IoT based Weather Forecasting and Crop Management System

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Abstract- The goal of this project is to create an economical, IoT-enabled weather forecasting and crop management system based on the ESP32 microcontroller. The DHT11/DHT22 temperature and humidity sensors, a soil moisture sensor, and a rain sensor are among the several sensors that are included into the system. For real-time monitoring, information is sent over Wi-Fi to the cloud and shown on an LCD screen. The automated decision-making based on real-time data made possible by the suggested approach guarantees increased agricultural efficiency. This IoT-based strategy provides a scalable and affordable solution for precision farming, smart city projects, and environmental monitoring.

Keywords- IoT, ESP32, Weather Forecasting, Crop Management, Automation, Smart Irrigation, Wireless Sensor Network, Environmental Monitoring, Cloud Integration, Precision Farming.

I. INTRODUCTION

As climate change intensifies and the demand for real-time environmental insights grows, accurate weather monitoring has become vital for sectors like farming, city planning, and ecological preservation. Traditional weather stations, however, remain expensive and out of reach for many smaller users. An Internet of Things (IoT)-based approach offers a cost-effective alternative by enabling cloud-based data gathering and live environmental tracking. In this project, the ESP32 microcontroller—a low-cost, Wi-Fi-enabled device—is used alongside sensors that monitor rainfall, soil moisture, and temperature. The system presents real-time readings on an LCD screen and uploads data to cloud servers for remote access. This setup aids in better crop planning, efficient water management, and building resilience against climate challenges, paving the way for smarter and greener communities.

II. RELATED WORK

Over the past few years, the use of IoT in agriculture and environmental monitoring has seen significant advancements. In 2020, Koppala Guravaiah and his team introduced a smart irrigation model that uses rainfall prediction to dynamically adjust watering schedules, aiming to reduce water consumption and enhance the ability of crops to cope with climate changes [1]. In a related study from 2019, Mrinmoy Sadhukhan et al. presented a weather forecasting system based on wireless sensor networks, focusing on delivering highly accurate environmental data through real-time monitoring [2]. Similarly, Md. Najmul Mowla and collaborators, in 2018, developed an automated irrigation system driven by soil moisture sensors, which minimized manual labor while promoting more efficient water use [3]. These contributions clearly illustrate the role of IoT technologies in modernizing agricultural practices. In 2021, Khan et al. proposed a low-cost weather monitoring setup using the ESP8266 microcontroller to collect data on temperature, humidity, and atmospheric pressure and upload it to a cloud server, though the system had certain limitations due to the hardware used [4]. Moving forward, the current project employs the ESP32 microcontroller, providing better processing capabilities, integrated communication modules, and greater reliability. In support of this choice, Gopi et al., in 2022, demonstrated the superior performance of the ESP32 in their air quality monitoring system, highlighting its dual-core processing and efficient cloud integration [5]. Drawing from these advancements, this project aims to deliver a more powerful and responsive IoT-based solution for real-time agricultural monitoring.

III. PROBLEM STATEMENT

Environmental factors including rainfall humidity and temperature play a vital function in figuring out agricultural productivity yet conventional farming strategies often fall quick in offering actual-time monitoring and forecasting abilities main to inefficient aid usage water wastage and heightened vulnerability to climate exchange farmers require a reliable and cost-powerful strategy to make informed records-driven choices that could raise yield and promote sustainable practices via integrating iot generation with esp32 microcontrollers and various sensors it turns into feasible to gather real-time environmental information and supply accurate weather forecasts drastically improving each agricultural control and disaster preparedness however demanding situations consisting of enhancing information precision making sure scalability and retaining affordability must still be addressed to facilitate substantial adoption throughout numerous farming environments.

IV. EXISTING SYSTEM

The general public of contemporary weather tracking structures are huge highly-priced and run thru authorities or educational organizations for correct climate forecasts these structures make use of satellite tv for pc television for pc facts and a number sophisticated sensors small-scale applications like farms colleges and person users who require localized real-time meteorological facts however frequently find them inaccessible this hole has been crammed in modern years via the improvement of iot-based climate stations which use less expensive microcontrollers and sensors to report essential meteorological facts like temperature humidity and precipitation these kinds of systems often hire esp8266 or esp32 microcontrollers which permit data switch to cloud structures for a long way flung get entry to even while current iot-based absolutely systems have proven promise in real-time tracking and records accessibility they will now not be character-exceptional moderately priced or simply integrate sensors present day-day systems are on occasion not optimized for nearby accessibility or individual-friendly presentations and they're frequently restricted to precise sensors or functionalities by means of manner of supplying an cheaper esp32-primarily based absolutely weather station with numerous included sensors an liquid crystal display display for real-time viewing and cloud connectivity for a ways off tracking this venture seeks to outperform cutting-edge variations.

