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Iot Based Smart Irrigation System using Artificial Intelligence

Dr. G. Nanthakumar[1], Mr. K. Pazhanivel[2], Abinesh A[3], Ganesh K. R[4], Harish V[5], Nagendran S[6]
Professor, Department of Computer Science and Engineering[1]
Assistant Professor, Department of Computer Science and Engineering[2]
Student, Department of Computer Science and Engineering[3,4,5,6]
Anjalai Ammal Mahalingam Engineering College, Thiruvarur, Tamil Nadu, India

Abstract*: Sustainable agriculture depends on effective water management, and the Internet of Things (IoT) and artificial intelligence (AI) combine to offer a novel approach to irrigation process optimisation. In order to improve water utilization in agriculture, this research suggests a comprehensive system that includes buzzers, LCD displays, relays, water pumps, soil moisture sensors, AI algorithms, and water pumps. An AI algorithm at the centre of the system evaluates data collected in real time from field-installed soil moisture sensors. These sensors gather information on the soil's moisture content, which offers important insights into the real water needs of the crops. After analysing this data, the AI programme decides how best to schedule irrigation. The system's integration with a relay is intended to regulate when a water pump is activated. According to the suggestions of the AI algorithm, the relay provides accurate control over the irrigation operation, enabling on-demand watering. By avoiding over- irrigation and conserving water, this lowers the chance of waterlogging and associated problems. The system has an LCD display to improve user engagement and offer real-time feedback. Important details like irrigation status, soil moisture levels, and AI-driven suggestions are conveyed through the display. With the help of this function, farmers may monitor the system's performance and make well-informed judgements. Furthermore, a buzzer is incorporated to deliver auditory notifications in the event of crucial occurrences, such low soil moisture levels or system faults.This guarantees timely resolution of problems that might affect crop health and system performance as a whole. A number of benefits are provided by the suggested AI-driven water management system, including improved agricultural output, water conservation, and operational effectiveness. Water scarcity and resource optimisation in irrigated fields are addressed by the system, which offers a comprehensive precision agriculture solution by utilising the capabilities of IoT devices, soil moisture sensors, relays, water pumps, buzzers, and LCD displays*

Keywords: Artificial Intelligence, Internet of Things, Moisture Sensor and Water Conservation

I. INTRODUCTION

1.1 Introduction:

Global food security relies significantly on the success of agricultural practices, with water management playing a pivotal role in determining agriculture's effectiveness. The prudent use of water resources is paramount to ensuring the success and sustainability of agricultural endeavors worldwide. Effective irrigation techniques are essential in this context, as they not only dictate the efficient utilization of water but also directly impact agricultural productivity and environmental conservation efforts. However, traditional irrigation methods often fall short in adapting to the dynamic challenges posed by changing climatic conditions and the diverse water requirements of different crops. This limitation underscores the critical need for precision water management strategies that can address these challenges while optimizing water usage, enhancing agricultural yields, and promoting environmental sustainability.

1.2 Challenges with Conventional Irrigation Techniques:

Conventional irrigation techniques, while widespread, often exhibit limitations in their adaptability and responsiveness to changing environmental conditions and crop needs. These techniques typically rely on fixed schedules or manual

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interventions to determine irrigation timings and volumes, which may not always align with the actual water requirements of crops.Furthermore, traditional irrigation systems lack the flexibility to adjust to fluctuations in climatic circumstances, such as variations in rainfall patterns or temperature extremes.

Additionally, the uniform application of water across fields may not account for variations in soil moisture levels or the specific water needs of individual crops, leading to inefficient water use and suboptimal agricultural outcomes. These shortcomings underscore the pressing need for innovative approaches to water management in agriculture that can overcome the limitations of conventional techniques.

1.3 The AI-Driven Approach to Precision Water Management:

This study suggests using new technology to manage water better for farming. Traditional ways of watering crops sometimes have problems, so this study proposes a new idea: using artificial intelligence (AI) and the Internet of Things (IoT) to make irrigation smarter. By combining these technologies with gadgets like screens, switches, sensors, and pumps, the goal is to use water more wisely, grow more food, and take care of the environment.

The AI and IoT technologies work together to monitor water use in real-time and make decisions about when to water crops. Soil moisture sensors placed in fields keep track of how wet the soil is and send that information to AI software.

The AI software analyzes the data and decides when and how much water crops need. This way, farmers can water their crops at the right times and avoid wasting water.

