SMART IRRIGATION OPTIMIZATION: INTEGRATING WEATHER PREDICTION AND IOT FOR PADDY CROPS

Epics Project Report submitted in partial fulfillment of the Requirements for the Award of the Degree of

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In

COMPUTER SCIENCE AND ENGINEERING

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2023

VELAGAPUDI RAMAKRISHNA SIDDHARTHA

ENGINEERING COLLEGE

(Autonomous, Accredited with 'A+' grade by NAAC)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the project report entitled **"SMART IRRIGATION OPTIMIZATION: INTEGRATING WEATHER PREDICTION AND IOT FOR PADDY CROPS**"submitted by **Para Hemanth Suresh(218W1A0542), Pogiri Saikiran(218W1A0546)** in partial fulfillment for the award of the Degree of Bachelor of Technology in Computer Science and Engineering to the Jawaharlal Nehru Technological University, Kakinada, is a record of Bonafide work carried out under my guidance and supervision.

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DECLARATION

We at this moment declare that the EPICS Project entitled **“SMART IRRIGATION OPTIMIZATION: INTEGRATING WEATHER PREDICTION AND IOT FOR PADDY CROPS”** submitted for the B.Tech Degree is our original work, and the dissertation has not formed the basis for the award of any degree, associate ship, fellowship or any other similar titles.

Place: Vijayawada

Date: 22-11-2023

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ABSTRACT

Efficient water management in agricultural practices is crucial for sustainable farming and resource conservation. This project aims to optimize water consumption for paddy crops by leveraging weather predictions, specifically rainfall forecasts, and real-time soil moisture data obtained from IoT devices. The process begins with the farmer imputing the regular watering duration, which is transmitted to a central server. Subsequently, the server collects data from IoT devices deployed in the fields, acquiring current soil moisture levels. Concurrently, it retrieves rainfall forecast data from online weather sources by employing machine learning algorithms. The server analyses this combined information to determine the most appropriate watering duration based on anticipated rainfall and soil moisture conditions. The results are then presented to the farmer through an interface. Upon confirmation, the IoT devices autonomously initiate the irrigation process, ensuring efficient water usage tailored to the crop's needs and environmental factors. This comprehensive system integrates predictive analytics with real-time data to optimize irrigation practices and promote sustainable farming methods for paddy cultivation.

KEYWORDS: Smart irrigation, IoT, Weather Forecasting, Machine Learning, Water Management, Farmer Interface, Soil Moisture

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CHAPTER 1
INTRODUCTION

1.1 Basic Concepts

Internet of Things (IoT)

The Internet of Things (IoT) is a foundational concept involving the interconnection of physical devices to the Internet, enabling them to collect and exchange data. In the context of this project, IoT is actualized through devices like NodeMCU ESP8266 and soil moisture sensors. These devices serve as data collection points in the agricultural field, facilitating the acquisition of real-time information crucial for informed decision-making in irrigation practices.

Machine Learning Algorithms

Machine learning algorithms, particularly the implementation of linear regression, play a pivotal role in the project. These algorithms analyze historical data related to soil moisture and weather conditions. By identifying patterns and relationships within this data, the algorithms predict optimized watering times. This data-driven approach enhances the precision of irrigation scheduling, ensuring that water resources are used efficiently.

Weather Forecasting Integration

The integration of weather forecasting adds a predictive dimension to the system. By anticipating upcoming weather conditions, specifically rainfall, the project adapts irrigation schedules accordingly. This proactive adjustment based on expected weather conditions enhances the system's responsiveness to environmental factors, contributing to more effective water management in agriculture.

Soil Moisture Sensing

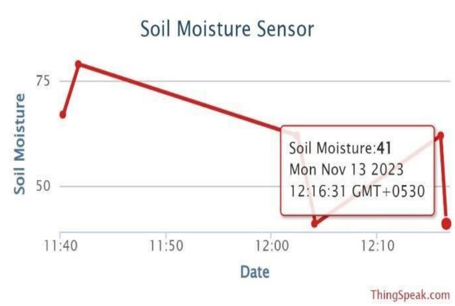
Soil moisture sensing involves the measurement of water content in the soil. In this project, resistive soil moisture sensors are strategically deployed in the agricultural field. These sensors provide real-time data on soil conditions, enabling the system to tailor irrigation practices to the specific moisture needs of the crops. This localized and precise approach contributes to resource-efficient irrigation.

Web Scraping

Web scraping is a data extraction technique employed to gather weather data from weather.com. This data encompasses crucial parameters such as precipitation levels and temperature fluctuations. By incorporating real-time weather forecasts through web scraping, the system enhances its decision-making accuracy. The dynamically updated weather information contributes to more responsive and adaptive irrigation practices.

ThingSpeak

ThingSpeak is a cloud-based platform that serves as a robust and versatile IoT analytics and application-enabling service. Developed by MathWorks, it provides a centralized hub for collecting, processing and visualizing data from Internet of Things (IoT) devices. With ThingSpeak, users can easily analyze and interpret complex datasets, utilizing MATLAB analytics for advanced insights. The platform supports real-time data streaming, enabling seamless integration with IoT devices for monitoring and control applications. ThingSpeak's user-friendly interface allows users to build custom dashboards, facilitating the visualization of data trends. Additionally, it features integrated support for web services and enables automatic triggering of actions based on predefined conditions. This cloud-based solution enhances accessibility, collaboration, and scalability, making it an ideal choice for diverse applications, from smart agriculture, like in this project, to industrial IoT implementations.



Data Processing and Analysis

Data processing, facilitated by platforms like ThingSpeak and optionally MATLAB analytics, is a fundamental aspect of deriving actionable insights from the collected data. This includes the calculation of optimized watering times based on the integration of soil moisture and weather data. The systematic processing of information ensures that the system provides farmers with meaningful and practical irrigation recommendations.

Django

Django is a high-level, open-source web framework for building robust and scalable web applications using the Python programming language. Developed with a focus on simplicity, flexibility, and reusability, Django follows the ModelView-Controller (MVC) architectural pattern. It provides a wide range of built-in features, including an Object Relational Mapping (ORM) system for database interactions, a templating engine for dynamic content rendering, and a secure authentication system. Django promotes rapid development by automating common web development tasks, allowing developers to concentrate on application-specific logic. Its modular and extensible design supports the creation of reusable components and the integration of third-party packages. Django's emphasis on best practices, security, and a pragmatic approach to web development has made it a popular choice for creating diverse web applications, from content management systems to custom business solutions.

Linear Regression

Linear regression, a statistical modeling technique, is a key component of the machine-learning aspect of the project. It establishes a linear relationship between historical data variables related to soil moisture and weather conditions. By utilizing this regression model, the system calculates the average precipitation for the upcoming 24 hours. The insights derived from this predictive analysis contribute to the system's ability to generate optimized watering times with a high degree of accuracy.

