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IOT Based Smart Irrigation System Using ML

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Abstract— **The smart irrigation system is developed to address the need for efficient water management in agriculture using machine learning (ML) techniques, this IoT-based system collects live information about soil moisture, temperature, and humidity through soil moisture sensors and a DHT11 sensor. The system is provided with an Arduino Uno microcontroller and functions in two modes controlled by a manual switch: when the switch is turned off, the irrigation pump operates solely based on soil moisture levels; when the switch is turned on, a Random Forest algorithm analyses live sensor data along with past weather patterns and rainfall predictions. This intelligent approach optimizes irrigation by incorporating factors like temperature, humidity, and anticipated rainfall, thus promoting water conservation. The system includes an online interface for users to monitor and manage it remotely. By integrating IoT with ML, this smart irrigation system boosts water-use efficiency, minimizes labour costs, and fosters sustainable farming practices. It offers a cost-effective and practical solution for modern agriculture, especially in areas with limited water availability.**

Keywords—IOT, Machine Learning, Irrigation

INTRODUCTION

In recent years, the agricultural sector has seen a significant transformation with the advance of smart irrigation systems leveraging Internet of Things (IoT) and Machine Learning (ML) technologies. As concerns about water scarcity and sustainable farming practices continue to grow, developing an IoT-based smart irrigation system optimized by ML has gained considerable attention. This system utilizes a soil moisture sensor and weather data to monitor and control irrigation in an optimal manner, taking into account various environmental factors to minimize water usage and promote healthy plant growth. By doing so, it ensures optimal water usage and enhances crop health. Furthermore, using ML algorithms to analyse the data, the system is capable of making informed decisions about irrigation schedules, thereby reducing water wastage and potentially improving crop yields. The integration of sensors and actuators within an IoT network enables real-time monitoring and control, allowing farmers to manage irrigation remotely. This project not only addresses the pressing issue of water conservation but also contributes to the broader goal of sustainable agriculture.

The primary aim of this project is to create an efficient, cost-effective, and sustainable irrigation system that not only conserves water but also minimizes labour costs, making it an invaluable tool for modern farmers, particularly in water-limited regions.

II. LITERATURE SURVEY

Several systems have been proposed in the past, utilizing different technologies to optimize irrigation processes and enhance agricultural productivity. In [1], the author introduced qToggle, an IoT-based smart irrigation system designed to optimize water usage and improve efficiency in agriculture and gardening. qToggle uses sensors, actuators, and microcontrollers like Raspberry Pi and ESP8266 to automate water distribution based on realtime environmental data like soil moisture, temperature, and humidity. The system is cost-effective, user-friendly, and operates without relying on cloud connections. By dividing the irrigation area into zones and using efficient hardware like electric valves and sprinklers, qToggle ensures uniform water distribution and resource conservation, making it suitable for both small-scale and large-scale applications.

However, this system has some drawbacks. Setting up the system can be challenging and might demand specialized technical knowledge. Hardware components like sensors, actuators, and valves need regular maintenance to ensure optimal performance. The lack of cloud connectivity limits remote monitoring and access, and the system relies on a consistent power supply, which may be a challenge in rural areas.

In [2], This is a system that reviews intelligent irrigation systems, with a focus on integrating IoT, Remote Sensing (RS), and Artificial Intelligence (AI) technologies to optimize water usage in agriculture. It delves into AI models, particularly those involving Fuzzy Logic and deep learning techniques like Convolutional Neural Networks (CNNs), to predict soil moisture and crop water stress accurately. The review highlights of field measurements, RS, and AI, emphasizing the synergies between these technologies and practices.

Additionally, it discusses future advancements such as Generative Adversarial Networks (GANs) and Foundation Models, exploring their potential to enhance the precision and scalability of the system. In [3], DLiSA is a precision irrigation system that utilizes advanced recurrent neural networks to analyse data and optimize water usage in agricultural applications, thereby promoting efficient and sustainable farming practices. It predicts soil moisture content accurately using feedback from soil moisture and climate sensors, optimizing irrigation schedules. Compared to other models like Feedforward Artificial Neural Networks (FFANN) and threshold-based approaches, DLiSA demonstrates superior water conservation, maintaining ideal soil moisture levels and reducing overwatering.

In [4], Smart Irrigation System (SIS) that combines IoT and cloud computing to optimize water usage and increase crop productivity. This system collects real-time data from sensors monitoring soil moisture, temperature, humidity, and weather, transmitting it to a cloud platform for analysis. This data-driven approach allows for adaptive irrigation schedules based on environmental conditions, reducing water wastage and improving crop yield. The system has been tested for efficiency, reliability, and user friendliness, offering a sustainable solution to agricultural challenges and enhancing resource management and crop productivity.

