SmartPlant: IoT-Based Intelligent Plant Monitoring and Care System

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Abstract—**Smart agriculture has emerged as an important solution for improving water management and crop health monitoring through modern technologies. This project presents an IoT-based Smart Plant Monitoring and Automatic IrrigationSystem integrated with Machine Learning, Flask Web Dashboard, Mobile Application, and Data Visualization using R. The system continuously monitors environmental parameters such as soil moisture, temperature, and humidity using sensors connected to an Arduino Uno. The collected sensor data is transmitted to a Flask-based backend server, where real-time monitoring is provided through a live dashboard and a mobile application developed using MIT App Inventor. Based on soil moisture levels, the system automatically controls a water pump using a relay module to ensure efficient irrigation and water conservation. In addition, a Machine Learning model predicts plant conditions and irrigation requirements for improved decision-making. The project also incorporates R programming for graphical visualization and analysis of sensor data trends. The developed system provides an efficient, low-cost, and user-friendly solution for smart farming applications, contributing towards sustainable agriculture and intelligent resource management.**

Index Terms—**Internet of Things (IoT), Smart Irrigation, Machine Learning, Arduino Uno, Flask, MIT App Inventor, Soil Moisture Monitoring, Automatic Water Pump Control, R Programming, Smart Agriculture, Real-Time Monitoring**

I. INTRODUCTION

Agriculture plays a significant role in ensuring food security and economic development, but traditional irrigation methods often lead to excessive water usage and inefficient crop management. With the advancement of Internet of Things (IoT) and Machine Learning (ML) technologies, smart agricultural systems have become an effective solution for automating irrigation and monitoring environmental conditions in real time. This project introduces an IoT-based Smart Plant Monitoring and Automatic Irrigation System that uses sensors to measure soilmoisture, temperature, and humidity continuously. The sensor data is processed using an Arduino Uno and transmitted to a Flask-based web server for real-time visualization through a web dashboard and mobile application. The system automatically controls a water pump through a relay module whenever the soil moisture level falls below a predefined threshold, ensuring efficient water management and reduced human intervention. Additionally, a Machine Learning prediction model is integrated to analyze plant conditions and support intelligent irrigation decisions, while R programming is used for data analysis and visualization. The proposed system provides a cost-effective, user-friendly, and sustainable approach toward modern smart farming and precision agriculture.

II. OBJECTIVES

The main objective of this project is to develop an intelligent and efficient smart agriculture system capable of monitoring plant conditions and automating irrigation processes using modern technologies. The proposed system aims to reduce water wastage, minimize manual effort, and improve plant health through continuous environmental monitoring and real-time data analysis. By integrating IoT, Machine Learning, Flask web technology, mobile application development, and R visualization, the system provides a complete smart farming solution for sustainable agriculture.

Objectives

1. To develop an IoT-based Smart Plant Monitoring System for real-time monitoring of plant environmental conditions.
2. To measure soil moisture, temperature, and humidity using sensors connected to an Arduino Uno.
3. To automate the irrigation process by controlling the water pump based on soil moisture levels.
4. To create a Flask-based web dashboard for live monitoring of sensor data.
5. To develop a mobile application using MIT App Inventor for remote access to plant monitoring information.
6. To integrate a Machine Learning model for predicting plant conditions and irrigation requirements.
7. To perform data visualizationand analysis using R programming for understanding sensor data trends.
8. To provide a cost-effective, user-friendly, and sustainable smart agriculture solution

III. LITERATURE SURVEY

Agriculture is one of the most important sectors contributing to food production and economic growth. Traditional irrigation systems often result in excessive water consumption and require continuous human supervision, leading to inefficient resource management. To overcome these limitations, researchers have focused on developing IoT-based smart irrigation and plant monitoring systems that automate irrigation processes and provide real-time environmental monitoring. Various studies have demonstrated that integrating sensors with microcontrollers such as Arduino Uno helps in monitoring parameters like soil moisture, temperature, and humidity, thereby improving irrigation efficiency and crop productivity.