1.2 Problem Statement

The problem at hand revolves around the inefficient use of water resources in paddy crop cultivation due to unpredictable weather patterns and outdated irrigation practices. Traditional irrigation methods often lead to overwatering or underwatering, resulting in suboptimal crop yields and resource wastage. The challenge lies in developing a smart irrigation system that integrates IoT devices and machine learning algorithms to analyze real-time soil moisture data and weather forecasts. This system must overcome obstacles such as limited adaptability, energy dependency, and the need for user expertise. The goal is to empower farmers with a user-friendly interface that facilitates precise irrigation scheduling based on dynamic environmental conditions. Addressing these challenges is crucial for promoting sustainable farming, conserving water resources, and enhancing the overall efficiency and productivity of paddy crop cultivation.

1.3 Client Details

Name: M.Appalanaidu

Age: 53

Occupation: Farmer

Village: Kanuru

Fig 1.3 Photograph with Client

1.4 Motivation

The motivation behind this project lies in addressing the pressing need for efficient water management in agriculture, driven by the challenges posed by unpredictable weather conditions and the imperative for sustainable farming practices. By leveraging the fusion of IoT devices, weather predictions, and machine learning algorithms, we aim to optimize irrigation practices for paddy crops. This innovative approach seeks to empower farmers with data-driven insights, enabling them to make informed decisions regarding watering schedules based on soil moisture and forecasted weather conditions. Ultimately, our goal is to minimize water wastage, maximize crop yields, and promote environmentally responsible farming techniques, contributing to a more sustainable agricultural ecosystem.

1.5 Objectives

1) **Efficient Water Management:** Develop an IoT-enabled smart irrigation system that optimizes water consumption for paddy crops by integrating real-time soil moisture data from IoT devices and forecasted weather information.

   This system aims to adapt irrigation schedules based on anticipated rainfall and soil moisture levels to ensure efficient water usage.

2) **Integration of Technology:** Implement IoT devices, such as NodeMCU ESP8266, soil moisture sensors, and relay modules, along with machine learning algorithms, to enable seamless communication between physical components and software. This integration facilitates automated and precise irrigation processes based on processed data and user inputs.

1.6 Scope

The project's scope involves optimizing water management practices exclusively for paddy cultivation. It includes leveraging weather predictions, real-time soil moisture data from IoT devices, and machine learning algorithms to enhance irrigation efficiency. This scope confines the investigation to address water consumption optimization solely within the context of paddy crops. The project will not delve into broader agricultural practices or consider factors beyond soil moisture data and rainfall forecasts, such as humidity or temperature, in determining irrigation strategies. This focused approach aims to develop a system specifically tailored to paddy cultivation, emphasizing the significance of soil moisture and rainfall data in driving efficient irrigation methods for this specific crop.

1.7 Advantages

- Implementation of efficient irrigation practices to promote water conservation.
- Dynamic adjustment of watering schedules based on real-time soil moisture and weather conditions.
- Project stands as a beacon of sustainability.
- Promotes responsible resource management for long-term health and resilience of agricultural ecosystems.
- Bridging the gap between conventional farming practices and cutting-edge technology.
- Empowering farmers with tools for efficient crop cultivation.
- Implementation of a user-friendly web interface.
- Ensures accessibility for farmers, providing intuitive tools.
- Utilization of IoT devices and machine learning for optimizing water usage.
- Enhances overall resource efficiency, reducing energy dependency.
- Fosters food security and economic stability for farmers.
- Precise irrigation schedules tailored to crop needs contribute to increased crop yields.

1.8 Applications

- The system finds direct application in smart agriculture by providing farmers with a data-driven approach to irrigation. The integration of real-time data and predictive analytics ensures optimal water usage and crop health.

- The project contributes significantly to water resource conservation by minimizing water wastage through precise irrigation scheduling. This aspect is particularly crucial in regions facing water scarcity.

- By tailoring irrigation schedules based on dynamic environmental conditions, the project aims to maximize crop yields. This application is vital for ensuring food security and economic stability for farmers.

- The adaptable nature of the system allows for its extension to a variety of crops beyond paddy. This adaptability broadens its applications, making it relevant to diverse agricultural practices.

- Minimizes water wastage by employing data-driven irrigation methods, contributing to the efficient use of water resources.

CHAPTER 2

LITERATURE SURVEY

This chapter contains the list of research papers that we have studied under the literature survey. We focused on the approaches for maintaining accuracy in these papers. Our study included the techniques used for developing and training the model.

2.1 IOT-based smart irrigation system

Ragab, M. A., Badreldeen, M. M. M., Sedhom, A., & Mamdouh, W. M. (2022). IOT-based smart irrigation system. International Journal of Industry and Sustainable Development, 3(1), 76-86.

Methodology: It presents an approach using a central component, the master control system, that serves as the core of the irrigation setup. It connects with both the drive unit and sensor microcontrollers, housing an extensive database of irrigation and fertilization schedules for various crops obtained from the Ministry of Agriculture. Programmed using Arduino C, the master microcontroller carries out two essential functions. Firstly, in the Plant Selection Process, users specify the crop for irrigation, allowing the microcontroller to choose the appropriate schedule. Subsequently, in the Irrigation and Fertilization Process, the system implements the selected schedule, integrating real-time sensor data from the sensors from the microcontroller to ensure precise and efficient irrigation and fertilization.
Limitations are dependencies on internet connectivity, data security, and cost.

Advantages:

- Automated Irrigation Management
- Efficient Resource Management
- 24/7 Monitoring and Control

Disadvantages:

- Dependency on Technology
- Risk of Sensor Malfunctions
- Limited Adaptability in Remote Areas.

2.2 EEWMP: an IoT-based energy-efficient water management platform for smart irrigation

Ullah, R., Abbas, A. W., Ullah, M., Khan, R. U., Khan, I. U., Aslam, N., & Aljameel, S. S. (2021).EEWMP: an IoT-based energy-efficient water management platform for smart irrigation. Scientific Programming, 2021,1-9.

Methodology: It discusses an approach that describes a SWAMP project dedicated to advancing agriculture through intelligent irrigation and efficient use of freshwater resources. It employs IoT-based smart irrigation systems, utilizing sensors deployed in the field to monitor soil conditions, weather, and crop status, The Energy-Efficient Water Management Platform (EEWMP) enhances the performance of the SWAMP system by introducing in-field sink nodes and fusion centers, resulting in reduced energy consumption and improved network stability. This approach offers promising solutions for precision agriculture and sustainable water management. Limitations include limited adaptability and energy dependency.

Disadvantages:

- Dependency on Sensor Accuracy
- Risk of Sensor Malfunctions
- Impact on Irrigation Decisions

2.3 Iot-based intelligent irrigation system for paddy crop using an internet-controlled water pump.

Sharma, B. B., & Kumar, N. (2021). Iot-based intelligent irrigation system for paddy crop using an internet-controlled water pump. International Journal of Agricultural and Environmental Information Systems (IJAEIS), 12(1), 21-36.

Methodology: It presents an Intelligent Irrigation System (IIS) for paddy fields. This system makes use of IoT technology and a set of sensors to continuously monitor soil conditions. The data collected by these sensors is transmitted wirelessly to a web server database, which facilitates precise water management. The system’s control interface is the web-based dashboard. Limitations are it requires user expertise and users need to be familiar with system operation and need to interpret the data provided by the sensors.