Besides helping farmers use water more efficiently, the AI-driven system also helps protect the environment. By only watering, when necessary, it reduces water waste and prevents soil erosion. Plus, it minimizes the risk of waterlogging and nutrient runoff, which can harm nearby ecosystems. By promoting smarter water use and reducing reliance on old-fashioned methods, the system supports biodiversity and keeps natural habitats healthy.

Overall, the AI-driven approach to precision water management aims to make farming more efficient and sustainable. By using technology to monitor water use, make smart decisions, and protect the environment, this system helps farmers grow more food while using fewer resources. It's a win-win for farmers, consumers, and the planet alike.

II. RELATED WORKS

The article titled "Design and Development of IoT-Based Smart Irrigation System," authored by [1] issue of the International Research Journal of Modernization in Engineering Technology and Science, explores the innovative application of Internet of Things (IoT) technology in revolutionizing irrigation practices. aThe article delves into the design, development, and implementation of a smart irrigation system that aims to modernize agricultural practices by automating and optimizing water management processes. In the contemporary agricultural landscape, the efficient utilization of water resources is of paramount importance, particularly inA light of pressing challenges such as water scarcity and resource inefficiency. Traditional irrigation methods, which often rely on manual intervention and outdated technologies, are no longer adequate to meet the demands of modern agriculture. The article addresses these challenges by proposing the integration of IoT technology into irrigation systems, thereby enabling real-time monitoring and control of water usage. The IoT-based smart irrigation system described in the article offers a comprehensive solution to the complexities of water management in agriculture.

The cited article, authored by [2], the article explores the application of IoT in revolutionizing irrigation practices. It likely delves into the design, functionality, and benefits of smart irrigation systems, which leverage IoT devices such as sensors, actuators, and controllers to automate and optimize water management processes in agriculture. The authors may discuss various aspects of smart irrigation systems, including their components, operation principles, and potential impact on addressing contemporary challenges in agriculture, such as water scarcity and resource inefficiency. Additionally, the article may highlight case studies or practical examples demonstrating the effectiveness and feasibility of IoT-based smart irrigation systems in real-world agricultural settings.

The referenced article, authored [3] explores the implementation of an IoT-based smart irrigation system utilizing artificial intelligence (AI). Published in the International Journal for Research Trends and Innovation in 2022, the article focuses on the integration of AI technology with IoT devices to enhance irrigation practices. The authors likely delve into the design and functionality of the smart irrigation system, emphasizing the role of AI algorithms in optimizing water usage and conserving resources. Key terms such as artificial intelligence, irrigation, Internet of

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Things, and water conservation are likely central to the discussion, as the article aims to highlight the significance of these technologies in modernizing agricultural practices. Additionally, the article may present case studies or practical examples showcasing the effectiveness of the IoT-based smart irrigation system in real-world scenarios, demonstrating its potential to address contemporary challenges in agriculture and contribute to sustainable water management practices.

The paper "IoT Based Smart Irrigation System Using Soil Moisture Sensor and ESP8266 NodeMCU" by [4], published in the International Journal of Computer Science and Information Technology Research, introduces a groundbreaking approach to agricultural irrigation management. Through the integration of IoT technology with soil moisture sensors and ESP8266 NodeMCU, the system offers real-time monitoring and control of irrigation processes. By collecting and analyzing soil moisture data, farmers can optimize irrigation schedules, leading to significant water savings and improved crop yield. The paper outlines the hardware setup, communication protocols, and software architecture of the system, highlighting its ease of implementation and scalability.

III. LITERATURE REVIEW

TITLE	AUTHOR NAME	YEAR	TECHNIQUE	DESCRIPTION
Design and development of IOT based smart irrigation system	Dr. Vivek Vaidya, Mr.Yash Chavan, Miss. Dineshwari Madavi, Mr. Utkarsh Meshram, Mr. Somesh Nandeshwar	April-2023.	Smart Irrigation for Crop.	The literature highlights the imperative of smart irrigation systems amid the global water crisis, emphasizing their role in conserving water and streamlining agricultural practices.
IoT Based Approach for Smart Irrigation System Suited to Multiple Crop Cultivation	Krishna Singh, Samyak Jain, Varun Andhra, Shilpi Sharma	2019	Effective way of crop Cultivation in IoT based.	This paper proposes an advanced automated irrigation approach tailored to India's multi-crop, integrating IoT and Data Science technologies.
An overview of smart irrigation systems using IoT.	Khaled Obaideena, Bashria A.A. Yousef , Maryam Nooman AlMallahi ,Yong Chai Tan MontaserMahmouda, HadiJaber,MohamadRamadanf	2022	Emphasizing water-usage through Sensory system.	This literature review explores SMART irrigation's role in advancing Sustainable Development Goals, emphasizing water-use efficiency through IoT and sensory systems.