Several existing systems utilize Wireless Sensor Networks (WSN) and IoT technologies for transmitting sensor data to cloud platforms or web applications for remote monitoring. Researchers have also developed smart irrigation systems using Flask, mobile applications, and web dashboards to enable users to access live environmental data conveniently. In addition, recent advancements in Machine Learning have enhanced the ability to predict plant health conditions, irrigation needs, and environmental changes based on collected sensor data. Studies involving data visualization tools such as R programming have further improved the analysis and interpretation of agricultural data trends.

Although many existing systems provide automated monitoring and irrigation functionalities, some solutions are costly, complex, or dependent on cloud infrastructure. The proposed project addresses these limitations by developing a low-cost, user-friendly, and efficient Smart Plant Monitoring and Automatic Irrigation System that integrates IoT, Machine Learning, Flask-based web applications, mobile applications, and R-based visualization for real-time monitoring, prediction, and intelligent irrigation management.

Dr. J. Narendra Babu [6][7][8][9]explored IoT applications in smart systems and emphasized combining embedded hardware with cloud connectivity for scalable IoT solutions, providing theoretical grounding for design decisions in this project.

IV. PROPOSED METHODOLOGY

The proposed system is designed to develop an intelligent IoT-based Smart Plant Monitoring and AutomaticIrrigation System capable of monitoring environmental conditions and automating irrigation processes in real time. The methodology involves the integration of hardware components, software technologies, Machine Learning techniques, and mobile applications to achieve efficient plant monitoring and water management.

Initially, sensors such as the soil moisture sensorand DHT11 temperature and humidity sensor are connected to the Arduino Uno microcontroller to continuously collect environmental data from the soil and surrounding atmosphere. The Arduino processes the sensor readings and transmits the data serially to the Python-based backend system. A relay module connected to a water pump is used to automate irrigation. Whenever the soil moisture value crosses a predefined threshold, the relay automatically activates the water pump to supply water to the plant, thereby reducing manual intervention and water wastage.

The collected sensor data is processed using a Flask-based backend server, which provides real-time monitoring through a live web dashboard. The dashboard displays parameters such as soil moisture, temperature, humidity, pump status, and prediction results dynamically. A mobile application developed using MIT App Inventor is integrated with the Flask server to allow users to monitor sensor values remotely through smartphones.

In addition, a Machine Learning model is incorporated to analyze environmental conditions and predict plant status or irrigation requirements based on sensor inputs. The sensor data is further analyzed and visualized using R programming, which helps in understanding environmental trends and system performance through graphical representations. The proposed methodology provides an efficient, low-cost, user-friendly, and sustainable smart agriculture solution for modern farming applications.

