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IOT AND MACHINE LEARNING APPROACH FOR SMART IRRIGATION MONITORING SYSTEM

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Abstract: Water scarcity is a serious challenge for agriculture, which heavily relies on insufficient monsoon rains. To address this issue, an Internet of Things (IoT) and Machine Learning (ML) based smart irrigation system is proposed. This system predicts irrigation requirements using environmental parameters and weather forecasting, optimized by an ensemble ML method. The system reduces water, labour, and plant nutrient usage with a low-cost prototype achieving above 90% accuracy. A flexible IoT platform is designed to enable developers to easily integrate IoT and ML components for customized analytical methods in precision irrigation. This platform benefits both IoT specialists and farmers by reducing water waste, lowering costs, and ensuring safer crop yields. An intelligent irrigation system is implemented using an IoT-enabled ML-trained system for optimal water consumption. IoT sensors capture real-time ground and environmental data, which is analyzed by ML to provide irrigation minimizing human intervention.

Index Terms - IOT, Smart Irrigation, Machine learning, Ensembling, Agriculture.

I. Introduction

Agriculture stands as the cornerstone of human civilization, providing sustenance, economic prosperity, and cultural identity across the globe. However, the efficacy of agricultural practices is intricately tied to the availability and management of water resources, making irrigation a pivotal component in agricultural systems worldwide. With the growing challenges posed by climate change, population growth, and dwindling water supplies, the need for innovative solutions in agriculture irrigation has become increasingly imperative. In response to these challenges, the convergence of Internet of Things (IoT) and Machine Learning (ML) technologies offers a transformative paradigm shift towards smart irrigation monitoring systems. IoT facilitates the seamless integration of sensors, controllers and communication networks, enabling real-time data collection and monitoring of various agricultural parameters. Concurrently, ML algorithms empower these systems to analyze vast datasets, discern patterns, and make informed decisions autonomously. This explores the synergistic fusion of IoT and ML in the domain of smart irrigation monitoring systems. By harnessing the power of connected devices and advanced analytics, these systems optimize water usage, enhance crop yields, and mitigate environmental impacts. Through a comprehensive review of existing literature, case studies, and technological advancements, this paper aims to elucidate the principles, applications, and future prospects of IoT and ML-driven approaches in revolutionizing agriculture irrigation management.

II. LITERATURE SURVEY

IOT ENABLED WSN AND MACHINE LEARNING TECHNIQUES TO SURVEILLANCE THE SMART IRRIGATION SYSTEM [1]

The paper proposes a secure and smart irrigation system using IoT-enabled WSN and machine learning techniques. It aims to classify data as anomalous or non-anomalous to prevent false information affecting the irrigation system. The two-phase classification involves machine learning models and a Fault Detection Algorithm (FDA). Experimental results demonstrate the effectiveness of the proposed scheme in classifying datasets with varying anomaly ratios.

IOT-BASED SMART IRRIGATION MANAGEMENT SYSTEM: DESIGN AND IMPLEMENTATION FOR EFFICIENT WATER USE IN AGRICULTURE [2]

This paper explores an IoT-based smart irrigation management system for efficient water use in agriculture. Implemented with sensors, controllers, and GSM technology, it enables automated and optimized irrigation. The system monitor soil moisture, temperature, and humidity, providing farmers real-time control via smartphones.

IOT-DRIVEN MODEL FOR WEATHER AND SOIL CONDITIONS BASED ON PRECISION IRRIGATION USING MACHINE LEARNING [3]

This article proposes an advanced irrigation system using IoT, wireless sensor networks, and machine learning for sustainable agriculture. The system monitors soil and weather conditions, predicts crop water requirements, and schedules precision irrigation. The use of machine learning, specifically the Linear Discriminant Analysis algorithm, resulted in an efficient irrigation prediction accuracy. The proposed system aims to enhance water utilization efficiency, reduce environmental impact, and contribute to sustainable agriculture practices.

IOT-DRIVEN MODEL FOR WEATHER AND SOIL CONDITIONS BASED ON PRECISION IRRIGATION USING MACHINE LEARNING [4]

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SMART IRRIGATION SYSTEM BASED ON IOT AND MACHINE LEARNING [5]

The paper introduces a smart irrigation system based on IoT and machine learning to address water scarcity in agriculture. Utilizing sensors for data collection, the authors employed machine learning algorithms, including K-Nearest Neighbors, achieving a recognition rate of 98.3%. The proposed system enhances water management and decision-making in agriculture, demonstrating the potential of Agriculture 4.0 technologies.

