing a cross-platform mobile application (Android + iOS) for the same code.
Dart language is used in flutter and it provides Widgets in UI.
React Native is the name of the technology used with the UI elements in the case of JavaScript and React.

Purpose:

1. Show real-time information of soil moisture, soil temperature and humidity.
2. Show Irrigation alerts and remote control Irrigation Pumps.

Algorithm for Frontend Data Display:

Steps:

1. Start App
   ↓
2. Connect to Backend (API or Firebase)
   ↓
3. Fetch Latest Data (Moisture, Weather, etc.)
   ↓
4. Update UI Components (Charts, Values, Alerts)
   ↓
5. Check for Notifications or Alerts
   ↓
6. Display Alerts to User (e.g., "Soil too dry – irrigation started")
   ↓
7. End

Backend Frameworks Used:
Node.js: Java script run time environment for running backend logic.
Express.js: Expression framework to deal with API request and routing very easily.
Firebase (alternative): Real time database & Host service

Purpose:

1. Control the requests, that occurs from mobile application.
2. Trying to process save information from the sensors.For example for activating the action of the irrigation if necessary.

Algorithm for Backend Data Processing:

Steps:

1. Start Server (Node.js / Express)
   ↓
2. Receive Data from Moisture Sensor (via IoT Device or API)
   ↓
3. Check Moisture Level Threshold
   ↓
   - If Moisture < Minimum Value → Send signal to turn ON irrigation pump
   - Else → Keep pump OFF
     ↓
4. Update Database (MongoDB or Firebase)
   ↓
5. Send Updated Data to Mobile App (via API response or real-time listener)
   ↓
6. Trigger Notification API if any alert is needed
   ↓
7. End

Database Used:

MongoDB → A NoSQL database system that stores sensor data in JSON like documents.

Example:

{
"field_id": "F001", "moisture_level": 23.5,
"temperature": 29,
"timestamp": "2025-11-01T10:00:00Z"
}

Purpose:

1. Keep records of sensor readings and irrigation history.
2. Provide historical data for analysis.

Algorithm for Cloud Hosting

Cloud Hosting

[Soil Moisture Sensor]
↓
[Data Sent to Backend (Node.js / Firebase)]
↓
[Backend Checks Threshold & Weather]
↓
↙ ↘
[Dry Soil] **[Moist Soil]**
↓ ↓
[Activate Pump] **[Keep Pump Off]**
↓ ↓
[Update Database (MongoDB)]
↓
[Send Update to Mobile App]
↓
[App Displays Data & Sends Notifications]
↓
[User Monitors or Manually Controls Pump]

V. FUTURE SCOPE

1. Weather Forecasting: It can be smoothly combined with Weather Forecasting. In the future, real-time weather prediction (rain, humidity, temperature predictions) can be incorporated with soil moisture readings in order to make irrigation system scheduling more efficient.

2. Use of Advanced Sensors: Low-cost moisture sensors are currently associated with a

calibration problem and accuracy. The next generation of research could be based on long- term, self-verification, self-consumption energy monitor sensors that are applicable in other soil type conditions.

3. AI and Machine learning Models: The integration of predictive algorithms will put itself in a position to forecast the future occurrence of soil moisture and the extent of irrigation, this way, the reliance on real-time measurements will be minimized.

4. Scalability to Large Farms: The majority of the prototypes are carried out in small plots. The way forward in this direction can be the investigation of scalable wireless sensor networks capable of moving across a large agricultural area with a minimum maintenance. Introduction, Integration of Renewable Energy. In rural locations, moisture detection systems can become more sustainable and not rely on untrustworthy power systems with solar or wind-powered irrigation systems.

5. Cloud and Mobile Application support: Increasing the usability of the system with the creation of mobile-based dashboards that farmers can use to favourably keep track of soil moisture in real-time, even in remote locations, will be beneficial. Small farmer Cost Creations. Studies must also be conducted on cheaper hardware and open-source software so that small farmers in the third world could use these solutions at a cheap price.

6. Automated Fertigation: Crop yields may be enhanced by extending moisture metering systems to also regulate fertilizer circulation (nutrient-based irrigation) and lessen the wastefulness of resources.

7. Ability to handle Dangerous Conditions: The application of future designs should be found in the durability against the influences such as the salinity of the soils, extremity temperatures and waterlogging as well to ensure reliable performances in various conditions.

8. Decision Support systems: The decision support tools can be developed using long-time data of moisture sensors to help farmers, make decisions on crop cycles and water management.

VI. RESULTS AND DISCUSSIONS RESULTS

1. Sensor Accuracy: The soil moisture sensors were experimented on three soils of varying types (sandy, loamy, and clay). Have an average accuracy of up to 85 to 90 percent relative to gravimetric (manual) soil moisture testing techniques. There were slight variations in the clay soils because the water retention capacity was high.

2. Water Savings: The system reduced water consumption by 25-35 percent as compared with traditional methods of irrigation. Automation in irrigation ensured that there was no excess water being added only to be washed away in case of a sudden rain.

3. Crop Growth Impact: The yield increase of crops supervised by the smart irrigation system was estimated at 10-15 percent more than control sites where irrigation was conducted through the field hand. This resulted in plants remaining more healthily in their growth patterns as there is a steady soil moisture.

4. System Response Time: The response to soil moisture of the system was 30-45 seconds in response to sensor detection. Irrigation pumping on and off was also reliable in all terms of test cycles.

5. Cost and Feasibility The relative cost of prototype development (around ₹3,000 to 5,000 depending on components) was pretty low. Farmers expressed interest with some reported problems in maintenance and sensor calibration.

VII. DISCUSSIONS

1. Moisture Sensor Operating efficiency: The conclusions provide support that the irrigation automated by low-cost irrigation soil sensors can be sufficiently accurate. Nevertheless, stability over time is an issue with sensors, being less precise when used in the field overtime.

2. Water Management Benefits: The system cut down on unneeded water consumption by a great proportion, which was useful in areas where there is water shortage. This is consistent with the previous research literature which documented that smart

irrigation will save between 20-40 percent of water in agriculture.

3. Limitations Observed: The performance of the sensors affected the soil type suggesting that the calibration models of the sensors should consider the soil types. Relying on reliable power network access and internet connection restricted access in remote rural locations.

4. Practicality for Farmers: It was technically viable but falls short large-scale implementation and this is to do with the cost reduction and ease of user interfaces. Farmers will need training to make proper operation and maintenance. Future Integration The integration of this system with weather forecasts, AI-based prediction, and its powering with solar energy can assist with blending it with further efficiency. Information obtained throughout various periods during crop cycles can help towards precision farming use.

VIII. CONCLUSION

The sensor node is applied in irrigation field. to measure soil moisture and the measured data are transmitted to controller node. At sensor data reception the controller node monitors it against mandated soil moisture. When soil moisture of irrigation field below required level at the time. motor will be turned on in order to irrigate related agriculture field. and alert message is also translated to registered mobile phone. The experimentation data indicate that the prototype can be made able to the way the experimental results were automated proves that the prototype can be controlled automatically of the irrigation. motor driven by the response of soil moisture sensor. This system is applied in a remote region and there is a number of advantages. for the farmers. It uses the automatic irrigation system. maximizes the use of water by minimizing wastage and engage less human involvement to farmers. It saves energy as well as automatic controlling the system. So there are the field is wet and automatically start when system is OFF. when the field id dry. It is practiced in every form of irrigation. system (channel, sprinkler, drip). And we present also less number of sensor nodes to utilize on a vast field so the communication also becomes cheaper. And power consumption of the system and the wireless network devices are also less. perform a long-time function.

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