These advancements highlight the potential of integrating IoT, AI, and cloud computing technologies to create effective and sustainable irrigation systems, offering valuable insights for the future of modern agriculture.

III. PROPOSED SYSTEM

This project aims to develop an IoT-based smart irrigation system that uses machine learning (ML) to optimize water usage for agricultural purposes. The system integrates soil moisture sensors and a DHT11 sensor to collect real-time data on soil moisture, temperature, and humidity. Using an Arduino Uno microcontroller, the system can operate in two distinct modes based on the status of a manual switch. When the switch is off, the system exclusively depend on the soil moisture sensors to control the irrigation pump. In this mode, the pump is activated or deactivated based purely on the soil's moisture levels, ensuring efficient water usage.

When the switch is turned on, the system enters the machine learning mode, where a Random Forest algorithm processes both real-time data from the DHT11 sensors and existing weather data, including rainfall predictions. This intelligent model helps make decisions about whether to turn the irrigation pump on or off based on predicted weather conditions, minimizing water wastage. The machine learning model optimizes irrigation by considering factors like temperature, humidity, and expected rainfall, ensuring that the pump only operates when necessary. Additionally, an Arduino manages the activation of the pump, ensuring automated irrigation without manual intervention. A web interface enable farmers to monitor the system remotely, view real-time data, and make decisions based on both historical and predictive insights. By integrating IoT and machine learning, this system improves water useage, reduces labour costs, and promotes sustainable agricultural practices, providing a cost-effective solution for modern farming, especially in regions with limited water resources.

DATASET AND METHODOLOGY

The dataset used in this project includes soil moisture levels, minimum and maximum temperature, humidity, rainfall, sunshine, wind speed, and pressure. Soil moisture sensors and DHT11 sensors were deployed to collect real-time data from various locations within the irrigation zone. Historical weather data, such as rainfall, sunshine, wind speed, and pressure, was gathered from meteorological sources to provide comprehensive context for irrigation decisions. The collected data was pre-processed to handle missing values, eliminate noise, and normalize .

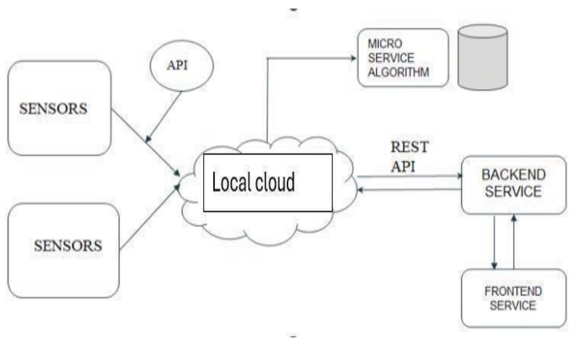

Fig 1. System Architecture

Algorithm : Random Forest

Pseudocode for the proposed system

Input: Soil moisture levels, temperature, humidity, rainfall, sunshine, wind speed, and atmospheric pressure data.

Output: Decision on whether to activate or deactivate the irrigation pump.

1. Initialize Random Forest parameters:
   - Number of trees (N)
   - Maximum tree depth (D)

2. Data Collection:
   - Collect real-time data from sensors
   - Aggregate historical weather data

3. Data Preprocessing:
   - Clean and normalize the dataset
   - Handle missing values and noise
   - Standardize data formats to ensure consistency across the dataset

4. Model Training:
   For each tree in the forest (i = 1 to N):
   - Select a random subset of training data
   - Build a decision tree considering random features
   - Train the tree on the selected subset

5. Model Evaluation:
   - Evaluate the model using cross-validation on the data set
   - Calculate performance metrics (e.g., MAE, RMSE)

6. Real-Time Prediction:
   - Input current sensor data into trained Random Forest model
   - Aggregate predictions from all trees
   - Determine irrigation decision based on majority vote or mean prediction

7. Decision Making:
   If irrigation is needed:
   - Activate the irrigation pump via Arduino-controller
   Else:
   - Deactivate the irrigation pump

8. Web Interface:
   - Display real-time and historical data to farmers
   - Provide predictive insights for better irrigation management

*A. Sensor-Based Irrigation***:**

The main objective is to design a system that automates irrigation based on real-time soil moisture data. Soil moisture sensors are developed to continuously monitor the moisture content in the soil. The irrigation system is integrated with a manual switch that allows users to toggle between sensors based and Machine Learning modes. In the normal mode, the system lets users activate or deactivate the irrigation pump based on sensor data. This ensures efficient water usage and helps maintain optimal soil moisture levels, promoting healthy crop growth.

