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Intelligent water management system Using IoT

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Abstract — Irrigation systems are crucial for agriculture, yet improper water distribution frequently results in wastage and increased water usage. This project demonstrates an Intelligent Water Management System using Internet of Things (IoT) that automates and optimizes water distribution for irrigation, resulting in more efficient water usage. The system is based on the Arduino UNO platform and includes essential components like a soil moisture sensor, servomotors, an LCD display, and an ESP8266 Wi-Fi module. The system has two modes of operation: Auto Mode, in which the system automatically measures soil moisture independently and regulates water supply to plants according to real-time measurements, and Manual Mode, in which users can monitor and operate the irrigation system remotely through a mobile app or web portal via the Wi-Fi module. The LCD shows the soil moisture and status of the system in real time, enabling users to track the performance of the irrigation system. The technology will minimize water loss, regulate irrigation time, and enable sustainable agriculture through automation of the irrigation process to save water more efficiently.
Keywords: Arduino uno, moisture sensor, 16x2 Lcd Display, ESP8266 WiFi module, Servomotors, Power supply.

1. Introduction

The smart irrigation system predicts soil moisture based on a machine learning algorithm and optimizes irrigation based on sensors and meteorological data. The water-saving, open-source, and affordable prototype enhances productivity and saves water by allowing distant control and real-time monitoring [1]. Smart irrigation systems automate irrigation and optimize water use based on sensors, regulators, and communication devices to provide crops with the correct amount of water at the correct time. The method improves crop productivity, eliminates water wastage, and increases farmer profitability. It is simple to install, quick to use, and remotely monitorable. In general, IoT-based irrigation is a good way to derive food security and sustainable agriculture [2]. By automating water based on real-time soil and environmental status, the Smart watering System—powered by an Arduino Uno and other sensors—improves the health of plants, energy efficiency, and water conservation. Its simple-to-use interface improves accessibility, and its modular design allows it to be configured to varied agricultural environments. For more flexible and effective irrigation, future developments might incorporate more sensors, wireless communication, machine learning, and weather integration [3]. IoT devices, the ThingsBoard platform, and a dashboard make up the three layers that make up the irrigation system, which guarantees safe communication and effective data transmission. Processing and visualizing real-time environmental data improves water usage efficiency and encourages sustainable farming methods. Future advancements will incorporate scalable frameworks and intelligent systems to enhance resource allocation and agriculture management in general [4].

2. Literature Review

Numerous studies focusing on intelligence water management systems have previously been conducted, usually as part of technical reports and research papers that cover various geographic areas.

Jain et al. [5] have developed system using arduino microcontroller. The hardware implementation includes a soil moisture sensor, water pump, solenoid valve, and power supply. The Arduino microcontroller initializes the attached devices, such as the water pump and soil moisture sensor, when it is turned on. The microcontroller uses the sensor to continuously check the moisture content of the soil. To provide water to the soil, the microcontroller activates the water pump if the moisture content drops below the predetermined threshold. The microprocessor turns off the pump when the appropriate amount of soil moisture is reached. The system maintains the optimal soil water condition for plant growth, and thus, the effective use of water is possible. Water use is minimized and irrigation efficiency maximized by this automated system.

Bhondve et al. [6] used system based on Arduino Uno, Ultrasonic Sensor, Water Flow Sensor (YF-S201), Solenoid Valve and ESP8266 Wi-Fi Module. Arduino Uno, which reads data from sensors, controls the system. Based on reflected waves and sound waves emitted, the ultrasonic sensor computes the water level. Real-time monitoring of water usage is facilitated by the water flow sensor (YF-S201) in order to observe the flow of water in the system. ESP8266 Wi-Fi module also facilitates wireless connectivity, because of which it is possible to remotely monitor and control the entire system using mobile app, making water management efficient.

Devika et al. [7] proposed a system consisting of 16x2 LCD display, driver circuit relay, DC pumping motor, copper electrode soil moisture sensor, and Arduino Uno microcontroller. The Arduino receives data from the soil moisture sensor, which senses the moisture content in the soil, to switch on/off the water motor via the relay. The motor is switched on during low soil moisture and switched off during adequate soil moisture to irrigate the plants. System status and moisture levels are part of the real-time data that are displayed on the LCD display. The relay switches on/off the motor and is held accountable for effective irrigation based on the soil condition.

Kanimozhi et al. [8] suggested method with Arduino Uno, Soil Moisture Sensor, DHT11 Sensor, LCD Display, Buzzer Relay Module Pump and Motor Power Supply. The system enhances water efficiency and responds to changes in environmental conditions. The Smart Irrigation System uses an Arduino Uno to sense soil moisture, temperature, and humidity through sensors. If soil moisture is below a predefined level, the system buzzes and activates the irrigation pump through a relay module. The LCD display shows real-time environmental condition and irrigation status.