Drawbacks of the existing system: The suggested iot-based weather station might encounter several hurdles including sustaining measurement accuracy fine-tuning sensor calibration coping with restricted operational capabilities depending on stable internet access dealing with elevated energy consumption expanding system scalability promoting ease of use and enduring harsh environmental factors.

V. PROPOSED SYSTEM

The proposed system is an IoT-based automated crop management and weather monitoring solution designed to support sustainable agriculture. It utilizes the ESP32 microcontroller and a collection of environmental sensors to gather real-time data on temperature, humidity, soil moisture, and rainfall. This data is used to make intelligent irrigation decisions through a machine learning model. The core objective is to reduce water waste and improve crop health by automating the irrigation process based on environmental conditions. A Support Vector Machine (SVM) classifier is trained using historical sensor data to recognize patterns associated with dry or moist soil conditions. Depending on the prediction output, the system sends a control command to activate or deactivate a water pump via a relay module. The rain sensor plays a crucial role in ensuring that irrigation does not occur during precipitation, even if the soil moisture level is low. This multi-sensor approach ensures reliable and context-aware decision-making, enhancing farming efficiency.

Objective of the proposed system: Integrating IoT into agriculture introduces a brand new method of tracking climate dynamics at once from the field. The recommended device will track key environmental parameters and deliver customized updates to farmers. in preference to counting on general forecasts, they can make knowledgeable alternatives regarding sowing, watering, and harvesting schedules. This real-time facts method complements performance, minimizes crop loss, and promotes better stewardship of herbal assets.

Block diagram of the proposed system:

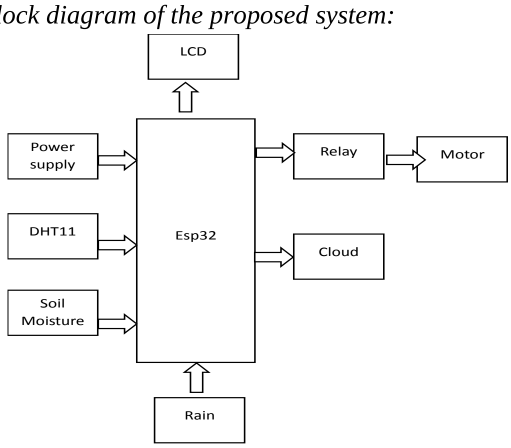

Fig 1: Block diagram of the proposed system

VI. SYSTEM MODEL

The proposed system, an automated crop management and weather monitoring system enabled by the Internet of Things, makes use of the ESP32 microcontroller. It uses a Support Vector Machine (SVM) model to make judgments based on real-time sensor data.

Hardware Components:

- ESP32 Microcontroller: Central regulator that reads detector inputs processes data and controls irrigation via relay activation it provides wi- fi and bluetooth connectivity for pall communication.
- DHT11/DHT22 Sensor: Detector measures ambient temperature and humidity.
- Soil Moisture Sensor: Detects the humidity level of the soil.
- Rain Sensor: Detects downfall to help gratuitous irrigation.
- Relay Module: Acts as an interface between the esp32 and the motor pump controlling irrigation operations grounded on system commands.
- Motor Pump: Activates or deactivates grounded on soil conditions.
- LCD Display (optional): Displays live detector readings locally.

Software/AI Components:

- SVM Classifier: Trained using environmental data ([temperature, moisture, soil moisture]) to classify conditions as:
  - 1 → Dry or irrigation needed → Motor ON
  - 0 → Moist soil or rainfall detected → Motor OFF
- Cloud Integration: Data is brought from a remote server using HTTP (PHP API).
- Serial Communication: A Python script running on a original machine fetches data from the pall makes irrigation prognostications using the svm model and transmits the performing control signal to the esp32 via a usb periodical connection.

Working Logic:

STEP1: Sensor data collection the ESP32 microcontroller is connected to detectors that continuously cover environmental conditions dht11 for temperature and moisture soil humidity detector for detecting the humidity position in the soil rain detector for relating downfall events.
STEP2: Uploading Data to garon: the ESP32 reads detector values at regular intervals and uploads them to a pall- grounded web garon using wi- fi the data is stored in a remote database and made accessible through a PHP-based API.