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IoT-Based smart irrigation System using artificial intelligence.	N.Rahul,S. Sumathi,S.rajaprabu, j.Prawin Kumar, R.Varthish	2022	Crop Irrigation using Artificial intelligence and reduce the wastage of water.	A smart irrigation System based on water is added to the soil or land during irrigation to support plant development . Rainfall could not always be enough to supply the plants with the water they need to develop , depending on various factors such as area , season and climate.
Iot Based Smart Irrigation System Using Soil Moisture Sensor And Esp8266nodemcu.	Ms.S.Shobana, B.SanjanaPandey, Padmashri.R, U.Triveni	April-june,2021	Using Soil Moisture Sensors and Esp8266 using in crop irrigation.	The key objective of the paper is to monitor the soil moisture content during its dry and wet conditions with the aid of a moisture sensor ,an automated water inlet setup which can also monitor and record temperature etc.

IV.METHODOLOGY

Sensor Integration:

In the sensor integration module,the focus lies on seamlessly integrating soil moisture sensors into the agricultural environment. This involves careful selection of sensors based on criteria like accuracy and durability,followed by the development of hardware and software components for data acquisition. The sensors are connectedto the main control unit, ensuring reliable communication and power supply.Through rigorous testing and calibration,the module ensures the accuracy and consistency of sensor readings, providing reliable data for irrigation decision-making.

Artificial Intelligence:

The artificial intelligence module employs advanced algorithms to analyze sensor data and optimize irrigation schedules. Preprocessing techniques are applied to clean and normalize the data before feeding it into machine learning models. These models, such as neural networks or decision trees, learn from historical data to make real-time irrigation decisions based on soil moisture levels. Continuous feedback mechanisms refine the models' predictions over time, ensuring adaptability to changing environmental conditions and improving overallsystem efficiency.

User Interface Module:

The user interface module focuses on providing a user-friendly interface for interacting with the irrigationsystem. It incorporates intuitive design principles to present relevant information, such as irrigation status and soil moisture levels, in a clear and concise manner. Interactive controls allow users to adjust irrigation schedules and customize system settings as needed. Feedback mechanisms, such as notifications and progress indicators, keep users informed about system actions and status updates, enhancing user experience and facilitating efficient systemmanagement.

Data Flow Diagram:

A Data Flow Diagram (DFD) for an IoT-based smart crop irrigation system enhanced with Artificial Intelligence (AI) showcases how data flows and interacts between different elements of the system.

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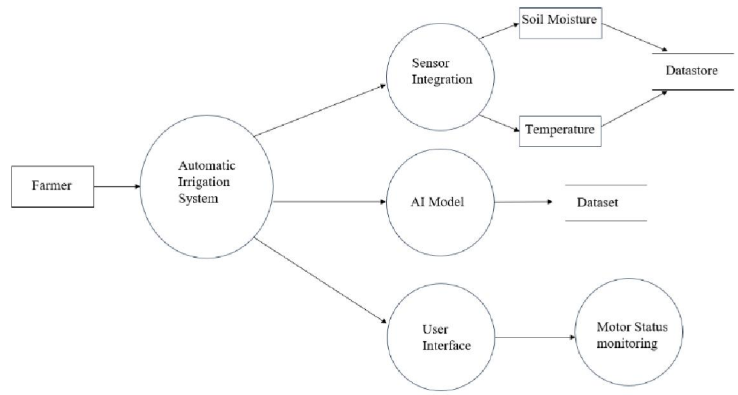

Fig. 1. Data Flow Diagram

Use Case Diagram:

A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved. In the use case diagram figure 2. shows the IoT-based smart irrigation system autonomously collects real-time data and analyzes it using AI algorithms to optimize irrigation. Actuators are then controlled to implement the optimized irrigation schedule, ensuring efficient water usage and maintaining crop/landscape health.

