A Smart IOT-Driven Irrigation Solution for Efficient Water Use and Improved Crop Productivity in India

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Abstract - In India, the most significant and revered profession is weather. In India, the majority of people with rural backgrounds make their living from agriculture. A nation's agricultural progress is aided by intelligent irrigation. About 10% of all exports and 16% of the country's GDP come from agriculture in India. Water is a key component of agriculture. Agriculture relies heavily on water. One technique to supply water is irrigation. Because they are not paying attention, [Internet of Things]. An IOT based automatic irrigation system is a smart system that uses sensors, internet connectivity, and automation to irrigate plants automatically. The system collect data from various sensors like soil moisture, temperature, and humidity, analysis the data using machine learning algorithm, and controls the irrigation process based on the analysis. The system can be controlled through mobile app or a web interface, allowing user to set the irrigation schedule and adjust the weather settings. Smart irrigation system is an efficient and effective way to automate irrigation, reduce water wastage, improve crop yield, and provide remote monitoring.

Key Words: Weather, Smart weather-IOT, temperature, humidity, water wastage

1. INTRODUCTION

Smart weather monitoring system defined as an advance technology and data driven techniques to optimize the process of watering plants, crops, or landscapes. It involves the integration of various sensors, weather forecasts, soil moisture, and automation systems to efficiently manage water resources and enhance agricultural or landscape irrigation practices.

By employing smart weather monitoring systems, water usage can be significantly reduced, leading to conservation of this valuable resource, as well as cost savings for farmers and property owners. These systems use real-time data and algorithms to optimize irrigation by adjusting schedules and water quantities according to environmental conditions, plant needs, and water availability, ensuring efficient water use without wastage. Smart weather technologies can be controlled remotely through mobile apps or computer interfaces, allowing users to monitor and manage irrigation processes from anywhere, further enhancing their efficiency and convenience.

The use of appropriate soil moisture sensors, which lessens the discomfort of tracking and documenting changes in soil moisture, is presented in this article. The temperature is measured and examined using the Arduino Mega microcontroller equipped with a temperature, moisture, and light-dependent resistor sensor [6].

When the IoT-based weather monitoring system starts, it measures the water level, humidity, and soil moisture using the ESP8266 module. It sends an SMS alert to the user's phone with the current readings. If the sensors detect that the water level is dropping, the system automatically activates the water pump. Similarly, if the temperature exceeds a preset limit, the fans are turned on. All this information is displayed on an LCD module and also updated on the IoT platform, showing real-time data on humidity, moisture, and water level along with the date and time, updated every minute [6].

2. TOOLS AND TECHNOLOGY

Smart weather systems leverage various advanced technologies to optimize water usage and enhance irrigation efficiency.

A. Sensor Technology

Soil Moisture Sensors: Measure soil moisture levels, allowing precise irrigation based on the actual needs of the soil. Weather Sensors: Gather current information on precipitation, wind speed, temperature, and humidity, enabling systems to adjust irrigation schedules based on current weather conditions. Rain Sensors: Automatically shut off irrigation systems during rainfall to prevent overwatering. Crop Sensors: Monitor specific crop conditions and growth stages, providing tailored irrigation solutions.

B. Data Analytics and Machine Learning:

Data Analysis Algorithms: Process data from sensors to analysis soil moisture levels, weather forecasts, and plant requirements, allowing for data-driven decision-making. Machine Learning Models: Predict irrigation needs based on historical data patterns, weather forecasts, and crop-specific information, optimizing watering schedules.

C. Automation and Control Systems:

Actuators: Control irrigation valves and water flow based on data analysis, ensuring precise and timely watering. Microcontrollers (e.g., Adriano, Raspberry Pi): Interface between sensors, data analysis algorithms, and actuators, facilitating automation. IoT Connectivity: Enable remote monitoring and control of irrigation systems through the Internet, allowing users to adjust settings and receive notifications via smart phones or computers. Mobile Applications and Web Interfaces.

User-Friendly Apps: Provide farmers and users with intuitive mobile applications to monitor soil moisture levels, adjust irrigation schedules, and receive alerts. Web Interfaces: Allow users to access the system via web browsers, enabling remote control and detailed data analysis.

D. Cloud Computing:

Data Storage: Store sensor data and analysis results in cloud-based platforms, ensuring accessibility from anywhere with an internet connection. Scalability: Cloud computing allows for scalable solutions, accommodating varying data storage and processing needs.