Advantages:

- Enhanced Root Development
- Prevention of Soil Erosion
- Mitigation of Soil Compaction

Disadvantages:

- Technical Expertise Requirement
- Return on Investment (ROI) Concerns
- Dependency on External Support

2.4 An IOT-based smart irrigation system using soil moisture and weather prediction.

Velmurugan, S. (2020). An IOT-based smart irrigation system using soil moisture and weather prediction.Sankha Sarkar ,Indrani Naskar,Sourav 9
Sahoo, Sayan Ghosh; International Journal of Innovative Science and Research Technology ISSN No:-2456-216, November – 2021.

Methodology: It discusses a system whose core consists of Firebase and NodeMCU, with Firebase receiving data from the field controller. NodeMCU processes this data and transmits it to the output, which is a smartphone. The smartphone serves a dual function, acting as both a data monitor and a controller for regulating water flow to the rice fields via an internet connection. The system utilizes a relay to activate the pump and automatically open the faucet for irrigation. Water is pumped from a reservoir to a solenoid valve, which directs it into the rice fields, facilitating remote and efficient irrigation control.

Advantages:

- Water Conservation
- Improved Soil Structure
- Optimal Plant Growth
- Reduced Water Wastage
- Disease Prevention

Disadvantages:

- High initial cost and complexity.

2.5 IoT-Based Automated Management Irrigation System Using Soil Moisture Data and Weather Forecasting Adopting Machine Learning Technique

Abo-Zahhad, M. M. (2023). IoT-Based Automated Management Irrigation System Using Soil Moisture Data and Weather Forecasting Adopting Machine Learning Technique. Sohag Engineering Journal, 3(2), 122-140.

Methodology: It presents an open-source intelligent irrigation system designed to predict field irrigation requirements by analyzing ground parameters like soil moisture, temperature, and environmental conditions in conjunction with weather forecasts sourced from the internet. The system's intelligence is underpinned by a sophisticated algorithm that considers both sensor data and weather predictions. It has been successfully implemented on a pilot scale, employing wireless sensor nodes, cloud-based data collection, and a web-based interface for data visualization. Additionally, the system incorporates a mobile application for irrigation management, offering both automated and manual control based on sensor data and weather forecasts, thereby enhancing water efficiency.

Advantages:

- Automated Decision-Making.

Disadvantages:

- Complexity and Implementation Challenges.

2.6 A Low-Cost Smart Irrigation Planning Based on Machine Learning and Internet of Things

Pandey, P., & Agarwal, S. A Low-Cost Smart Irrigation Planning Based on Machine Learning and Internet of Things. Available at SSRN 4414709.

Methodology: It presents a smart irrigation system that combines multiple sensors, Arduino microcontrollers, and machine learning to optimize crop watering. It utilizes a variety of sensors and weather forecasts to make irrigation predictions, with a 50/50 balance between 10 machine learning and ontology-driven data. The system is structured into four layers: perception, transport, processing, and application, and data is transmitted using a GSM module. The K-Nearest Neighbour algorithm is utilized for predictions, and real-time recommendations are delivered through a mobile app. The system considers crop type, climate, and soil type to enhance irrigation efficiency and reduce water consumption.

Advantages:

- Cost-Effective Sensor Deployment

Disadvantages:

- Sensitivity to Environmental Conditions.

2.7 Smart Irrigation System Techniques Using Artificial Intelligence and IoT

Blessy, J. A (2021, February). Smart irrigation system techniques using artificial intelligence and IoT. In 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV) (pp.13551359). IEEE.

Methodology: It proposes a smart irrigation system that combines IoT, AI, and ML technologies. The IoT sensors are used to collect real-time data on soil moisture levels, which are then processed and analyzed through AI and ML algorithms. These algorithms enable the system to generate optimized irrigation schedules and recommendations tailored to specific crop needs. The central objective revolves around efficient water management, with a focus on improving crop yields by utilizing data-driven insights derived from the integrated technologies.

Advantages:

- Precision Irrigation
- Resource Efficiency
- Cost Savings
- Data-Driven Decision-Making

Disadvantages:

- Vulnerability to Cybersecurity Threats
- Cost of Technology Maintenance
- Adaptation to Environmental Conditions

CHAPTER 3

ANALYSIS & DESIGN

This chapter includes an analysis of the requirements for the proposed project.
This chapter contains:

- Functional Requirements.
- Non-Functional Requirements

3.1 Functional Requirements

Functional requirement analysis entails a thorough examination, analysis, and description of software requirements and hardware requirements to meet actual and also necessary criteria to solve an issue. Analyzing functional Requirements includes several processes. The Functional Requirements include:

Software Requirements

Arduino IDE

Arduino Integrated Development Environment (IDE) is a user-friendly platform designed for programming Arduino microcontrollers. Offering a simplified interface, it allows both beginners and experienced developers to create and upload code effortlessly. With a straightforward editor, it supports languages like C and C++, making it accessible to a wide range of users. The IDE includes a robust set of libraries and functions that simplify complex tasks, enabling rapid prototyping and experimentation. Its compatibility with various Arduino boards ensures versatility in hardware development. Real-time serial monitoring aids in debugging, while the built-in examples and comprehensive documentation enhance the learning experience. Overall, Arduino IDE stands as a powerful tool, that promotes innovation and creativity in the field of embedded systems and electronics.

ThingSpeak

ThingSpeak is a cloud-based platform that serves as a robust and versatile IoT analytics and application-enabling service. Developed by MathWorks, it provides a centralized hub for collecting, processing and visualizing data from Internet of Things (IoT) devices. With ThingSpeak, users can easily analyze and interpret complex datasets, utilizing MATLAB analytics for advanced insights. The platform supports real-time data streaming, enabling seamless integration with IoT devices for monitoring and control applications.

ThingSpeak's user-friendly interface allows users to build custom dashboards, facilitating the visualization of data trends. Additionally, it features integrated support for web services and enables automatic triggering of actions based on predefined conditions. This cloud-based solution enhances accessibility, collaboration, and scalability, making it an ideal choice for diverse applications, from smart agriculture, like in this project, to industrial IoT implementations.

Django

Django is a high-level, open-source web framework for building robust and scalable web applications using the Python programming language. Developed with a focus on simplicity, flexibility, and reusability, Django follows the Model-View-Controller (MVC) architectural pattern. It provides a wide range of built-in features, including an Object-Relational Mapping (ORM) system for database interactions, a templating engine for dynamic content rendering, and a secure authentication system. Django promotes rapid development by automating common web development tasks, allowing developers to concentrate on application-specific logic.

NumPy

NumPy, a fundamental Python library for numerical operations, is instrumental in manipulating large arrays and performing various mathematical computations. Its robust capabilities enable efficient handling of complex mathematical operations and data structures, making it an essential tool for scientific computing in Python.

learn

Scikit-learn is the wise tutor for your project. It provides tools for building and using classifiers, which are like the students who learn from the data. It's the guide that helps your project understand and predict things with finesse.