3. Contribution

This project maximizes the irrigation water supply by creating an Intelligent Water Management System that significantly enhances the practice of water management. For efficient use of water and to avoid wastage, the system utilizes an Arduino Uno and soil moisture sensor to mechanize irrigation. Flexibility and convenience are promoted by having two modes: Auto Mode, in which soil moisture irrigates automatically, and Manual Mode, in which irrigation is manually operated by the user using a web interface or mobile app. Customers can also view real-time soil moisture and system performance through an LCD display. This project offers a green alternative to irrigation in agriculture, saving water resources while enhancing productivity through water efficiency, wastage avoidance, and healthy plant growth.

4. Proposed System

The Proposed Intelligent Water Management System saves water by automatically managing irrigation. Fig. 1 shows the block diagram of the proposed system. Hardware components employed in this system include Arduino Uno, soil moisture sensor, servomotors, LCD, and Wi-Fi module.

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The system opens the water valve and turns on irrigation when the soil gets dry. The system operates in two modes: Auto Mode, where watering is automatically done, and Manual Mode, where users can control watering remotely using a mobile application or web interface. The LCD panel displays the soil moisture level and the system condition. The Wi-Fi module enables customers to monitor and control their systems from anywhere. This technology avoids water waste and promotes plant growth by giving the appropriate amount of water.

4.1. System Architecture

Hardware Components

- Lcd Display
- Moisture Sensor
- Arduino UNO
- Wi-Fi Module
- Servo Motor
- Modes
- Voltage Regulator
- Relay

Software Components

- Embedded C
- Arduino Uno

4.2. Hardware Model

Fig.1. Block Diagram

4.2.1. LCD Display

The 16x2 LCD display shown in Fig. 2 is frequently used in embedded systems and electronics to show text-based data, including prompts, status messages, and sensor readings. Utilizing a parallel

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interface and either 8 or 4 data pins in addition to control pins, it displays 16 characters per line on two lines. Many variants, which are powered by 5V DC, have a backlight to enhance visibility in low light. Because of its small size and low power consumption, it is perfect for battery-powered gadgets. Given the libraries available for platforms like as Arduino, programming the 16x2 LCD is a straightforward process. Clear communication is provided by this display, which is widely used in consumer electronics, data logging, home automation, and educational, hobbyist, and professional projects.

Fig.2. 16X2 LCD display

4.2.2. Wifi module ESP 8266

For Internet of Things applications, the ESP8266 WiFi module shown in Fig. 3 is an affordable, multipurpose microcontroller with built-in WiFi. It can function in both station and access point modes and supports 802.11 b/g/n standards. It is powered by an 80 MHz 32-bit RISC CPU with a 4 MB total flash memory and 160 KB of SRAM. It can be used in a variety of projects, for example, smart irrigation systems, as it supports a number of GPIO pins for the attachment of sensors and actuators. It is simple to use for distant monitoring and control via mobile apps or web interfaces as it is low power, supports an onboard TCP/IP stack, and is supported by the Arduino IDE.

Fig.3. WIFI module 8266

4.2.3. Servo motor

In irrigation systems, a servo motor as shown in Fig. 4 is most suitable for precise control, especially for functions like sprinkler positioning, water flow adjustment, and opening and closing valves. It works on the principle of accepting Pulse Width Modulation (PWM) pulses, which makes it rotate to precise angles. In the scenario of efficient consumption of water in irrigation, a servo motor can be used to open or close valves, place sprinkler heads, or modulate water flow based on real-time feedback. In the scenario of automated irrigation systems, the motors are durable, energy efficient, and easy to work with microcontrollers like Arduino. Servo motor-based smart irrigation systems can make maximum use of resources and achieve sustainability through efficient water distribution, prevention of wastage, and dynamic response to varying environmental conditions.

Fig.4. Servo motor

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4.2.4. Modes

1. Auto mode
2. Manual mode

Modes connection is shown Fig.5. Auto and manual modes in irrigation systems have different benefits. During auto mode, the device automatically modifies watering according to predetermined thresholds, weather, and soil moisture levels. With this mode, water waste is minimized and healthy plant growth is encouraged by only turning on irrigation when needed. It works best in vast or isolated agricultural regions where ongoing manual monitoring is impractical. Manual mode, on the other hand, gives consumers direct control over the watering process. When certain parts of the field need additional water or when a user want to change the automated settings, this mode can be helpful. It is adaptable and permits changes according to urgent requirements, although it could take more time and work from the user.