STEP3: Data retrieval using python a python script running on a original machine periodically sends requests to the garon to cost the most recent detector values the script parses the json response and excerpts temperature moisture and soil humidity values.

STEP4: Vaticination using svm model the recaptured data is fed into apre-trained svm model the model analyses the input data and classifies the current environmental state into:

- 1 → Soil is dry or conditions require irrigation.
- 0 → Soil has sufficient moisture or it is raining; irrigation is not needed.

STEP5: Transferring control command to ESP32 grounded on the models vaticination the python script sends a command 1 or 0 to the ESP32 through a periodical connection usb the command is decoded and transmitted via periodical communication using pyserial.

STEP6: Irrigation control prosecution the ESP32 receives the command and triggers a relay module consequently still the relay turns on the motor pump to start irrigation:

- If command = 1, the relay turns ON the motor pump to start irrigation.
- If command = 0, the relay turns OFF the motor pump, halting irrigation.

STEP7: Continuous Monitoring: This cycle reprises at fixed intervals eg every 10 seconds allowing the system to stoutly respond to changes in soil and rainfall conditions in real- time.
Overall, the system automates crop irrigation by continuously covering temperature moisture soil humidity and downfall using ESP32- connected detectors detector data is uploaded to a pall garon and recaptured by a python script which uses an SVM model to prognosticate irrigation requirements grounded on the vaticination a control command is transferred to the ESP32 via periodical

communication driving a relay to operate the motor pump consequently this cycle runs automatically at regular intervals icing real- time data- driven irrigation opinions and effective resource operation.

Flow chart of the proposed system

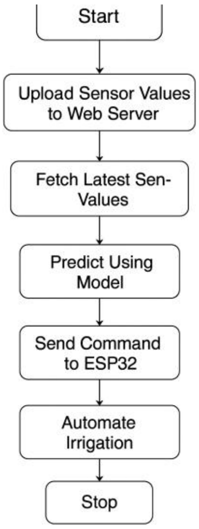

Fig 2: Flow chart of the proposed system

VII. SIMULATION RESULTS

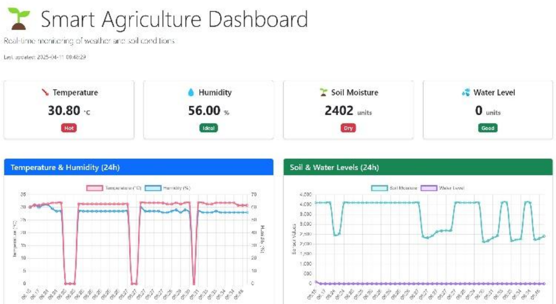

Fig 3: Web dashboard

Recent Readings

Time	Temperature (°C)	Humidity (%)	Soil Moisture	Water Level
2025-04-11 08:48:29	30.80	56.00	2402	0
2025-04-11 08:48:22	30.80	56.00	2287	0
2025-04-11 08:48:14	30.80	56.00	2230	0
2025-04-11 08:34:16	31.80	56.00	4095	0
2025-04-11 08:34:08	31.80	56.00	4095	0
2025-04-11 08:34:01	31.80	56.00	2275	0
2025-04-11 08:33:55	31.80	56.00	2227	0
2025-04-11 08:33:48	31.80	57.00	2179	0
2025-04-11 08:33:35	31.30	56.00	4095	0
2025-04-11 08:33:28	31.30	56.00	4095	0

Fig 4: Recent Readings

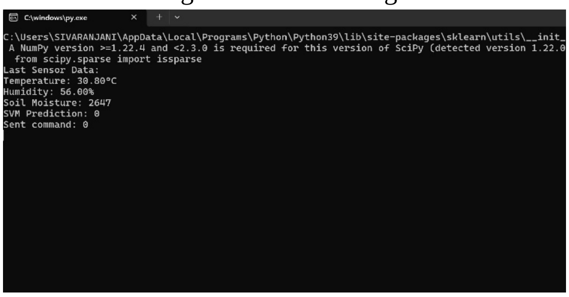

Fig 5: Soil is moist – send OFF signal

Fig 5: Soil is dry – send ON signal

VIII. CONCLUSION

The developed IoT-based weather forecasting and crop management system successfully demonstrates the integration of real-time environmental monitoring with intelligent automation. By using sensors to collect temperature, humidity, soil moisture, and rainfall data, the system ensures accurate and timely decision-making for irrigation. The implementation of a machine learning-based automation logic enhances efficiency by reducing manual effort and optimizing water usage. With minimal cost and reliable performance, this solution is well-suited for small to medium-scale farmers aiming to adopt precision agriculture practices. Overall, the project contributes to sustainable farming by promoting smart irrigation, conserving resources, and improving crop health through data-driven automation.