BeautifulSoup

Beautiful Soup is a Python library widely used for web scraping tasks, aiding in the extraction of data from HTML and XML files. This library parses HTML content, facilitating navigation, search, and modification of the parsed tree structure, making it simpler to extract specific information from web pages. Its intuitive features and methods allow users to navigate through the parsed document, locate elements based on tags or attributes, and extract useful data for analysis or other purposes.

Pandas

Pandas is an open-source library in Python that is made mainly for working with relational or labeled data both easily and intuitively. It provides various data structures and operations for manipulating numerical data and time series. This library is built on top of the NumPy library of Python.

Pandas is fast and it has high performance & productivity for users.

Hardware Requirements

- NodeMCU ESP8266
- Soil Moisture Sensor
- Relay Module (Single Channel)
- Water pump (12V)
- Jumper Wires
- 9V Battery
- Breadboard(Optional)
- USB Cable (Type -B)

3.2 Non-Functional Requirements

Non-functional requirements describe how a system must behave and establish constraints on its functionality. This type of requirement is also known as the system's quality attributes. The Non-functional requirements of this project are:

Usability: Usability defines how difficult it will be for a user to learn and operate the system. It is assessed by using Efficiency of Use.

Reliability: Reliability defines how likely it is for the software to work without failure for a given period. Reliability decreases because of bugs in the code, hardware failures, or problems with low light conditions and more than one person in the frame. To measure software reliability, you can count the percentage of operations that are completed correctly or track the average period the system runs before failing.

Performance: Performance is a quality attribute that describes the responsiveness of the system to various user interactions with it. Poor performance leads to a negative user experience.

Availability: Availability is gauged by the period that the system's functionality and services are available for use with all operations. So, scheduled maintenance periods directly influence this parameter. And it's important to define how the impact of maintenance can be minimized. When writing the availability requirements, the team must define the most critical components of the system that must be always available. You should also prepare user notifications in case the system or one of its parts becomes unavailable.

Scalability: Scalability requirements describe how the system must grow without negative influence on its performance. This means serving more users, processing more data, and doing more transactions. Scalability has both hardware and software implications. For instance, you can increase scalability by working in good light conditions, in less noisy places, using optimizing algorithms, etc

3.3 Usecase Diagram

The depicted use case diagram outlines a "Smart Irrigation Optimization" system involving key actors and interactions for efficient water management in agricultural practices. The system includes actors like Farmer, CentralServer, IoTDevice, and ThingSpeak.

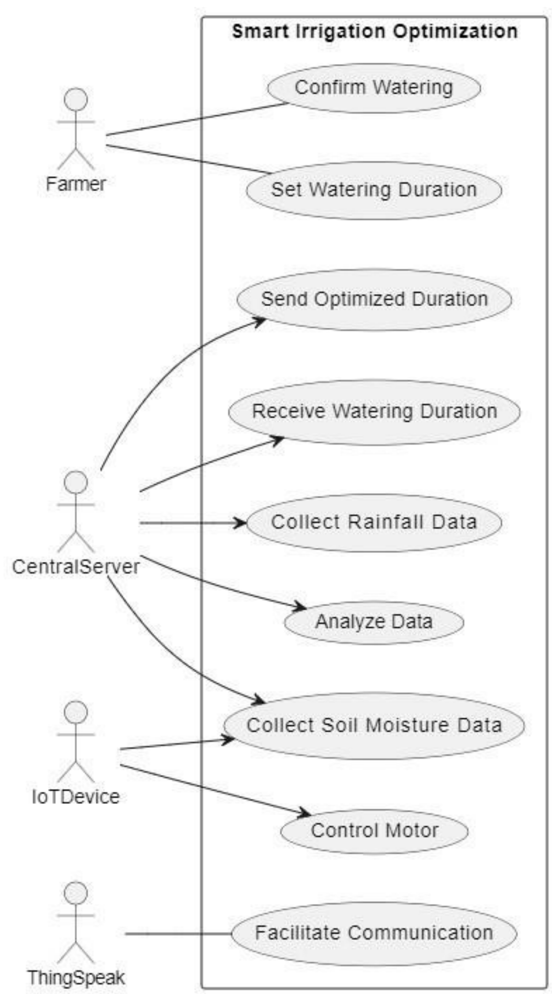


Figure 3.3: Usecase diagram for Smart Irrigation Optimization

The Farmer, as the end-user, interacts with the system by initiating actions such as setting the watering duration and confirming the watering process. The CentralServer serves as the core component, responsible for managing the system's functionalities. It receives inputs like the watering duration from the Farmer, collects rainfall data, gathers soil moisture data from both IoT device and their sources, and performs data analysis to determine optimized watering durations. The IoT device, deployed in the field, plays a crucial role by collecting soil moisture data and controlling the irrigation motor based on instructions received from the central server. ThingSpeak serves as a communication facilitator, ensuring seamless data exchange between the system components. Overall, this system aims to optimize irrigation practices by leveraging data analysis techniques and incorporating soil moisture and rainfall information to tailor watering processes for sustainable and efficient agricultural practices.

3.4 Sequence Diagram

The sequence initiates as the Farmer inputs the desired watering duration through an interface, transmitting this data to the Server for processing. Subsequently, the Server triggers a request for soil moisture information from the ThingSpeak platform, continuously receiving updated soil moisture data from the IoT device via ThingSpeak's interface in a continuous loop. This flow ensures the Server remains updated with real-time soil moisture levels. The received soil moisture data is then relayed back from ThingSpeak to the Server for comprehensive analysis. Simultaneously, the Server accesses and retrieves forecasted rainfall data from external sources, using machine learning algorithms to predict rainfall patterns for the forthcoming 24 hours. Utilizing the combined dataset, the Server conducts a detailed analysis, integrating predictive analytics to optimize watering practices tailored to the crop's needs. Once optimized, the Server communicates the calculated watering duration back to the Farmer for confirmation. Upon receiving confirmation, the Server transmits the approved watering duration to ThingSpeak, which in turn relays this information to the IoT device. This prompts the IoT device to trigger the Motor, facilitating the precise allocation of water to the field based on the prescribed watering duration, effectively completing the irrigation process, and ensuring efficient water usage for the paddy crops.