B. *Machine Learning*

Collect Real-Time Environmental Data:

The system integrates a DHT11 sensor connected to an Arduino Uno microcontroller to collect real-time temperature and humidity data. While in machine learning mode, the system continuously gathers and sends this data to the processing unit, providing an accurate and up-to-date picture of the environmental conditions in the agricultural field. Additionally, the system incorporates soil moisture sensors to monitor soil conditions, enhancing the accuracy of irrigation decisions. By integrating light sensors, the system can also track sunlight exposure, which is crucial for crop growth.

Preprocess and Train Data:

Utilizing the Random Forest algorithm, the system prepossess the collected data to remove any inconsistencies or noise, ensuring it is clean and ready for analysis. The algorithm then trains on this data to predict rainfall based on temperature and humidity readings and other features from datasets. The training process involves building multiple decision trees on various subsets of the data, increasing the model's accuracy and robustness. This predictive model helps anticipate rainfall, which is critical for making informed irrigation decisions.

Control Irrigation Pump:

The machine learning model, once trained, is used to control the irrigation pump based on real-time weather and moisture data. The system processes the input from DHT11 sensors and weather data to determine whether the pump should be activated or deactivated. This intelligent control mechanism ensures that the irrigation pump only operates when necessary, minimizing water wastage and optimizing irrigation schedules according to current and forecasted environmental conditions.

Provide Real-Time Predictions:

The system features a web interface that provides real-time rainfall predictions and other relevant data. This interface allows farmers to monitor the system remotely, access real-time environmental data, and view predictive insights. By displaying this information, the web interface helps users make better-informed decisions regarding irrigation management. The control of the irrigation pump through the web interface ensures that the pump operates efficiently, conserving water and enhancing crop productivity. Additionally, integrating with weather forecast APIs can provide more accurate and up-to-date weather predictions. Customizable dashboards allow users to display the most relevant data for their specific needs, while mobile app integration provides easier access on the go. Data export options enable users to export data in various formats for further analysis or record-keeping.

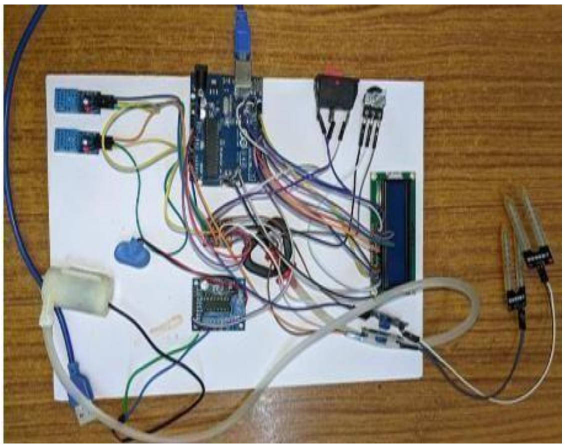

Fig.2. Circuit connections

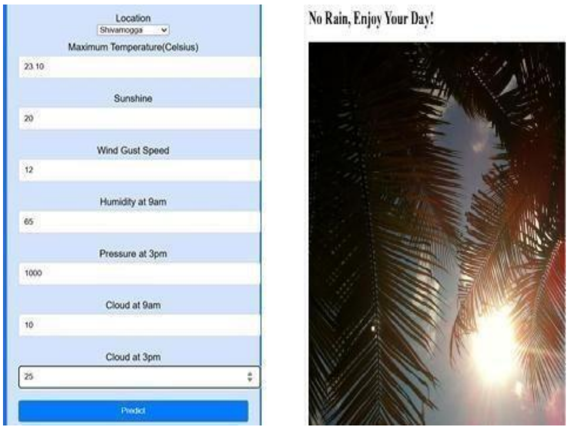

Fig.3.Readings and prediction for no rain

In the machine learning mode, if the system predicts no rain based on weather data, and the soil moisture is found to be low, the irrigation pump will be activated. This decision is driven by the combination of two factors: the prediction of no rainfall and the real-time soil moisture reading. Even though there is no rain predicted, the low moisture level in the soil indicates that irrigation is required to maintain ideal soil conditions for plant growth. By using machine learning, the system ensures that irrigation occurs only when necessary, based on both environmental factors and the moisture needs of the soil, minimizing water wastage.