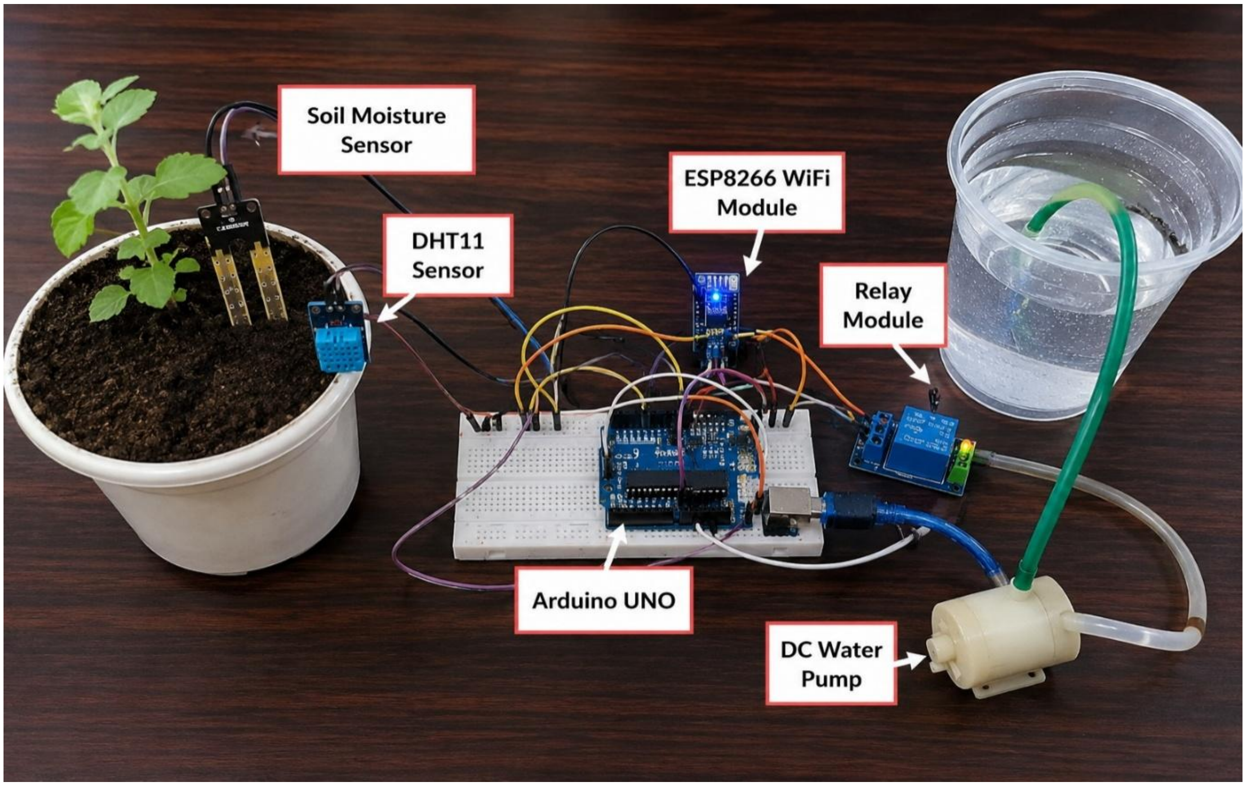
V. SYSTEM ARCHITECTURE

The proposed Smart Plant Monitoring and Automatic Irrigation System is designed using an integrated architecture consisting of sensing devices, a microcontroller unit, a backend server, Machine Learning components, visualization tools, and a mobile application. The architecture enables real-time monitoring, intelligent decision-making, and automatic irrigation control for efficient plant management.

In the proposed system, the soil moisture sensor and DHT11 temperature and humidity sensor continuously collect environmental data related to plant conditions. These sensors are connected to the Arduino Uno, which acts as the central microcontroller responsible for processing sensor readings and transmitting the collected data to the backend system through serial communication. Based on the soil moisture level, the Arduino controls a relay module connected to a water pump for automatic irrigation.

The transmitted sensor data is received and processed by a Python Flask backend server, which stores and displays the live data on a web dashboard. The dashboard provides real-time information such as soil moisture, temperature, humidity, pump status, and Machine Learning prediction results. A Machine Learning model integrated into the backend analyzes sensor values and predicts plant conditions or irrigation requirements for intelligent decision-making.

The system also includes a mobile application developed using MIT App Inventor, which communicates with the Flask server through Wi-Fi to display live monitoring data on smartphones. Additionally, the collected sensor data is analyzed and visualized using R programming, enabling graphical representation of environmental trends and system performance. The overall system architecture provides an efficient, scalable, and user-friendly smart agriculture solution that supports sustainable water management and precision farming.