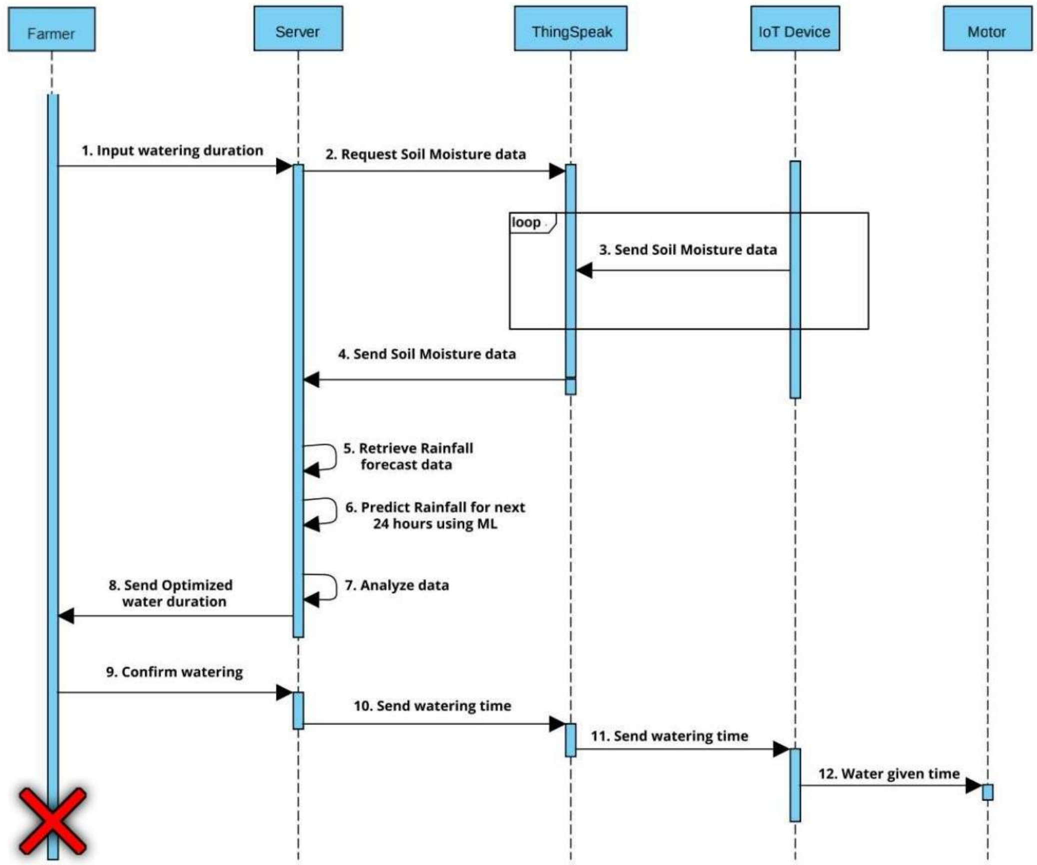


Figure 3.4: Sequence Diagram for Smart Irrigation Optimization

3.5 Class Diagram

The class diagram outlines the key entities and their relationships within a water management system. It comprises classes such as Farmer, CentralServer, IoTDevice, ThingSpeak, Motor, and SoilMoistureSensor, each encapsulating specific attributes and methods. The Farmer class holds the watering duration attribute and a method to set this duration. CentralServer manages received watering duration, optimized duration, and collected rainfall data, featuring methods for data reception, analysis, and optimization. IoTDevice handles soil moisture data, communication channels, and motor control, having functions for data reception and motor activation. The thingSpeak class encapsulates channel and API information for communication. The Motor class manages activation status and motor control functions, while SoilMoistureSensor handles sensor-related attributes and data retrieval functions. Relationships denote interactions, including the Farmer communicating with CentralServer, CentralServer interacting with IoTDevice and SoilMoistureSensor, IoTDevice communicating with ThingSpeak and controlling the Motor, and its management of the SoilMoistureSensor. These interactions depict the flow of data and control mechanisms within the water management system.

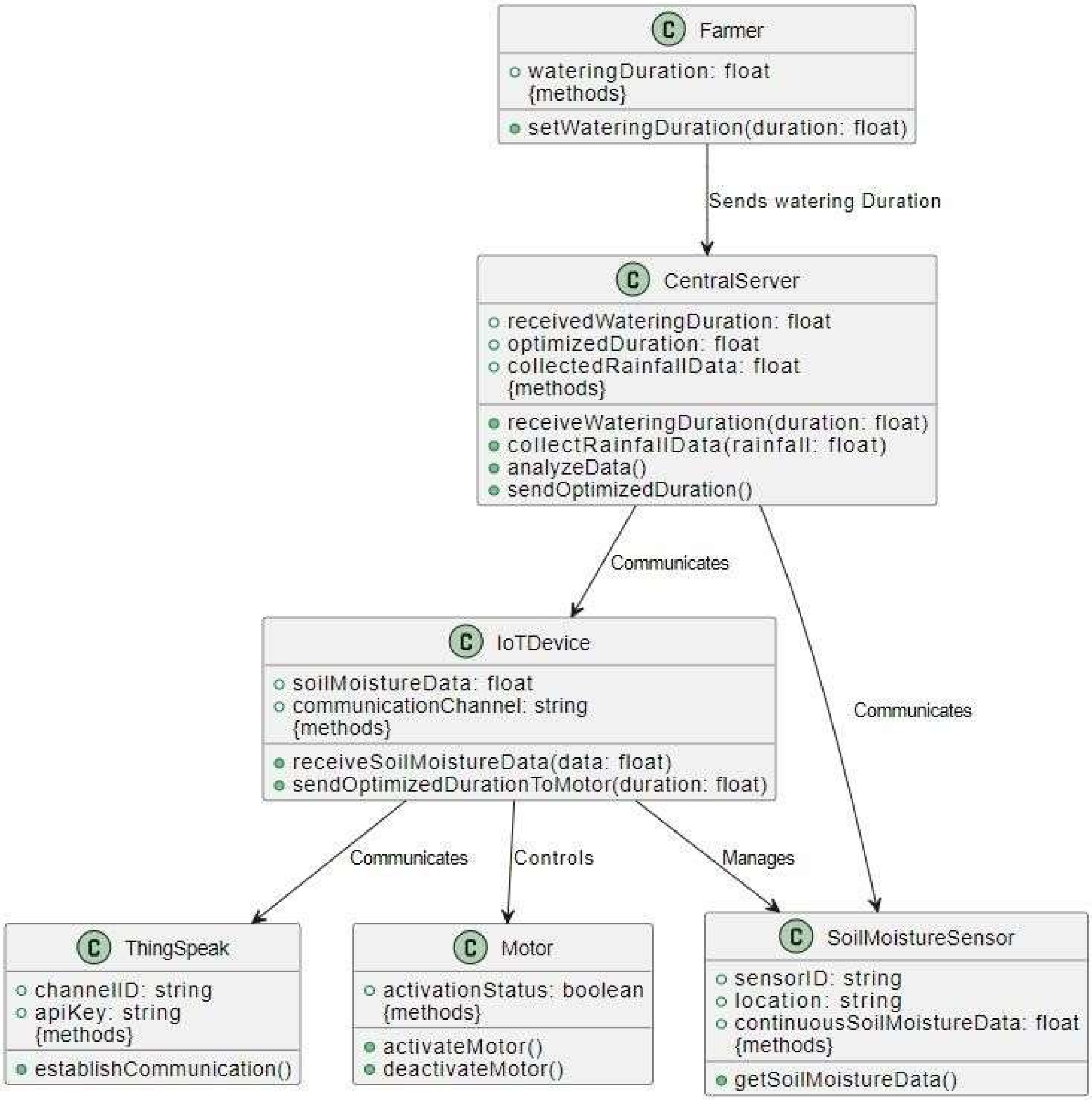


Figure 3.5: Class Diagram for Smart Irrigation Optimization

CHAPTER 4

PROPOSED SYSTEM

This chapter includes the proposed system architecture along with the modules of methodology and dataset collection.