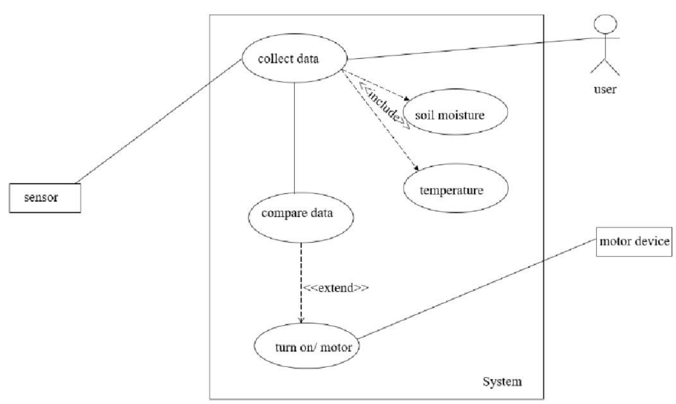

Fig. 2. Use case Diagram

V. COMPONENTS

Soil moisture sensor module

It is employed to measure the soil's moisture content. This technology makes use of a capacitance-based soil moisture sensor.

The details are described below.

1. Working Temperature - -40°C to 60°C
2. Operating Voltage – 5V DC
3. Operating current :- 40Ma.

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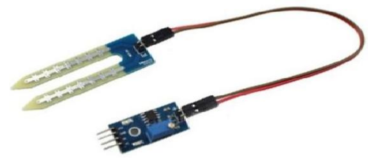

Fig. 3. Soil moisture Sensor

Arduino Uno

It is an open source microcontroller with a built-in programme for successful functioning. the software usedto create the Arduino IDE programme. It use loop logic to carry out logic. To ensure a 5V DC supply, the Arduino power source may be provided through a DC converter.

1. Operating voltage – 5V 50
2. Digital pins- 14 (0- 13)
3. Analog pins- 6 (A0 – A5)
4. Microcontroller- ATMega328P.

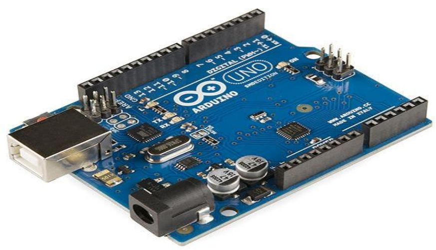

Fig. 4. Arduino Uno

Wi-Fi Module

The system may communicate data over the internet by connecting through wifi, which is made possible bythe ESP-8266 wifi module.

1.Operating voltage- 3.3V DC
2.Working Temperature - -40^{o}C to 125^{o}C
3.Flash memory size- 512 KB
4.Pins used – VCC, Ground, TX, RX, & Reset pins
5.Program used via Arduino IDE or AT- Commands

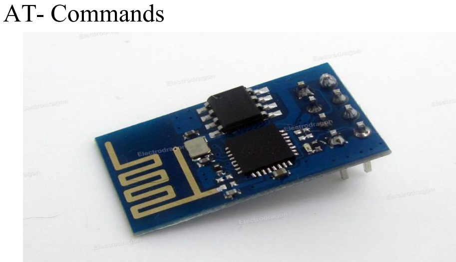

Fig. 5. Wi-Fi

Relay module

Relay is a switch that may be controlled electronically or electromechanically. There is a port marked withthe letters (NO), which is often open. Relay switch receives a 5V DC power source, which causes the relay coil to get magnetised and trip off, signalling that the circuit is closed. By looking at the green light, which shows that it isON, this situation may be detected.

1.Operating voltage- 5V DC
2.Output parameters – 10A 25^{o}V AC
3.Input control signal current – 1.5 - 1.9 mA.

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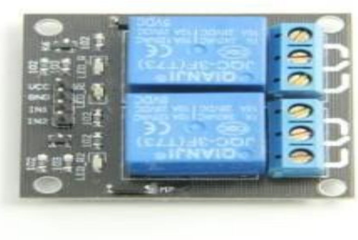

Fig. 6. Relay

VI. DESIGN

System Architecture:

The system architecture in Figure 5 depicts an IoT-based smart irrigation system leveraging artificial intelligence, incorporating components like a moisture sensor, LCD display, Arduino Uno microcontroller, motor, power supply unit, AI model, Wi-Fi module, buzzer, relay, and a mobile app interface. The moisture sensor measures soil moisture levels, which are displayed on the LCD screen and transmitted to the Arduino Uno. The Arduino, equipped with a Wi-Fi module, communicates the data to the AI model for analysis. The AI model processes the data and generates commands to control the motor and relay for irrigation purposes based on optimal moisture levels. Additionally, the system includes a buzzer for alerts and a mobile app interface for real-time monitoring and control of the irrigation process.