E. Sensing and Satellite Technology:

Satellite Imagery: Utilize satellite data to assess large agricultural areas, enabling precision irrigation planning based on regional conditions. Remote Sensing: Use remote sensing technologies to monitor vegetation health and detect moisture stress, providing valuable data for irrigation decisions.

F. Communication Protocols:

Wireless Communication: Use wireless protocols such as LoRaWAN, Zigbee, or Bluetooth to transmit data between sensors, controllers, and the central system. Cellular Connectivity: Enable communication via cellular networks, ensuring connectivity in remote or large agricultural areas.

G. Advanced Water Delivery Systems:

Drip Irrigation: Implement precise water delivery systems like drip irrigation, which can be easily integrated with smart technologies for efficient water distribution directly to plant roots. Precision Sprinklers: Use advanced sprinkler systems that adjust water output based on specific areas' needs, ensuring uniform irrigation.

H. Required Sensors for Smart Weather System

Measuring Range: Soil moisture sensors usually have a specified measuring range, indicating the minimum and maximum soil moisture levels they can accurately measure.

Accuracy: This indicates how close the sensor's measurements are to the actual soil moisture content. Accuracy is often expressed as a percentage of the measured value.

Resolution: Resolution refers to the smallest detectable change in soil moisture content that the sensor can measure. It is usually expressed as a percentage.

Calibration: Soil moisture sensors may need calibration to ensure accurate readings. Some sensors come pre-calibrated, while others require manual calibration.

Response Time: This indicates how quickly the sensor can provide a stable reading after being inserted into the soil. Faster response times are desirable for real-time monitoring applications.

B. Temperature Sensor:

Range: The temperature range over which the sensor can accurately measure temperature (usually in Celsius or Fahrenheit). [-40°C to 85°C].

Accuracy: How close the measured temperature is to the actual temperature, often expressed in degrees Celsius or Fahrenheit.

C. Crop Sensor:

Spectral Bands: Plant health sensors often measure specific spectral bands, such as near- infrared (NIR) and red light, to calculate vegetation indices like NDVI (Normalized Difference Vegetation Index). Index Values Range: Higher NDVI values indicate better plants. NDVI readings often range from -1 to 1.

Resolution: Indicates the smallest detectable change in vegetation index values.

Accuracy: Specifies how close the sensor's measurements are to the actual vegetation index values [10].

4. METHODOLOGY

Developing a smart irrigation involves several steps and stages, including planning, designing, development, testing, and deployment.

Developing a smart irrigation is together requirements. This involves understanding the client's needs and expectations, determining the size and type of the irrigation system, and identifying the necessary sensors and equipment needed for the system.

System Design: Based on the gathered requirements, a system design is created. This involves selecting the appropriate hardware and software platforms, defining the system architecture, and selecting communication protocols. Sensor Selection and Placement: In this stage, sensors are selected and placed in strategic locations to quantify environmental variables such as soil moisture, temperature, humidity, and sunlight. The selection and placement of sensors are critical to ensure the accuracy of the system. Development: After the system design is completed and sensors are placed, the development phase begins. This phase involves programming the microcontrollers or processors, developing the user interface, and integrating the hardware and software components of the system.

Testing: The testing phase is important to ensure that the system meets the requirements and functions as expected. The system is tested in different scenarios, and any issues found are corrected.

Deployment: After testing, the system is ready for deployment. The system is installed in the irrigation area, and the sensors are connected to the internet. The user interface is also made available for the user to control and monitor the system.

Overall, developing an IoT-based automatic irrigation system requires a multidisciplinary approach that includes expertise in hardware, software, and data analysis.

A. Equipment Used in Intelligent Irrigation Systems

Arduino-Uno:

The Arduino is a microcontroller board based on the ATmega328 (datasheet). It offers 14 digital input/output pins, with 6 capable of PWM output, along with 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The board comes fully equipped to support the microcontroller — users can start by simply connecting it to a computer through a USB cable or by powering it with a battery or an AC-to-DC adapter.