Fig.5. Modes connection

4.2.5. Power supply relay

In irrigation systems, a power supply relay shown in Fig. 6 regulates parts like solenoid valves and pumps. It enables the operation of high-power devices with low-power signals from sensors or microcontrollers (like Arduino), automating water flow according to variables like soil moisture. To illustrate, a relay can activate a pump when the moisture level is low and switch it off when it is high enough. With this automation, irrigation systems operate more efficiently, use less water, and require less manual intervention.

Fig.6. Power supply

4.2.6. Moisture sensor

By monitoring variations in electrical resistance or capacitance, a moisture sensor shown in Fig. 7 determines the amount of water in the soil. By lowering water waste, encouraging healthier plants, and offering real-time soil moisture data, it aids in the optimization of irrigation in landscaping, greenhouse management, and agriculture. There are two kinds: capacitive sensors, which measure capacitance and provide more precision, and resistive sensors, which measure resistance. Contemporary sensors frequently have wireless connectivity for remote monitoring, which supports sustainability and resource management. Additionally, they are employed in building to guard against damage caused by moisture.

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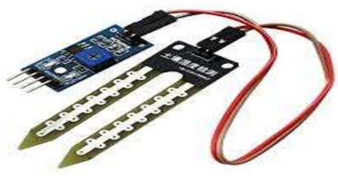

Fig.7. Moisture sensor

4.2.7. Arduino Uno

The Arduino Uno microcontroller board shown in Fig. 8 is based on the ATmega328P chip, which is used to create basic to sophisticated electronic projects. With its 14 digital and 6 analog input/output pins, it can interact with a wide range of sensors and gadgets. Coding and uploading programs is made easier by the Arduino IDE (Integrated Development Environment), which makes programming the board simple. . It may be driven by an external power supply or USB connection.Being the primary controller of the Intelligent Water Management System, the Arduino Uno takes input from the soil sensor, controls the servomotor to open or close the valve, and connects with the LCD display and Wi-Fi module.

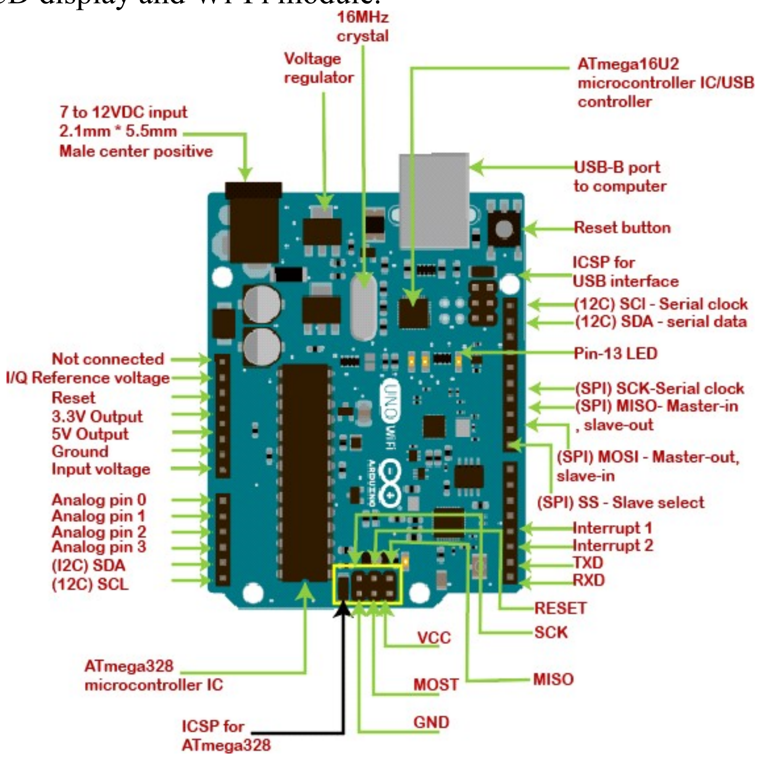

Fig.8. Ardunio UNO

4.3. Software Implementation

4.3.1. Arduino UNO

The Arduino Integrated Development Environment (IDE)