4.1 Architecture

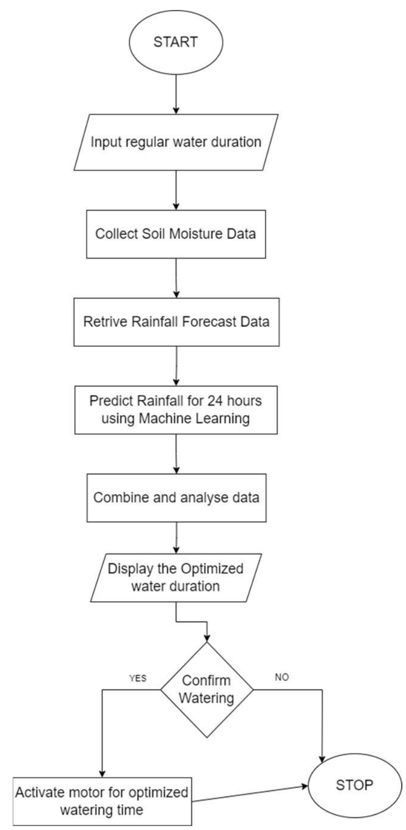


Figure 4.1: Architecture diagram

At first, the farmer inputs the regular water duration through the interface for watering. Simultaneously, IoT collects soil moisture values. Additionally, we retrieve rainfall forecasting data and apply machine learning to obtain data for the next 24 hours. We then analyze both values and display the total watering time to the farmer. Upon confirmation, we water the field.

4.2 Proposed Methodology

Our model blueprint consists of two units especially an IoT module and an interface for the farmer.

1. IoT Module:

It shows the schematic representation of various components of the IoT module. It consists of a NodeMCU esp8266, a resistive soil moisture sensor, a relay module, and, a water pump. The NodeMCU esp8266 serves as a communication gateway between the physical components (water pump, soil moisture sensor, and the relay module) and the interface, ensuring that the irrigation system operates based on the processed data and user input. It can be used as a standalone device that has 4 channels of pulse width modulation (PWM), which is controlled via programming with the help of Arduino IDE.

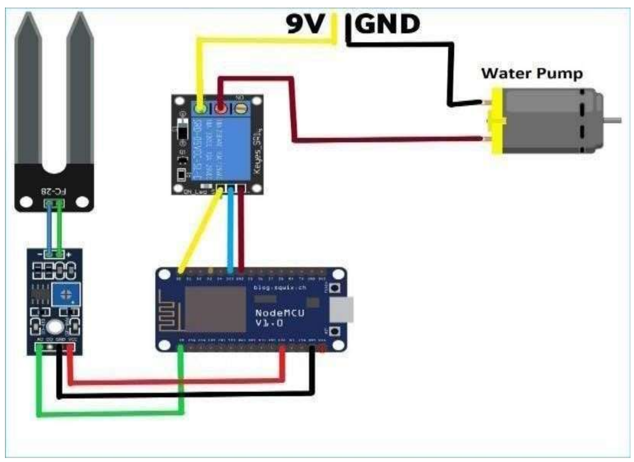


Figure 4.2.1: Schematic representation of IoT module

Fig 4.2.1, collects the soil moisture data from the soil moisture sensor, which fetches the moisture content in the soil in terms of VWC (Volumetric Water Content). It sends the soil moisture content data to the backend of the interface for processing using the WIFI module by sending an HTTP request. The server processes these requests and responds accordingly. After the processing of the data on the server, NodeMCU receives the output (calculated watering time) from the interface. It controls the relay module to manage the water pump based on the received watering time. The relay module acts as a switch connected to esp8266, which is used to turn ON/OFF the water pump for a specific period, which is derived as an output from the interface. The water pump is connected to a relay module, which is used to pump water to the field.

2. Farmer’s Interface:

Fig 4.2.2.1 shows the basic representation of the interface for the farmer. The interface presents the farmer with a comprehensive list of locations, allowing him to choose the specific field he intends to irrigate. Another component of the interface is the input section, where farmers can provide their estimates for the neutral watering time based on the different phases of the crop growth cycle.

Figure 4.2.2: Farmer’s Interface

The farmer can trigger the irrigation process by clicking on the “SUBMIT” button. This action sends a signal to activate the IoT device, initiating the automated watering sequence for the selected field. The soil moisture data is received from the esp8266. Weather data is sourced from wether.com. utilizing a web scrapping technique. The retrieved weather data included crucial parameters for the next 24 hours, focusing on precipitation levels and temperature fluctuations.

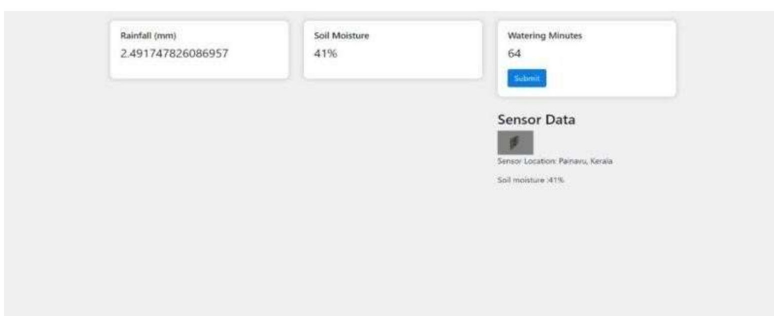


Figure 4.2.2: Farmer’s Interface

The acquired weather data undergoes processing using a sophisticated linear regression machine learning algorithm. The algorithm computes the average precipitation (in millimeters) for the upcoming 24 hours and displays the result based on considering the threshold soil moisture (for paddy crops) needed for the optimal growth of the crop. ThingSpeak, a cloud-based backend, handles the processing of the data, which displays the optimized watering time to the farmer and automatically sends the output signal (period) to the esp8266, which configures the relay module based on the received signal to irrigate the field for the output period.

4.3 Linear Regression Model

In this study, linear regression has been employed as a predictive modeling technique to analyze and forecast rainfall patterns over 24 hours. The linear regression model aims to establish a mathematical relationship between time, represented as the independent variable (x), and predicted rainfall, denoted as the dependent variable (y). The model assumes a linear relationship, expressed by the equation ($y = mx + c$), where (m) represents the slope of the regression line, (c) is the y-intercept, and (x) is the time in hours. The Python code utilizes the sci-kit-learn library to implement linear regression. The Linear Regression class is instantiated, and the model is trained using historical data on time and corresponding actual rainfall amounts. The model then predicts future rainfall values based on the learned coefficients. This approach enables the identification of temporal trends and patterns in rainfall, offering a valuable tool for short-term weather forecasting. The predictive accuracy of the model is assessed through metrics such as Mean Absolute Error (MAE), providing insights into the reliability of the linear regression predictions.