Using sensors for soil moisture, temperature, and rain which are directly connected to main controller. The system includes a web application for visualization and supervision.

INTELLIGENT IRRIGATION SYSTEM BASED ON ML AND IOT [6]

The proposed Intelligent Irrigation System combines Machine Learning (ML) and Internet of Things (IoT) to optimize water usage in agriculture. Using sensors and ML algorithms like Support Vector Regression (SVR) and K-Means Clustering, the system predicts soil moisture, and a web-based interface controls irrigation based on the predictions. This integrated approach aims to enhance crop yield, conserve water, and improve overall productivity in agriculture.

III. PROPOSED SYSTEM

The proposed smart irrigation system addresses these shortcomings by adopting a significantly more data-driven approach. It utilizes an array of sensors, including multiple DHT11 sensors, soil moisture sensors, and a rain sensor, to gather comprehensive real-time data on temperature, humidity, soil moisture, and localized rainfall. Additionally, the system integrates weather forecasting, ensuring that irrigation decisions are informed by both current conditions and upcoming weather patterns. A key innovation lies in the implementation of machine learning techniques on a Raspberry Pi. Ensemble learning methods are used to analyze the collected environmental data and accurately predict irrigation needs. This IoT-powered, machine learning-driven approach minimizes human intervention and reduces water waste while promoting optimal crop health. The flexible IoT platform also allows for easy
customization and future expansion, making it adaptable to diverse agricultural settings.

IV. METHODOLOGY

Block diagram

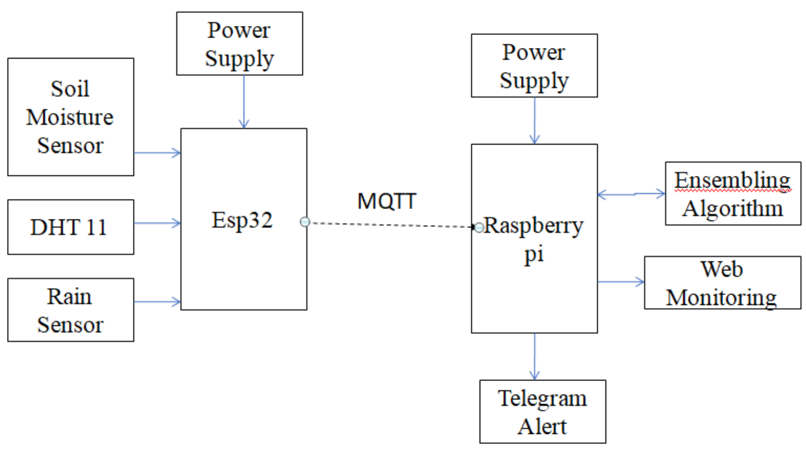

Fig 1. Block diagram

HARDWARE COMPONENTS

NODEMCU ESP8266:

The ESP8266 is a highly popular and versatile Wi-Fi module that has become a staple in the world of electronics and IoT (Internet of Things). Developed by Espressif Systems, the ESP8266 is renowned for its compact size, low cost, and powerful capabilities. It features a built-in TCP/IP stack, making it capable of connecting to Wi-Fi networks and facilitating seamless communication with the internet. Equipped with a powerful 32-bit microcontroller, the ESP8266 allows for standalone programming, eliminating the need for an additional microcontroller in many projects. Its widespread adoption in the maker community is attributed to its compatibility with popular development platforms like Arduino, making it accessible to hobbyists and professionals alike.

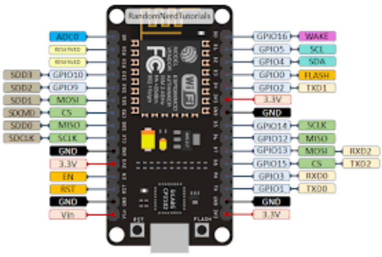

Fig. NodeMCU ESP8266

SOIL SENSOR:

Soil sensors, also known as soil moisture sensors or hygrometers, play a crucial role in agriculture, environmental research, and land management. By measuring soil moisture levels in real-time, these sensors help optimize irrigation practices, prevent overwatering or underwatering, and promote water efficiency and crop yield maximization. In addit tudy of ecosystems, plant-soil interactions, and the water cycle in ecology.