Unlike previous boards, the Uno does not use the FTDI USB-to-serial driver chip. Instead, its Atmega16U2 (or Atmega8U2 in versions prior to R2) is configured as a serial-to-USB converter. The 8U2 HWB line on the Uno board is connected to ground via a resistor, enabling the setup of DFU mode. Some of the new features of the Arduino include:

The board introduces new pinouts: SDA and SCL pins have been added close to the AREF pin, along with two additional new pins positioned near the RESET pin. One of these is the IOREF pin, which enables shields to automatically adjust to the voltage supplied by the board. This ensures compatibility with both 5V boards (using AVR microcontrollers) and future boards like the Arduino, which operate at 3.3Voltag. The second new pin is currently unconnected and reserved for future use. The RESET circuit has been enhanced for greater reliability. Additionally, the Atmega16U2 microcontroller has replaced the older 8U2, offering improved functionality. The name "Uno," meaning "one" in Italian, signifies the upcoming release of Arduino 1.0. Moving forward, both the Uno and Arduino 1.0 will serve as the reference standards for the Arduino platform. The Uno represents the latest development in the series of USB Arduino boards and acts as the reference model; for a detailed comparison with earlier versions, refer to the Arduino board index.

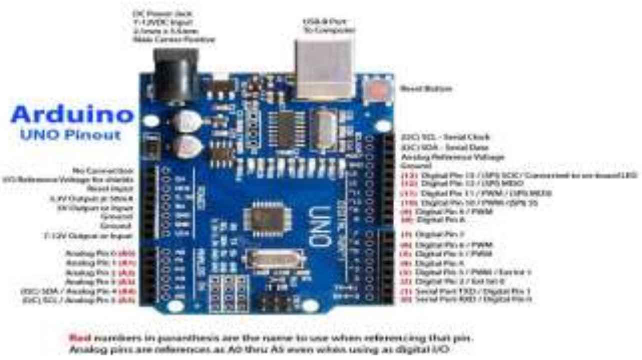


Fig -1: Arduino[1]

B. Soil Moisture:

Soil moisture is vital for the health of both garden plants and crops in irrigated fields. The nutrients in the soil supply essential nourishment for plant growth, while watering not only sustains the plants but also helps regulate their temperature.

Water helps regulate a plant's temperature through a process akin to transpiration. Furthermore, when plants grow in moist soil, their root systems develop more efficiently. However, excessive moisture can create anaerobic conditions, fostering the growth of harmful soil pathogens. This article provides an overview of how soil moisture sensors work and their applications.

The relationship between the computed property and soil moisture needs to be adjusted, as it may differ based on ecological factors like soil type, temperature, and electrical conductivity. The soil's moisture content can influence the reflected microwave emission, which plays a key role in remote sensing applications for hydrology and agriculture.

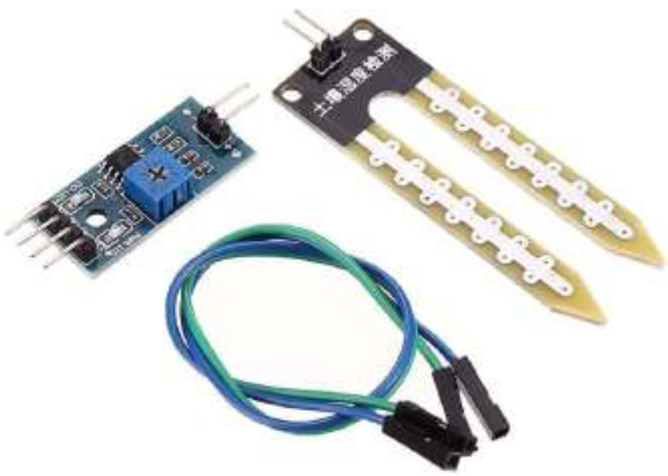


Fig -2: Soil Moisture Sensor

C. Temperature Sensor:

In this project, temperature will be continuously monitored. If it surpasses the preset threshold in the microcontroller, a buzzer will sound in the circuit, alerting industry personnel to halt the process immediately.

Therefore, the LM35 temperature sensor must continuously monitor the temperature, while the microcontroller compares it to the preset value. Once the temperature reaches the predefined threshold, the microcontroller activates the buzzer, causing it to emit a loud sound.