Python code for predicting rainfall for 24 hours

```
from sklearn.linear_model import LinearRegression
import numpy as np
# Instantiate Linear Regression model
rainfall_model = LinearRegression()
# Train the model with historical time and rainfall data
rainfall_model.fit(np.array(time_hours).reshape(-1, 1), np.array(rainfall_mm))
# Predict future rainfall values
next_24_hours = np.array(range(1, 25)).reshape(-1, 1)
predicted_rainfall = rainfall_model.predict(next_24_hours)
```

The code demonstrates the key steps of initializing the model, training it with historical data, and utilizing it to make predictions for the next 24 hours. This linear regression approach provides a straightforward yet effective means of understanding and forecasting rainfall variations over time. It serves as a foundation for further exploration and refinement of weather prediction models.

Utilizing the linear regression model in this context is pivotal for enhancing our understanding and predicting rainfall patterns. Linear regression allows us to uncover underlying trends and relationships between time and rainfall, providing valuable insights into the temporal dynamics of weather conditions. By modeling these relationships, we gain the ability to forecast rainfall over the next 24 hours, aiding in short-term weather predictions. This predictive capability is particularly important for planning and decision-making in various sectors, including agriculture, transportation, and emergency management. The simplicity and interpretability of linear regression make it an accessible yet effective tool for researchers and meteorologists, offering a foundational approach to grasping the temporal intricacies of rainfall and advancing our capabilities in weather forecasting.

4.4 Watering time calculation

Paddy grows well on loamy and clayey soils. Soils typically exhibit an average soil moisture sensor value of 20% to 30% before watering. For paddy crops, the optimal soil moisture level is around 50% to 60%, though actual requirements depend on diverse factors such as soil type, weather, and irrigation practices. After watering, on average soils may reach 50% to 60%. Both clayey and loamy soils are ideal for rice cultivation due to their water retention abilities, crucial for the submerged conditions during rice growth. Cultivation practices vary based on regional choices, climate, and the adaptability of rice varieties to specific soil types.20% moisture value in the soil which is before watering corresponds to 4.5 mm of watering which is calculated using the below formula. The normal watering given by my farmer daily is taken as 7mm. So, the total watering that is present is taken at 11.5mm on average before considering the rainfall data. x hours given by the farmer for 7 mm of watering daily. So the optimized watering time is calculated as (11.5- (rainfall in mm) +soil water) which is displayed to the farmer as output.

The following logic is used to calculate the watering time:

```
//Calculating Sensor Value
Soil_Water(mm) = Sensor_Value*50*0.45*0.01

//Calculating balance water in mm
Total_Balance=Total_Required(11.5)-(Soil_Water(mm)+Rainfall(mm))

//Calculating Time
Timefor1mm=WaterDuration(hours)/7(mm)
Total_Time(hours)=Timefor1mm*Total_Balance
Time(minutes)=Total_Time(hours)*60
```

CHAPTER 5

IMPLEMENTATION

5.1 Hardware Setup

The figure 5.1 represents the hardware implementation for NodeMCU ESP8266 which serves as the central processing unit, which facilitates communication between various physical components and the software. In NodeMCU, the 3.3V pin is connected to the VCC of the soil moisture sensor, and the GND pin is connected to the GND pin of the moisture sensor, which establishes a common reference point for the electrical potential between the components.

Figure 5.1: Hardware Implementation

A link is established between the VCC terminal of the relay module and the 5V pin, and another GND pin to the ground (GND) of the relay module. For data communication, digital pins (D1 and D2) are connected to the signal pin of the moisture sensor and the signal pin (IN) of the relay module. Normally, the open (NO) and common (COM) terminals of the relay are connected to the power supply of the water pump. The NodeMCU controls the water pump via a relay module. It sends a high signal to activate the relay, allowing current to flow to the water pump and initiating irrigation. When watering is complete, allow the signal to deactivate the relay, stopping the pump.

5.2 Interface Implementation

The figure 5.2 is designed using Django, which is an open-source web framework used for rapid development and clean, pragmatic design. It also leverages the REST API (Representational State Transfer Application Programming Interface) for building and interfacing with web services that adhere to the principles of REST architecture. The linear regression algorithm processes soil moisture and weather data by establishing a linear relationship between these variables and calculating the average rainfall. The ThingSpeak platform receives soil moisture and weather data from the NodeMCU and employs data processing mechanisms, potentially using MATLAB analytics, to compute optimized watering times. The processed results are then presented through a customizable dashboard on the ThingSpeak platform. ThingSpeak initiates an automatic signal transmission to the NodeMCU IoT module, which triggers the water pump, achieving and data-driven smart irrigation system.

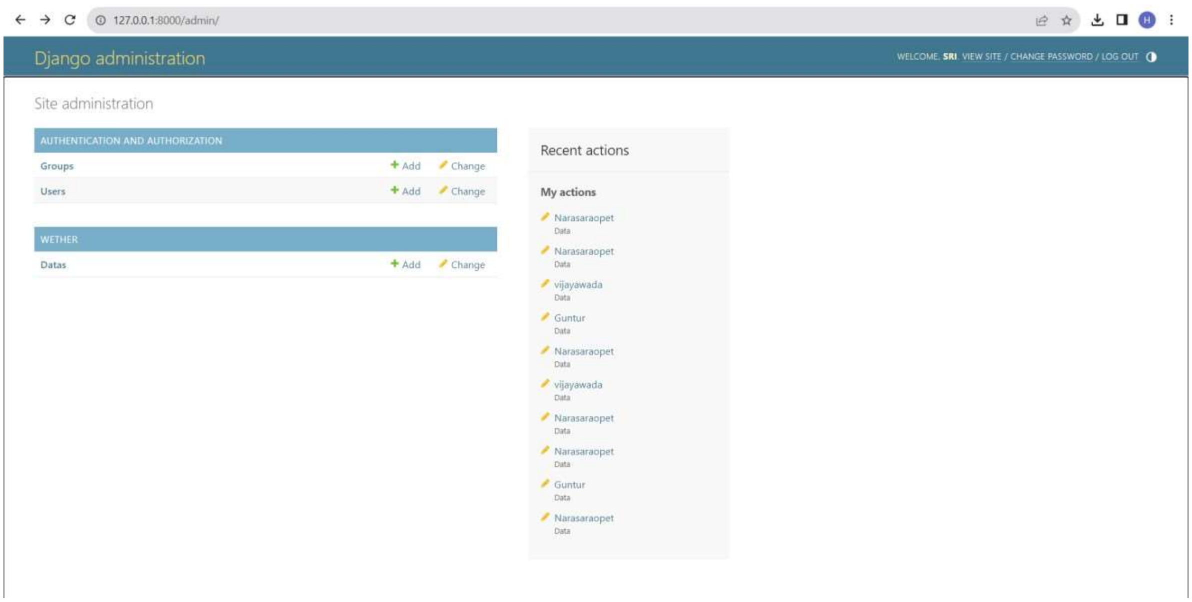


Figure 5.2: Django Administration

5.3 Client Satisfaction Report

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

V. R. SIDDHARTHA ENGINEERING COLLEGE

LETTER OF SATISFACTION

Place: Vijayawada

Date: 22/11/2023

From: Magireddy Appalanaidu

Subject: Satisfaction report on Smart Irrigation Optimization: Integrating Weather Prediction And IoT For Paddy Crops.