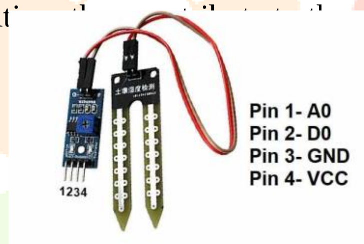

Fig. Soil Moisture Sensor

DHT11 SENSOR:

The DHT11 sensor, developed by Aosong, is notable for its affordability, ease of use, and compatibility with microcontrollers. It provides a calibrated digital signal output, eliminating the need for analog-to-digital conversion. Combining a capacitive humidity sensor and a thermistor, it delivers accurate readings for temperature (0°C to 50°C) and relative humidity (20% to 90%). Its precision suits applications such as weather stations, HVAC systems, and climate monitoring.

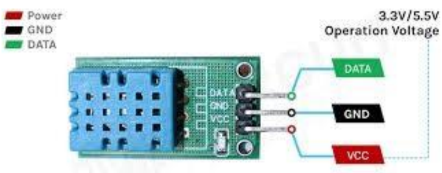

Fig. DHT11

RAIN DROP SENSOR:

The raindrop sensor, widely used in weather monitoring, home automation, and automotive applications, detects rain or water droplets. It relies on a conductive surface that alters its resistance upon contact with water. When raindrops hit the sensor, it measures resistance changes, generating electrical signals for rainfall detection. These signals trigger automa[illegible] windows, activating windshield wipers, or sounding alarms.

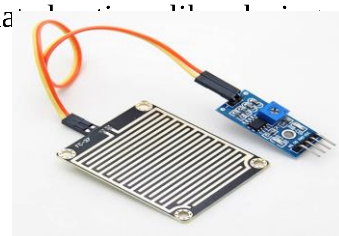

Fig. Rain Drop Sensor

RASPBERRY PI:

The Raspberry Pi, developed by the Raspberry Pi Foundation, is a compact and affordable single-board computer series launched in 2012. It integrates CPU, GPU, RAM, and other components onto a single die, offering impressive performance at a reasonable price. Widely used for learning programming and electronics, it features ARM quad-core processors, USB ports, Ethernet, HDMI output, Wi-Fi, Bluetooth, and GPIO pins. Its versatility extends to DIY projects, home automation, education, and commercial applications, with pre-installed Raspberry Pi OS facilitating coding and IoT solutions.

Fig. Raspberry pi

ENSEMBLING MODEL:

Ensembling, a potent technique in machine learning, merges predictions from multiple models to boost performance by compensating for individual weaknesses and leveraging strengths. Through methods like bagging, boosting, and stacking, it harnesses diverse models such as Random Forest, Gradient Boosting, and Support Vector Regression, creating a robust predictive framework. This approach, spanning classification, regression, and anomaly detection tasks, yields state-of-the-art results by amalgamating complementary insights. By combining techniques like RIDGE and Lasso for regularization, ensembling ensures stability and superior performance across various datasets, solidifying its status as a cornerstone in machine learning.