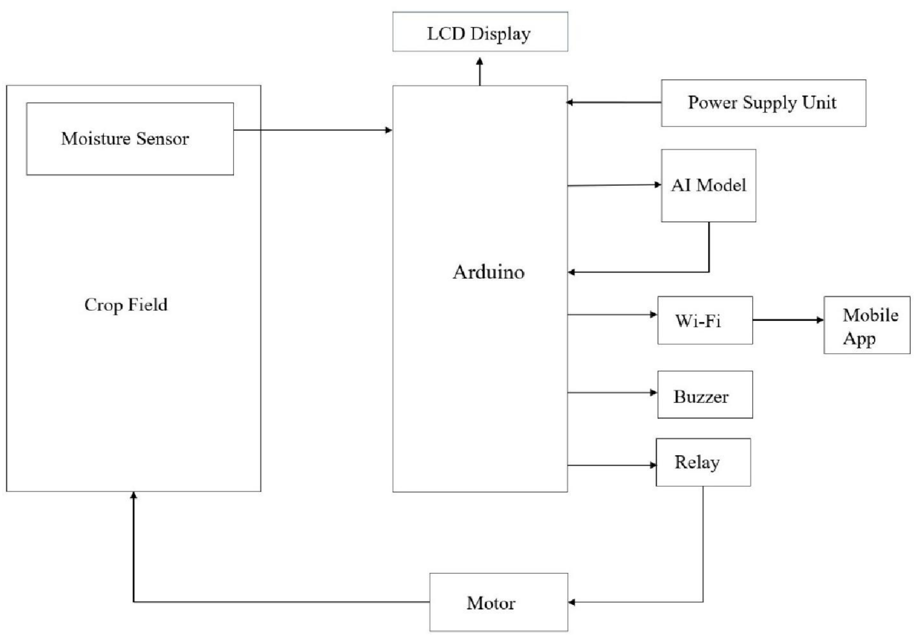

Fig. 7. Block Diagram

VII. IMPLEMENTATION

In implementing the proposed system, We begin by setting up hardware and communication protocols. Integrated sensors monitor soil and environmental conditions continuously. AI-driven analysis enables optimized irrigation schedules, with real-time feedback and ongoing refinement for efficient plant care.

Step 1: Initialize system components and communication protocols.

Step 2: Continuously monitor and store real-time soil moisture and environmental data.

Step 3: Utilize AI algorithms to analyze collected data for optimal irrigation scheduling.

Step 4: Determine irrigation timing and duration based on analysis results.

Step 5: Interface with relays to activate water pumps according to schedule.
Step 6: Display irrigation status and provide feedback through LCD and buzzer notifications.
Step 7: Continuously evaluate and refine system performance based on feedback.

VIII. FLOWCHART

A flowchart for the IoT-based smart irrigation system using AI represents a visual diagram illustrating the sequential flow of actions and decisions within the system. It outlines the process of collecting soil moisture data, analyzing it using AI algorithms, and controlling irrigation accordingly, ensuring a clear understanding of the system's functionality and logic.

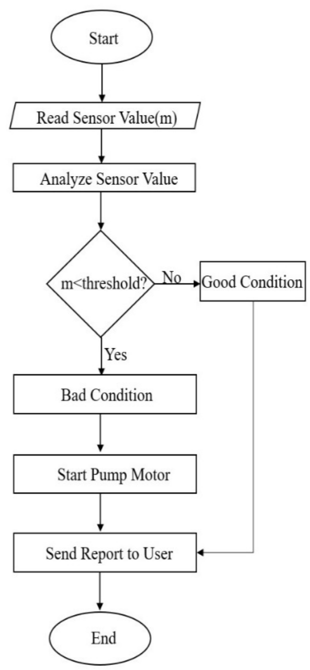

Fig. 8. FlowChart

IX. GRAPH

This graph illustrates the relationship between soil moisture levels and the state of the motor.The X-axis represents varying levels of soil moisture, indicating the wetness or dryness of the soil.The Y-axis depicts the corresponding state of the motor, indicating whether it's activated or deactivated based on the soil moisture readings.

