Developing a Smart Irrigation System Using NodeMCU

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***Abstract*—The IoT-based smart irrigation system is an innovative approach to water conservation and agriculture management. This system employs the Internet of Things (IoT) technology and uses sensors, microcontrollers, and wireless communication to automate the irrigation process. The system continuously monitors soil moisture level and determines & supplies the optimum amount of water required for the crops using a pumping motor connected to the farm. This system can help farmers save water, reduce energy costs, and improve crop yields. The system can also be remotely monitored using the Thingspeak IoT platform.**

***Keywords*— Irrigation scheduling, Soil moisture sensors, Automation, Water conservation, Weather forecasting, Real-time monitoring.**

I. INTRODUCTION

Smart irrigation systems represent a sophisticated technology that enables efficient and sustainable utilization of water in a variety of applications including agriculture and landscaping[1]. These systems employ an amalgamation of sensors, software, and communication technologies to control and monitor irrigation systems based on real-time environmental conditions such as temperature, humidity, soil moisture, and precipitation. With the burgeoning global population, there is an impending need to increase agricultural production, which consequently demands more water, which is already a scarce commodity in many areas. Smart irrigation systems offer a promising solution to these challenges by reducing water wastage and boosting irrigation systems' efficiency.[2] Through precision water management, these systems help farmers to optimize water use, resulting in significant water savings and improved crop yields, and also reduce the energy consumption and costs associated with irrigation systems. The rapid advancement in communication and sensor technologies, including Wireless sensor networks, the Internet of Things (IoT), Machine Learning, and Artificial Intelligence (AI), has facilitated the development and implementation of these systems.[3] This research paper aims to provide an in-depth overview of smart irrigation systems and their application in agriculture and landscape, highlighting their various components, benefits, challenges, and potential for wider adoption in the future.[4]

II. LITERATURE REVIEW

The research paper proposes a low-cost IoT-based smart irrigation system that supplies water when low soil moisture levels are detected. The authors describe the design and development of the system, which uses a soil moisture sensor, a microcontroller, and a Wi-Fi module to automate the irrigation process.[5] The paper presents a detailed description of the system architecture, hardware components, software tools, and the algorithm used for the system.

The authors begin by discussing the importance of water conservation in agriculture and how an efficient irrigation system can help achieve this goal.[6] They highlight the drawbacks of traditional irrigation methods, such as over-irrigation and under-irrigation, and how it affects plant growth and yield. They argue that an IoT-based smart irrigation system can help optimize the irrigation process and conserve water.[7]

The authors then present the system architecture, which includes a soil moisture sensor, a microcontroller, and a Wi-Fi module. They describe how the sensor is connected to the microcontroller and how the microcontroller communicates with the Wi-Fi module to send data to the cloud.[8] The results of their experiments demonstrate the effectiveness of the system in conserving water and improving crop yields. They show that the system can save up to 60% of water compared to traditional irrigation methods. They also demonstrate how the system can be used to remotely monitor and control the irrigation.[8]

Furthermore, the paper describes the hardware components used in the development of the IoT-based smart irrigation system. The authors detail the specifications and functionality of the soil moisture sensor, which is a key component of the system. They also explain the microcontroller used in the system and its role in controlling the irrigation process based on the data received from the soil moisture sensor. Additionally, the authors provide a detailed description of the Wi-Fi module used in the system, which is responsible for transmitting the data to the cloud for storage and analysis.[9]

The paper also presents the algorithm used in the system to optimize the irrigation process based on the soil moisture level. The authors describe the various parameters used in the algorithm, such as the desired soil moisture level, the threshold values, and the time interval for watering. They also discuss the importance of calibration of the system to ensure accurate measurement of soil moisture levels.[10]

Overall, the paper provides a comprehensive overview of the design and development of the IoT-based smart irrigation system, highlighting its potential to conserve water and improve crop yields in agriculture. The results of the experiments conducted by the authors demonstrate the effectiveness of the system and its ability to optimize irrigation and reduce water waste. The authors conclude by emphasizing the importance of adopting such smart technologies in agriculture to promote sustainable practices and mitigate the effects of climate change.[10]

III. METHODOLOGY

Components Used-

a. Soil moisture sensor
b. Water flow sensor
c. Relay module
d. Motorized water valve
e. ESP8266 Wi-Fi module
f. Power supply unit

Steps -

The methodology for implementing a smart irrigation system using a Node MCU and connecting it with the Blynk app involves several steps:

- Hardware setup: The first step involves assembling the hardware components required for the smart irrigation system. This includes a Node MCU microcontroller, soil moisture sensor, water pump, relay module, and power supply. The soil moisture sensor is connected to the Node MCU analog input, and the relay module is connected to the Node MCU digital output, which controls the water pump[9].
- Software setup: Once the hardware setup is complete, the next step involves configuring the software components. This includes installing the Arduino IDE and necessary libraries, such as the Blynk and Adafruit MQTT libraries. The Node MCU is programmed to read the soil moisture sensor values and control the water pump through the relay module[9].
- Blynk app setup: The Blynk app is then set up, and a new project is created with the necessary widgets to control the smart irrigation system. This includes a gauge widget to display the soil moisture levels, a button widget to turn the water pump on/off, and a notification widget to receive alerts when the soil moisture level drops below a certain threshold[10].
- Cloud connectivity: The Node MCU is then connected to the Blynk cloud server using the Wi-Fi network. The device is registered with the Blynk app, and the authentication token is generated to establish the connection[11].