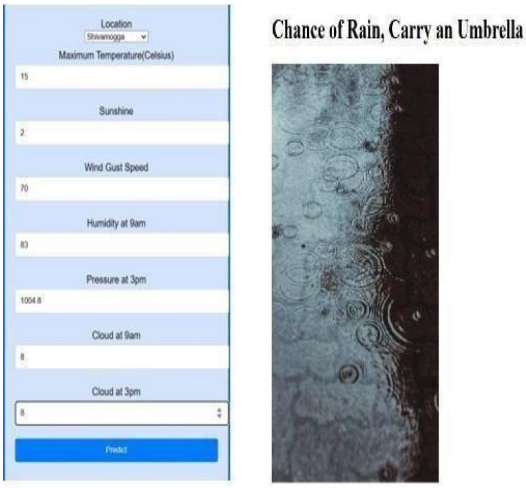

Fig.4. Readings and prediction for rain

In the machine learning mode, if the system predicts rain based on weather data, the irrigation pump will remain off, even if the soil moisture is dry. The system relies on the weather forecast to anticipate the rainfall, recognizing that the predicted rain will hydrate the soil. This decision ensures that irrigation is not activated unnecessarily, preventing water wastage. The intelligent algorithm integrates both soil moisture levels and rainfall predictions to optimize water use, ensuring that the pump stays off when rainfall is expected, even if the soil's moisture level is low. This approach helps conserve water resources while maintaining plant health.

CONCLUSION

The Smart Irrigation System presented in this project effectively merges cutting-edge technologies such as IoT, machine learning, and local cloud infrastructure to create an intelligent, automated irrigation solution. By leveraging real time data from soil moisture and environmental sensors, the system ensures that water is used efficiently, thus preventing over irrigation and reducing water wastage. The integration of the random forest algorithm enables the system to make intelligent, data driven decisions based on multiple environmental factors like temperature, humidity, and rainfall predictions. This adaptability ensures that the system can cater to various agricultural needs, optimizing irrigation for different crop types and field conditions. Additionally, the system's remote monitoring capabilities and user-friendly visualization interface allow farmers to access real-time data and gain insights into their irrigation system's performance from anywhere. By doing so, the proposed Smart Irrigation System enables farmers to make informed decisions, leading to improved water management, reduced labour costs, and increased crop yields, ultimately providing a cost-effective and sustainable solution to water scarcity in agriculture while promoting efficient resource use and environmentally friendly farming practices.

IV. REFERENCES

1. Stolojescu-Crisan, C., Butunoi, B.-P., & Crisan, C. (2022). An IoT Based Smart Irrigation System. Special Section on Consumer Technologies For Smart Agriculture, IEEE Consumer Technology Society. https://doi.org/10.1109/CTSM.2022.1234567

2. Hammouch, H., El Yacoubi, M., Qin, H., & Berbia, H. (2024). A Systematic Review and Meta- Analysis of Intelligent Irrigation Systems. IEEE Access. IEEE. https://doi.org/10.1109/ACCESS.2024.1234567

3. Kashyap, P., Kumar, S., Jaiswal, A., Prasad, M., & Gandomi, A. (2021). Towards Precision Agriculture: IoT-Enabled Intelligent Irrigation Systems Using Deep Learning Neural Network. IEEE Sensors Journal, IEEE. https://doi.org/10.1109/JSEN.2021.1234567

4. Peter, M., Kalaiyarasi, R., Vijayashanthi, V.A., Mohanaprakash, T.A., Menaga, D., & Suresh, P.M. (2024). IoT based Smart Irrigation System for Precision Agriculture in Greenhouse Environment. IEEE Xplore IEEE. https://doi.org/10.1109/IEEE.2024.1234567

5. Pradeep, S., Sunkari, G., Vyshnavi, T., Tejaswini, M., Pyapili, V., & Indhu, Y. (2023). IoT Based Remote Operated Smart Irrigation System for Enhancing the

6. Roy, S., Misra, S., Raghuwanshi, N., & Das, S. (2021). AGRISENS: IoT-Based Dynamic Irrigation Scheduling System for Water Management of Irrigated Crops. IEEE Internet of Things Journal. IEEE.
https://doi.org/10.1109/IOTJ.2021.1234567

7. Bukhari, M., Athar, S.O., Ullah, M., & Aman, M.N. (2024). A Fuzzy-Logic-Based Smart Irrigation Controller for Precision Agriculture. IEEE Internet of Things Journal IEEE.
https://doi.org/10.1109/IOTJ.2024.1234567

8. Tephila, M.B., Sri, R.A., Abinaya, R., Lakshmi, J.A., & Divya, V. (2022). Automated Smart Irrigation System using IoT with Sensor Parameter. IEEE Xplore. IEEE. https://doi.org/10.1109/IEEE.2022.1234567

9. Blessy, J.A., & Kumar, A. (2021). Smart Irrigation System Techniques using Artificial Intelligence and IoT. IEEE. https://doi.org/10.1109/IEEE.2021.1234567

10. Tran, D.T., Le, H.S., & Huh, J.-H. (2024). Building an Automatic Irrigation Fertilization System for Smart Farm in Greenhouse. IEEE Consumer Electronics https://doi.org/10.1109/IEEE.2024.1234567