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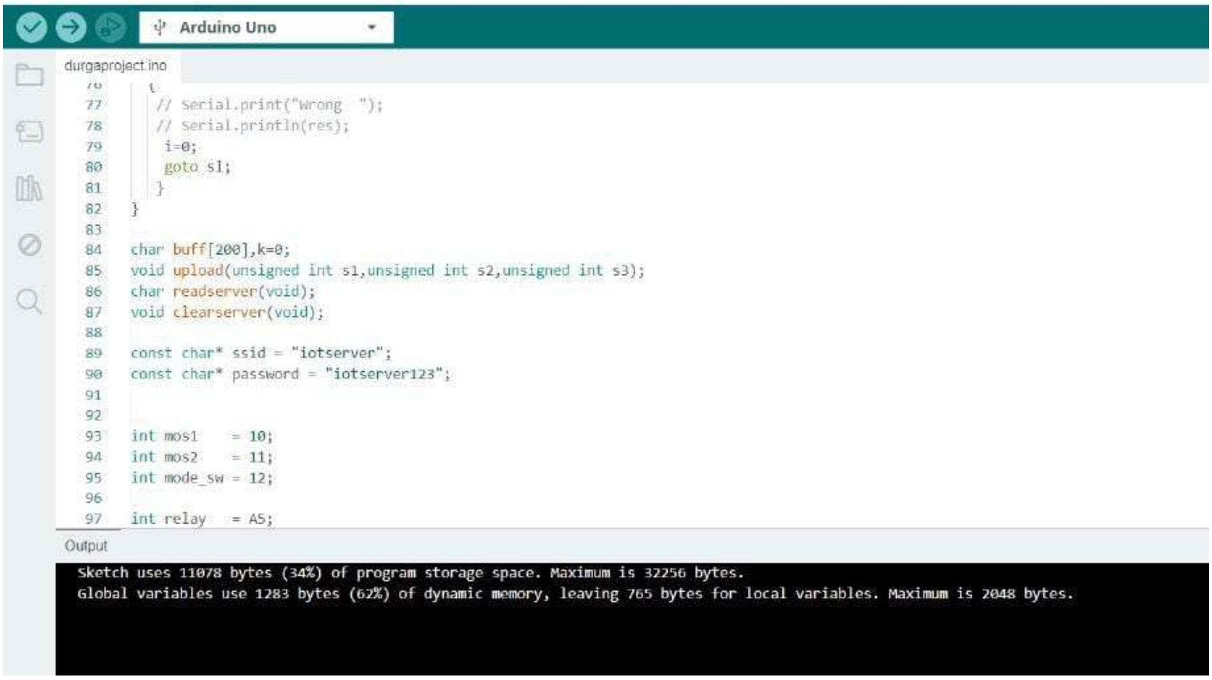

Fig.9. Software implementation

Optimized for programming with Arduino microcontrollers, the IDE supports code writing and uploading and is an excellent choice for users of all levels. Maybe the most significant benefit of the Arduino IDE is its easy-to-use interface, which features a code editor that features syntax highlighting, auto-completion, and error checking. It supports the writing of efficient, readable code by users. The IDE allows users to benefit from the power of C and C++ while minimizing the complexity typically associated with these languages by enabling a simplified version of these languages. This enables beginners to learn programming concepts without being overwhelmed. In addition, the Arduino IDE comes pre-loaded with a number of libraries that provide ready-to-use functionality for controlling hardware like motors, sensors, and displays. Fig. 9 shows the software implementation.

4.3.2. Embedded C

For microcontrollers and other embedded systems with limited process and memory resources, embedded C is an extended programming language that bridges the gap between embedded devices and C capabilities. Embedded C offers programmers low-level hardware access so that they can create low-level code that talks directly to system peripherals. Through bit manipulations, fixed-point arithmetic, and direct memory access, embedded C has widespread usage in industries including industrial automation, consumer electronics, telecommunications, and the automotive industry. Embedded C also offers specialized libraries and APIs to ease development on different hardware platforms with pre-defined functions for interrupt handling, timer management, and GPIO management. Embedded C is highly efficient and portable for real-time applications because it supports modular programming, which makes code reuse possible.

4.4. Implementation

Intelligent Water Management System is aimed at solving water conservation and efficient crop management issues by optimizing and automating the irrigation process in agricultural fields. For automatic and manual irrigation control, this system depicted in Fig. 10 is developed on an Arduino platform and consists of required components like three servo motors, moisture sensor, lcd display,

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and ESP8266 Wi-Fi module. A large canal and two small canals, which are named as "baby canals," form the system. Servo motors are used to control the water distribution precisely in the field.

In order to know if the soil is damp or dry, the moisture sensor is always checking the moisture level of the soil. When the system is operating in Auto Mode, watering is based on the sensor reading. When the system is operating in Manual Mode, an internet-connected smartphone allows the user to remotely control the watering system. Control and monitoring of the irrigation process in real time are facilitated using the ESP8266 Wi-Fi module, allowing communication between the user's smartphone and Arduino. In case one particular part of the field needs more water than other parts, it allows the user to control the irrigation process.