IX. ACKNOWLEDGEMENT

The authors are grateful to Sri Ramakrishna Institute of Technology, Coimbatore for facilitating and supporting this research work.

REFERENCES

[1] Duy Thanh Tran; Hoanh Su Le; Jun-Ho Huh, " Building an Automatic Irrigation Fertilization System for Smart Farm in Greenhouse" in 2024 International Conference on Communication information and Computing Technology (ICIIS), 2024.

[2] Chiara Pero; Sambit Bakshi; Michele Nappi; Genoveffa Tortora “IoT-Driven Machine Learning for Precision Viticulture Optimization” 2024 IEEE Journal of Selected Topic in Applied Earth Observations and Remote Sensing, Dec 2023.

[3] Md. Najmul Mowla; Neazmul Mowla; A. F. M. Shahen Shah; Khaled M. Rabie; Thokozani

Shongwe, "Internet of Things and Wireless Sensor Networks for Smart Agriculture Applications: A Survey" in IEEE Access, 2023.

[4] Yaeseul Sung, Seungmin Lee, Yeonkyung Kim, Hanbai Park "Development of a Smart Air Quality Monitoring System and its Operation Using ESP32" in Feb. 2022.

[5] J.E. Tamil Malar; M. Vaishnavi, "IoT based Smart Irrigation System using ESP32 " 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, Sept 2022.

[6] Perumal. B, Nagaraj. P; B. Gayathri Durga, T. Harish Muthu Kumaran, Innamuri Venkata Devika, M. Jeya Akshaya "Internet of Things based Weather and Water Quality Monitoring System" in 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC), Sep 2022.

[7] Mrinmoy Sadhukhan; Sudakshina Dasgupta; Indrajit Bhattacharya, "An Intelligent Weather Prediction System Based on IOT" September 2021.

[8] Patel, V., & Desai, N." Sensor based Automated Irrigation System with IOT: A Technical Review" in International Journal of Advanced Agricultural Research, 9(1), 47-55, 2021.

[9] Koppala Guravaiah, S Srinivasulu Raju, " e-Agriculture: Irrigation System based on Weather Forecasting" 2021 International Conference on Communication information and Computing Technology (ICIIS), RUPNAGAR, 2021.

[10] Juyoung Park Aekyung Moon Eunryung Lee Seunghan Kim, "Understanding IoT climate Data based Predictive Model for Outdoor Smart Farm" on 2021 International Conference on Information and Communication Technology Convergence (ICTC), Dec 2021.

[11] M. Khan et al., "IoT-enabled weather monitoring system using ESP8266 microcontroller for real-time data collection and remote access," Int. J. Innov. Res. Technol., vol. 7, no. 5, pp. 123–130, 2021.

[12] A. Gopi and R. Kumar, "Development of an air quality monitoring system using ESP32 microcontroller," J. Environ. Monit., vol. 15, no. 2, pp. 85–92, 2022.

[13] L. Zhang and P. Li, "Comparative analysis of DHT11 and DHT22 sensors for environmental monitoring applications," Sensors J., vol. 20, no. 8, pp. 1105–1113, 2020.

[14] R. Singh, S. Gupta, and K. Sharma, "IoT-based soil moisture monitoring system for efficient water management in agriculture," Agric. Sci. Technol., vol. 12, no. 4, pp. 212–218, 2020.

[15] J. Lee and S. Choi, "Smart home environmental monitoring with LCD display integration for real-time visualization," J. Smart Home Technol., vol. 13, no. 3, pp. 205–213, 2019.

[16] T. Sharma and A. Verma, "Cloud-based environmental monitoring systems: A review of platforms, advantages, and data security challenges," Int. J. IoT Appl., vol. 6, no. 3, pp. 145–153, 2021.

[17] Espressif Systems, "ESP32 Technical Reference Manual," 2019. [Online]. Available: https://www.espressif.com/en/products/socs/esp32

[18] Aosong Electronics, "DHT11/DHT22 Sensor Specifications," 2020. [Online]. Available: https://www.aosong.com/en/products/details/asp

[19] MathWorks, "ThingSpeak Documentation," 2021. [Online]. Available: https://thingspeak.com