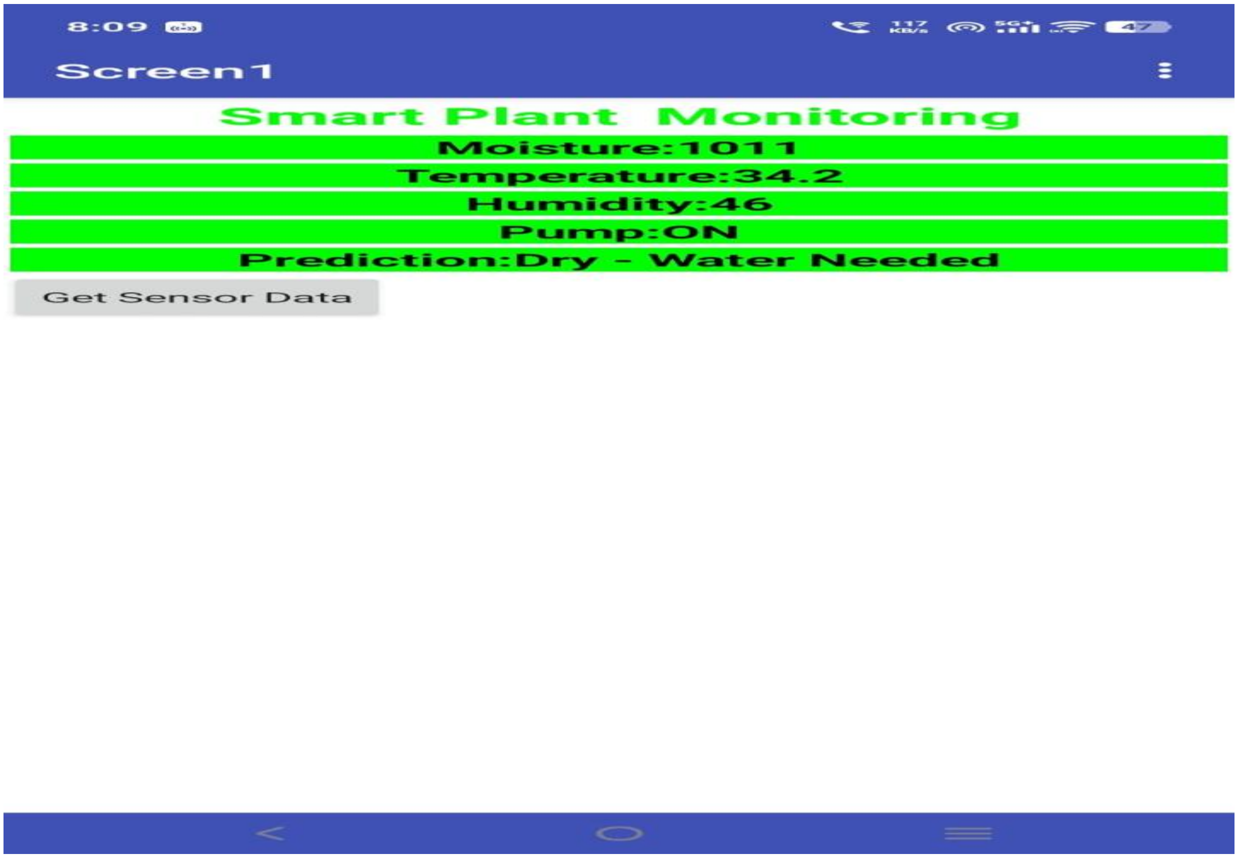


VI. RESULTS

The proposed IoT-based Smart Plant Monitoring and Automatic Irrigation System was successfully designed and implemented to monitor environmental conditions and automate irrigation processes in real time. The system effectively collected sensor data such as soil moisture, temperature, and humidity using the soil moisture sensor and DHT11 sensor connected to the Arduino Uno microcontroller. The collected data was transmitted successfully to the Flask-based backend server, where live monitoring was achieved through a dynamic web dashboard.

The developed web dashboard displayed real-time sensor values, pump status, and Machine Learning prediction results accurately. The automatic irrigation mechanism functioned efficiently by activating the relay-controlled water pump whenever the soil moisture level crossed the predefined threshold value, thereby reducing manual effort and minimizing water wastage. The mobile application developed using MIT App Inventor successfully communicated with the Flask server and provided real-time monitoring of environmental parameters through smartphones.

The integrated Machine Learning model was able to analyze sensor data and generate prediction outputs related to plant conditions and irrigation requirements. Additionally, the use of R programming enabled effective graphical visualization and analysis of sensor data trends, helping users understand environmental variations over time. The overall system demonstrated reliable performance, low-cost implementation, user-friendly operation, and effective water management, making it suitable for smart agriculture and sustainable farming applications.