To ensure that they are always informed of the watering needs of the field, users can also receive real-time alerts or reports on the condition of moisture and system. The general goal of this project is to create a smart, efficient, and easy-to-use irrigation system that saves water, reduces labor costs, and improves plant health. The technology offers an environmentally friendly approach to modern farming by combining real-time moisture monitoring with automation and remote control. It can also be scalable in larger agricultural environments. Aside from fulfilling the practical needs of water management, this project demonstrates how IoT technology applied to the agriculture sector to enhance efficiency, sustainability, and output.

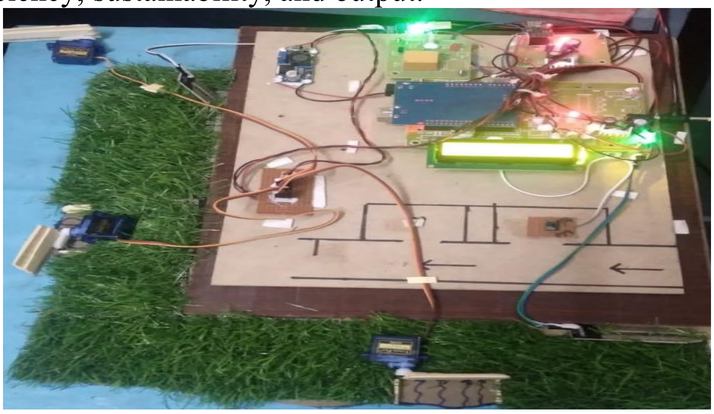

Fig.10. Circuit Diagram

5. Result

In this case, the result was efficiently optimizing irrigation, the Intelligent Water Management System reduced water loss. The servomotor performed well in managing water flow under Auto Mode, and the soil moisture sensor accurately detected dry soil to trigger irrigation. Users may use a smartphone application to operate the machine remotely in Manual Mode. System performance and soil moisture were displayed on the LCD panel in real time. Through efficient utilization of water, the technology supported better water management and healthier growth of plants.

S.No	Field1	Field2	Mode	Gate1	Gate2	Main_Gate	Date
1	Dry	Dry	Manual	Close	Close	Open	2025-01-31 14:39:08
2	Dry	Dry	Manual	Close	Close	Open	2024-11-29 14:47:31
3	Dry	Dry	Manual	Close	Close	Open	2024-11-29 14:45:46
4	Dry	Dry	Manual	Open	Open	Close	2024-11-29 14:11:45
5	Dry	Dry	Manual	Close	Close	Open	2024-11-29 14:08:21
6	Dry	Dry	Manual	Close	Close	Close	2024-11-29 10:28:17
7	Dry	Dry	Manual	Close	Close	Close	2024-11-29 10:26:49
8	Dry	Dry	Manual	Close	Open	Close	2024-11-29 10:25:03
9	Dry	Dry	Manual	Close	Close	Close	2024-11-27 15:25:27
10	Dry	Dry	Manual	Open	Close	Open	2024-11-27 15:23:44
11	Wet	Wet	Manual	Close	Close	Open	2024-11-27 15:22:14
12	Dry	Dry	Manual	Close	Close	Open	2024-11-27 15:20:28
13	Dry	Dry	Manual	Open	Open	Open	2024-11-23 15:08:23
14	Dry	Dry	Manual	Open	Open	Close	2024-11-23 15:06:38
15	Wet	Wet	Manual	Open	Open	Close	2024-11-23 15:05:10
16	Dry	Dry	Manual	Open	Open	Close	2024-11-23 15:03:24
17	Dry	Dry	Manual	Open	Open	Close	2024-11-23 15:01:39
18	Wet	Dry	Manual	Open	Open	Close	2024-11-23 15:00:12
19	Dry	Dry	Manual	Open	Open	Close	2024-11-23 14:58:26
20	Dry	Dry	Manual	Close	Open	Close	2024-11-22 17:48:16

Fig.11. Result

6. Conclusion

The Intelligent Water Management System is employed as real-time soil moisture information efficiently automates irrigation, making water more efficient and promoting healthier plant growth. Employing servomotors, a Wi-Fi module, an Arduino Uno, and a soil moisture sensor, the system conserves water and provides customizable control in manual and automatic modes. The utility of the system is also enhanced by the real-time monitoring offered by an LCD display. This concept presents a financially viable and eco-friendly method for optimizing irrigation in gardening and agricultural environments, enhancing plant maintenance and water conservation.

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