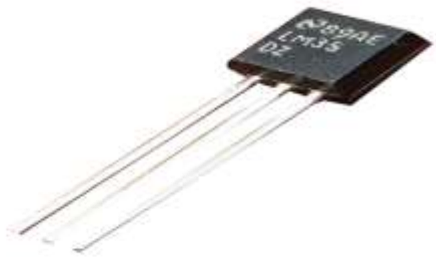


Fig -3: Temperature Sensor

D. LCD Display:

This type is widely used in practice because of its low cost and versatile applications. It is based on the HD44780 microcontroller (by Hitachi) and can display messages on two lines, with 16 characters per line. It can show all alphabet letters, Greek symbols, punctuation marks, mathematical symbols, and more. Additionally, users can create and display their own custom symbols. Features such as backlighting, cursor visibility, and automatic message scrolling (both left and right) add to its usefulness.

Fig -4: LCD Display

5. ANALYSIS

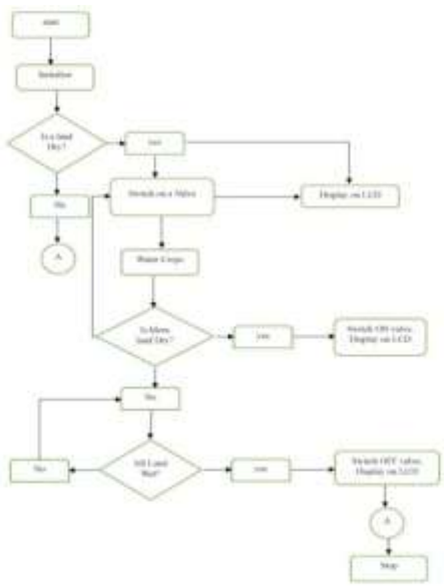


Fig -5: Flow Chart of Soil Moisture Sensor

Fig -6: Soil Moisture Sensor

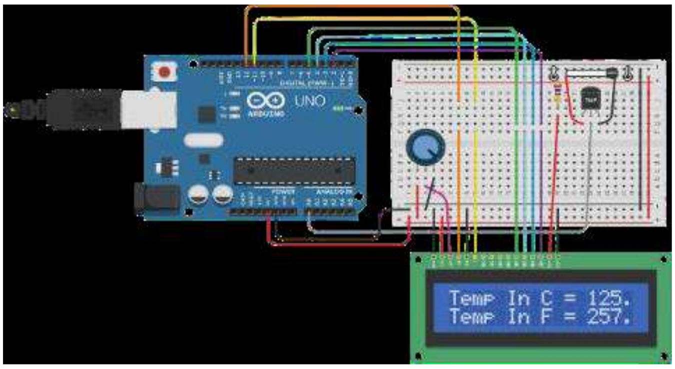
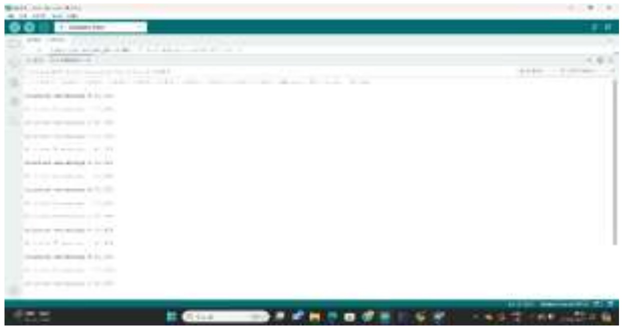


Fig -7: Temperature Sensor



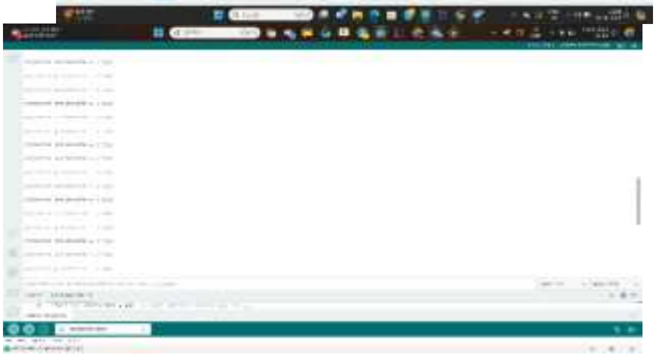


Fig -8: Measurement for dry soil

Fig -9: Graph for wet soil

Fig -10: Measurement for wet soil

3. CONCLUSIONS

Farmers and groundskeepers can benefit from the convenience and flexibility of remotely monitoring and controlling irrigation schedules via web-based platforms or mobile apps. The use of these intelligent irrigation technologies is anticipated to rise in tandem with growing concerns about water conservation and scarcity, encouraging more effective and sustainable water management techniques in a variety of industries.

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