- Testing and deployment: Finally, the smart irrigation system is tested to ensure that it is working correctly. The system is deployed in the desired location, and the Blynk app is used to control and monitor the system remotely[11].

Block Diagram of Smart irrigation system

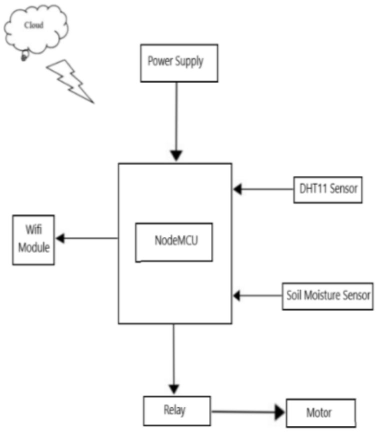


Table Comparison of water management of smart irrigation system and manual irrigation system

System Type	Water is given to plant (ml/sec)	Time Required (min)	Area (m^2)
Smart irrigation system	5.67	4.09	0.045
Manual Base irrigation system	9.89	3.68	0.045

[12]

Equations

The calculation for the Sensor-Based Watering System

The circular vessel (tank) of the plant has an area of 0.045 square meters, calculated using the formula πr2. The discharge rate for saturation, Q1, is 7.67 milliliters per second, while the discharge rate for flood, Q2, is 7.42 milliliters per second. The sensor placed on the ground recorded a dryness value of 669, which exceeded the maximum dry level defined in the program, triggering automatic irrigation. After 1 minute of irrigation, the demand was satisfied, and the engine stopped automatically. However, a few seconds later, the plant environment became dry again, and the drought level dropped to 420, prompting the engine to restart and stop irrigation automatically, maintaining a constant value[12].

Area of the circular vessel (tank of the plant), =

πr2 = 0.045 m2

Total discharge by saturation,

Q1 = [V (volume) / T (time)] ml / sec.= 7.67 ml/sec

Total discharge for flood, Q2 = 7.42 ml/sec.

Pump power equation: This equation is used to calculate the power required by the water pump to deliver a given flow rate of water. The pump power equation can be expressed as:

Pump power = (flow rate x pressure) / pump efficiency

where the flow rate is the volume of water delivered per unit of time, pressure is the force exerted on the water by the pump, and pump efficiency is the ratio of the output power to the input power[13].

Flow rate equation: This equation is used to calculate the flow rate of water through a pipe or channel. The flow rate equation can be expressed as:

Q = A x V

where Q is the flow rate, A is the cross-sectional area of the pipe or channel, and V is the velocity of the water.

Water requirement equation: This equation is used to calculate the amount of water required by a plant to grow and produce a given yield. The water requirement equation can be expressed as:

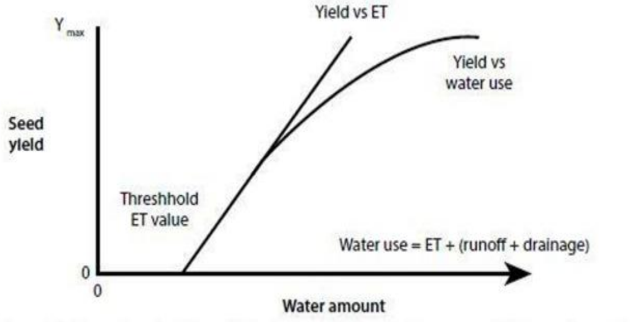
Water requirement = crop water use x yield

where crop water use is the total amount of water required by the plant during its growth cycle, and yield is the amount of produce harvested per unit area.[14]

Water balance equation: Irrigation requirement = (ETc x Kc) - (P + RO + D)

Soil moisture balance equation:

$\Delta\theta = P + I - RO - ET$



Pump power equation: Pump power = (flow rate x pressure) / pump efficiency

Flow rate equation: Q = A x V

Water requirement equation: Water requirement = crop water use x yield

Using an automatic irrigation system saves water and time compared to manual irrigation, which requires more water and is prone to leaks. Many farmers believe that more water means more crop production, but this is not true. Each crop needs an optimal amount of water for maximum yield, and an automated system can help farmers find this optimal amount. The relationship between crop yield and water is not always straightforward, but an automated system can help find the maximum irrigation requirement for maximum performance. Optimal irrigation planning is important for maximizing water use efficiency and achieving other goals. The economic value of irrigation applications can be assessed using water production functions and analysis methods.[14]