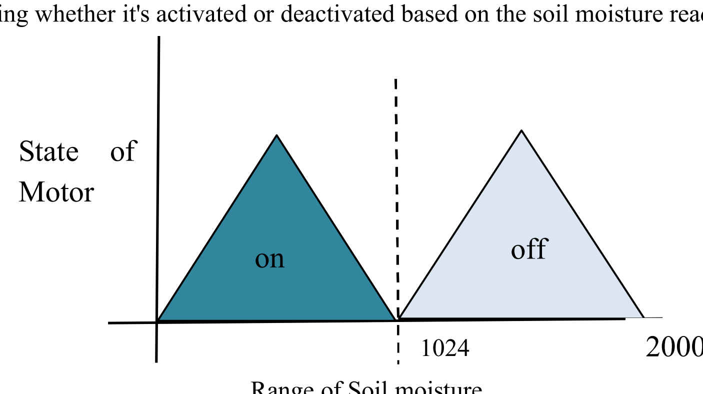

Fig. 9. Soil Moisture graph

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X. RESULT

The Figure 8 shows the mobile application through which the farmer monitors the irrigation process. Figure 9 and Figure 10 shows the output of the proposed system. It indicates the Soil moisture, pump status and Reading Time and show the history of pump status.

Fig. 10. Auto Irrigation App

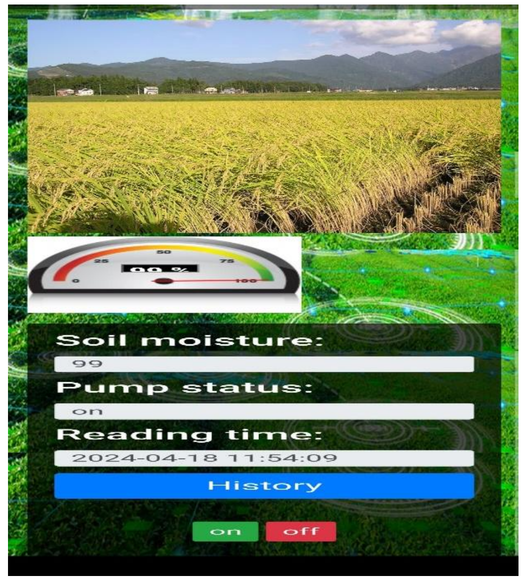

Fig. 11. Test case 1

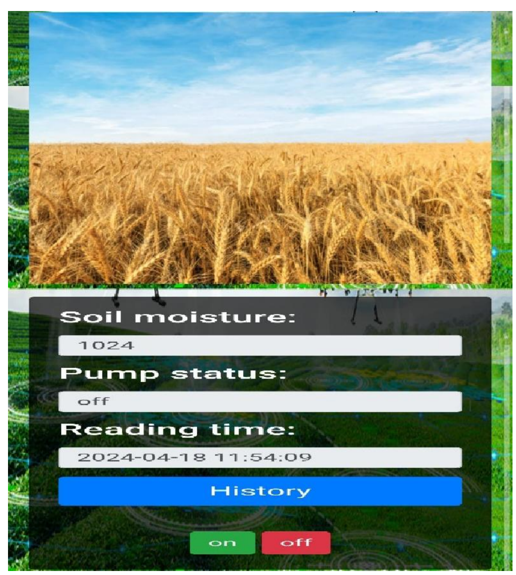

Fig. 12. Test Case 2

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X. CONCLUSION

In conclusion, the development and implementation of an AI-driven solution for precise water management in piped and micro-irrigation networks present a significant step forward in sustainable agriculture practices. By leveraging advanced technologies such as AI algorithms, soil moisture sensors, and microcontrollers, the system effectively optimized water usage while maintaining crop productivity. The integration of components like the LCD display, buzzer, relay,and water pump ensured seamless operation and user-friendly experience. Through continuousmonitoring and analysis of soil moisture levels, the system dynamically adjusted irrigation schedules to meet the specific needs of crops and soil conditions. This not only led to reduced water consumption but also minimized environmental impact by preventing water wastage, waterlogging, and soil erosion. Overall, the AI-driven solution offers a promising approach to address the challenges of water scarcity and agricultural sustainability, paving the way for more efficient and responsible water management practices in the future.

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