I am satisfied with the output of the project that was implemented with our requirements on Smart Irrigation Optimization System. The project has been designed as per the requirements whichare:

- User-Friendly
- Cost-Effective
- Easy Maintenance

This project satisfied all the requirements mentioned above. I am glad that this project will be helpful for us.

Project by: Batch 16

Para Hemanth Suresh - 218W1A0542

Pogiri Sai Kiran - 218W1A0546

Guide: Raga Madhuri Ch (Assistant Professor)

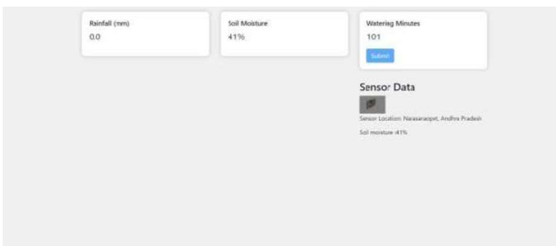
అప్పలనాయుడు

Signature

CHAPTER 6

RESULT

The following results are obtained when the whole model is implemented. Whenever the farmer gives the input of normal watering time, a signal is sent to activate the IoT module which fetches the moisture data and integrates with the interface for processing of data. The result which is the optimized watering time is shown on the ThingSpeak platform.



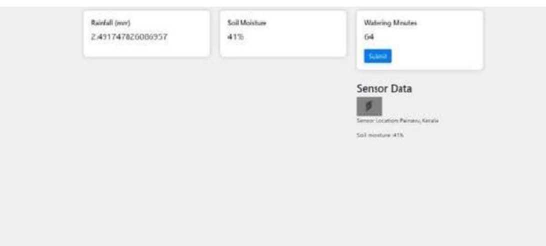


Figure 6.1: When no rainfall Figure 6.2: When rainfall

The above Fig 6.1, is the output when there is no rainfall in the upcoming 24 hours, so the optimized watering time is displayed purely based on the threshold soil moisture value of the paddy crop.

The above Fig 6.2, is the output when there is a certain amount of rainfall in the upcoming 24 hours, so the processing is done based on the average rainfall (mm and threshold moisture value of the paddy crop. The optimized watering time(min) is displayed.

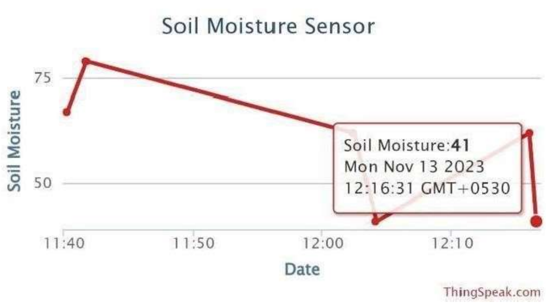


Figure 6.3: Soil Moisture in ThingSpeak Figure 6.4: Watering Time in ThingSpeak

The above figs, it is a graphical representation of the soil moisture and watering time in a particular period. It is displayed in the ThingSpeak platform which gives a brief understanding of the watering periods in the past few days.

MODEL ACCURACY

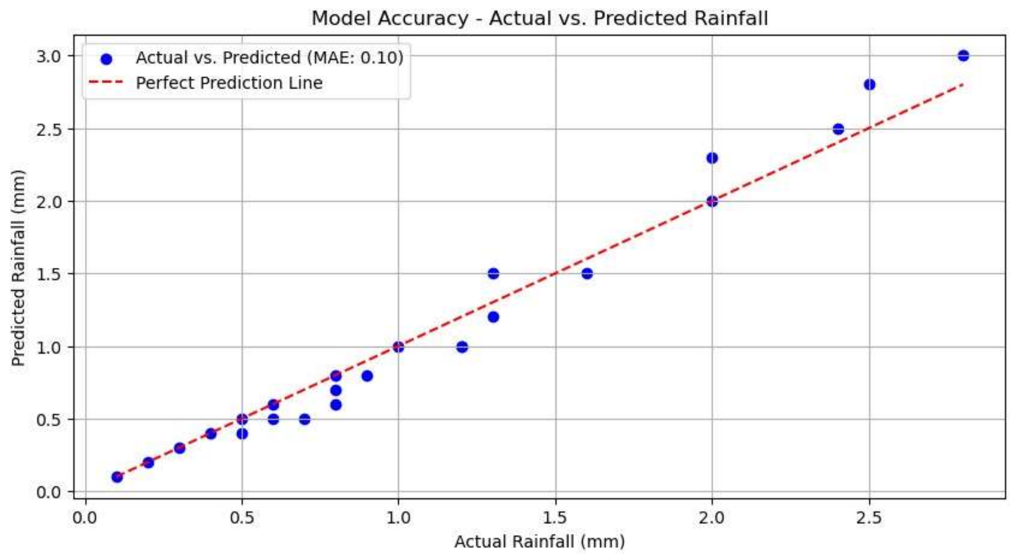


Figure 6.5: Model Accuracy Graph

This scatter plot illustrates the accuracy of a linear regression model in predicting rainfall over 24 hours. The blue points represent the predicted rainfall values generated by the model, while the red dashed line indicates a perfect prediction scenario where actual rainfall equals predicted rainfall. The scatter plot compares the model's predictions to the actual observed rainfall values. Each blue point represents a specific period, showcasing how well the model aligns with the actual data. The red dashed line serves as a reference for perfect predictions, where the model would exactly match the observed rainfall. The Mean Absolute Error (MAE) is calculated and displayed on the plot, providing a quantitative measure of the model's accuracy. Points below the red dashed line indicate instances where the model underpredicted the rainfall. Points above the line suggest overpredictions. The proximity of the points to the line provides a visual indication of the model's overall accuracy. Understanding the relationship between actual and predicted rainfall is crucial for assessing the reliability of the model. The Mean Absolute Error serves as a quantitative metric, summarizing the average magnitude of prediction errors. A smaller MAE indicates better accuracy.

CHAPTER 7

CONCLUSION AND FUTURE WORK

In conclusion, the project successfully addressed the optimization of water consumption specifically for paddy crops by leveraging real-time soil moisture data from IoT devices and rainfall forecasts. The developed system integrated weather predictions with machine learning algorithms to determine appropriate irrigation schedules, thereby enhancing water efficiency tailored to the crop's needs and environmental factors. The implementation showcased significant improvements in water management practices for paddy cultivation, emphasizing the importance of utilizing advanced technologies to optimize irrigation while focusing on resource conservation and sustainable farming methods.

For future endeavors, expanding the system's capabilities to incorporate additional environmental factors such as humidity and temperature could further refine the irrigation optimization process, providing a more comprehensive understanding of the crop's requirements. Additionally, enhancing the machine learning models by integrating more sophisticated algorithms or considering historical data analysis might improve the system's predictive accuracy for irrigation scheduling. Moreover, extending the application of this system to other crops or agricultural settings beyond paddy cultivation could broaden its impact, promoting sustainable water management practices across various farming domains. Further research into remote sensing technologies and advanced data analytics could also contribute to developing more robust and adaptable irrigation systems for agricultural sustainability.

CHAPTER 8

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