IV. RESULTS & DISCUSSIONS

When the program is uploaded to Arduino IDE soil moisture sensor will display the dryness value of the soil. We have to set the dryness level of soil supposed we set the value at 400 when the dryness of the soil become exceeding 400. Then the pump will automatically start once the dryness value is reached pump is automatically turned off. If we want to flood the system or field, the humidity sensor must remain at a higher level or the programming value must be lower than the fixed value. The graph shows that the engine starts irrigating when the dryness value is higher and switches off when the soil reaches a balanced state. [15]When we placed the sensor in the soil, the dryness value was 669, and irrigation began as the dryness value exceeded the maximum dryness level defined in the program. After one minute of watering, the motor stopped automatically when the demand was fulfilled. A few seconds later, the surrounding soil was dry, and the dryness value was 420. The motor started again for a few seconds and stopped automatically at a constant value.

The automatic irrigation system requires only 1350ml of water, whereas the manual system needs 1650ml of water, which also suffers from water leaks.[16] Adopting the automatic system not only saves water but also saves time. Many farmers in our country lack adequate knowledge of irrigation and mistakenly believe that more water leads to higher agricultural production. However, this is not the case since all crops require an optimal level of water for maximum yield, which is challenging to determine manually. Nevertheless, an automated irrigation system can help farmers locate the optimal point for their crops. As we can see in Table no 1 smart irrigation system also takes minimum time and provide the accurate or required water resource here the total water loss is 0.70 ml/l and the total time loss has 3.22 min hence we improved the efficiency of an irrigation system using smart irrigation system technology.[17]

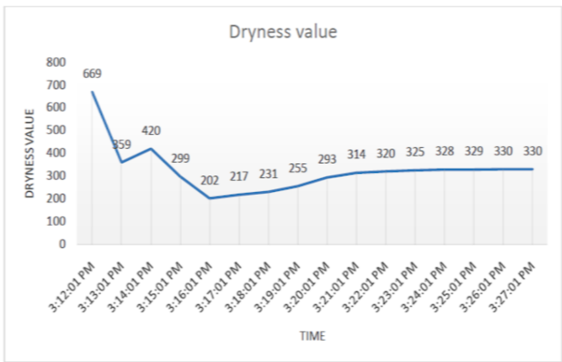


Fig no 2. Graphical representation of dryness level vs Time.

V. FUTURE SCOPE

There are several potential areas for future development and improvement for a smart irrigation system using Node MCU. Here are a few examples:

Integration with weather data: Incorporating real-time weather data can further optimize the irrigation process by adjusting watering schedules based on precipitation forecasts and evapotranspiration rates.[20]

Multi-zone irrigation: The system can be expanded to support multiple zones, allowing for targeted watering of specific areas with varying moisture needs.

Water quality monitoring: In addition to moisture sensing, the system can be enhanced to monitor water quality parameters such as pH, salinity, and nutrient levels to ensure optimal plant growth.

Machine learning algorithms: Machine learning algorithms can be used to analyze data collected by the system, enabling predictive modeling and intelligent decision-making for irrigation management.[22]

Mobile app integration: A mobile app can be developed to provide users with real-time information about their irrigation system, allowing them to monitor and adjust settings from anywhere.

Integration with precision agriculture technologies: Smart irrigation systems can be integrated with precision agriculture technologies such as GPS mapping, yield monitoring, and variable rate application to further optimize crop production and resource utilization.

Solar-powered irrigation: Node MCU can be integrated with solar-powered irrigation systems to reduce energy costs and make the system more sustainable.[19]

Overall, there are many possibilities for future development and improvement of smart irrigation systems using Node MCU, with the potential to enhance crop production and conserve water resources

VI. CONCLUSION

The study developed an intelligent irrigation system using a microcontroller with a Node MCU, relay, soil moisture sensor, motor, and battery. The system utilizes soil moisture sensors to prevent excessive or insufficient irrigation, providing a potential solution to the problems faced in manual irrigation. The system was tested on clayey and sandy soil in a pot for flood saturation and irrigation. [21]The results showed that the sensor-based irrigation system required less water and less time than the manual irrigation system, with increased irrigation efficiency. As we can see in Table no 1 smart irrigation system also takes minimum time and provide the accurate or required water resource here the total water loss is 0.70 ml/l and the total time loss has 3.22 min hence we improved the efficiency of an irrigation system using smart irrigation system technology The system worked automatically without assistance, making it more efficient and convenient. However, the study is limited to a small-scale test and further research is needed for large-scale agriculture.[22]

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