V. RESULTS

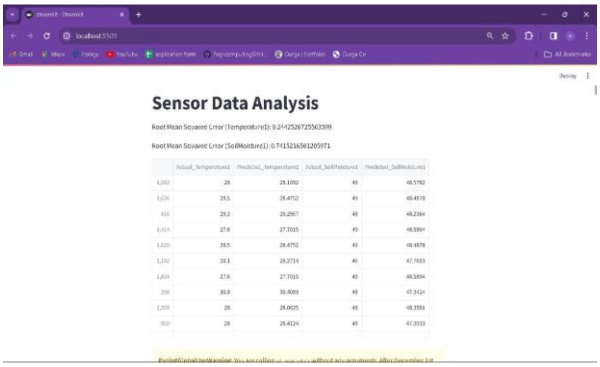

Fig. Sensor Data Analysis

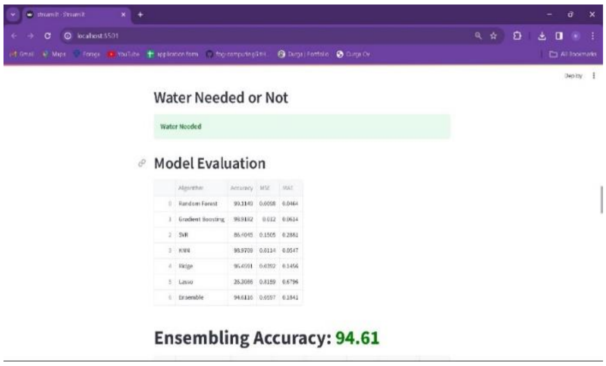

Fig. Model Evaluation

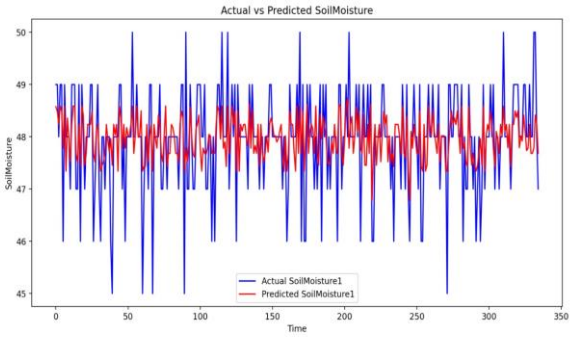

Fig. Actual Temperature and Predicted Temperature

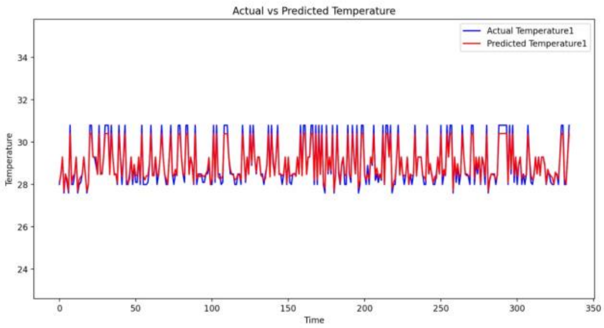

Fig. Actual Soil Moisture and Predicted Soil Moisture

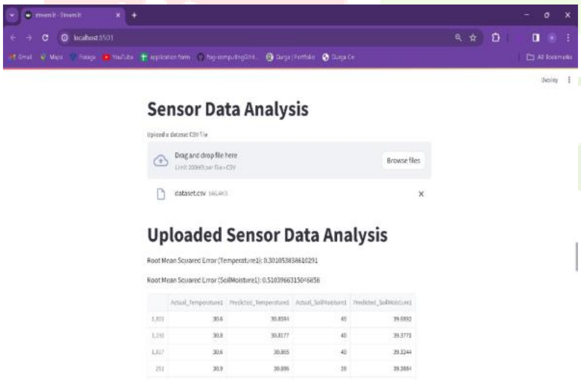

Fig. Uploaded Dataset Sensor Data Analysis

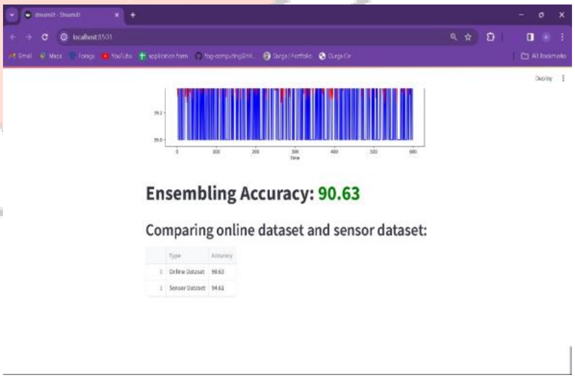

Fig. Comparing online dataset and sensor dataset

VI. CONCLUSION:

Smart irrigation projects demonstrate significant potential to address the challenges of water scarcity and inefficient irrigation practices in agriculture. By combining sensor-driven data collection, weather forecasting integration, and ensemble machine learning, the system paves the way towards precision irrigation and optimized resource management. This novel approach promises to reduce water wastage, improve crop yields, and lower operational costs for farmers. The flexible IoT infrastructure and machine learning emphasis create exciting opportunities for further refinement, customization, and integration with broader smart farming technologies.

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