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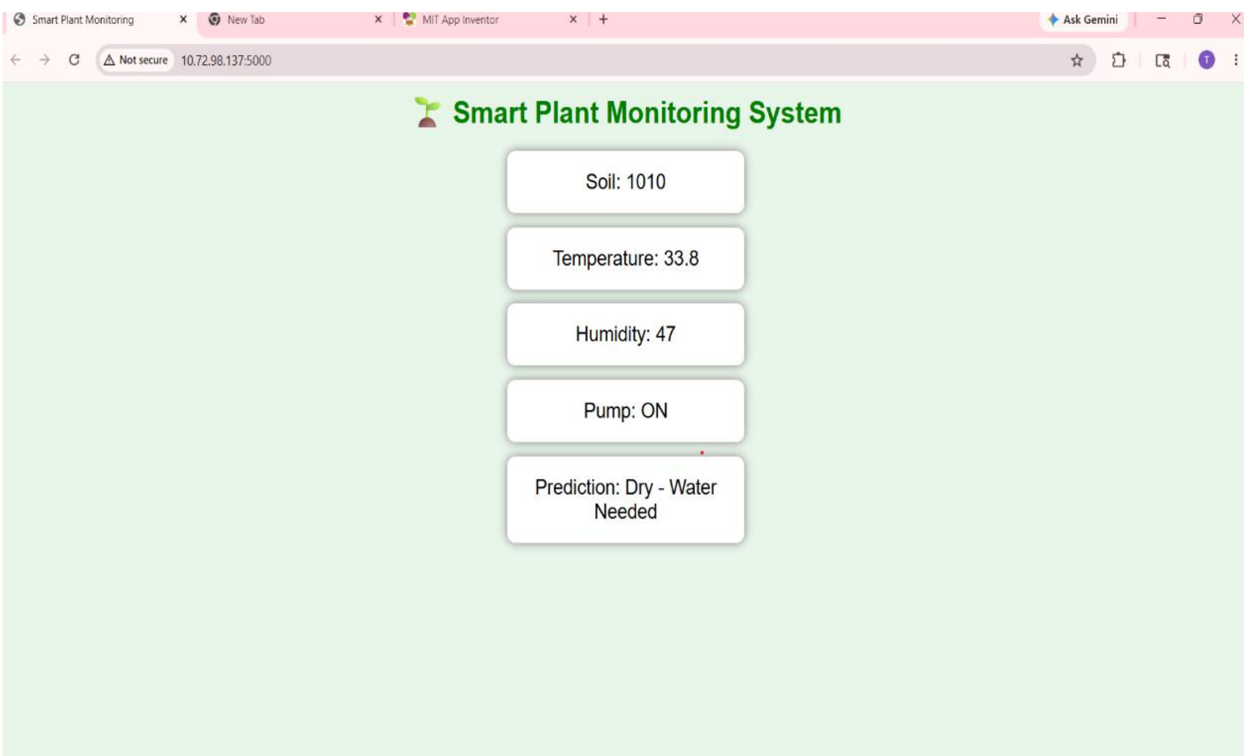

VII. CONCLUSION

The proposed IoT-based Smart Plant Monitoring and Automatic IrrigationSystem successfully demonstrates the application of modern technologies in smart agriculture for efficient plant monitoring and water management. The system effectively monitored environmental parameters such as soil moisture, temperature, and humidity using sensors connected to the Arduino Uno microcontroller. By integrating a relay-controlled automatic irrigationmechanism, the system was able to automate water supply based on soil moisture conditions, thereby reducing manual effort and minimizing water wastage.

The integration of a Flask-based web dashboard and a mobile applicationdeveloped using MIT App Inventor enabled real-time monitoring of sensor data and system status from remote locations. Furthermore, the incorporation of a Machine Learning model enhanced the intelligence of the system by providing prediction results related to plant conditions and irrigation requirements. The use of R programming for data visualization and analysis helped in understanding environmental trends and system performance effectively.

Overall, the developed system provides a low-cost, efficient, user-friendly, and sustainable smart farming solution suitable for modern agricultural applications. The project contributes towards precision agriculture, efficient resource utilization, and the advancement of intelligent irrigation systems for future smart farming technologies.

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