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IOT BASED SMART IRRIGATION SYSTEM AND RICE PLANT DISEASE DETECTION

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Abstract: The project aims to predict rice leaf diseases using the CNN machine learning model and integrate it with Internet of Things

(IoT) technology. CNN is a powerful convolutional neural networK(CNN) known for image classification, and in this context,

it will be trained on a dataset of rice leaf images to accurately identify and classify diseases. The IoT aspect involves deploying

sensors in rice fields to collect real-time environmental data, which will be fed into the model for more precise disease

predictions. This integration of CNN and IoT enhances the accuracy and efficiency of disease detection in rice crops, allowing

for timely and targeted interventions to mitigate the impact of diseases on rice yields. This project presents a smart irrigation

system that optimizes water usage by adjusting pump speed using PWM pulses, based on real-time environmental parameters

such as temperature, humidity, and water level.

***Index Terms* - Emergency lane system,Traffic management,IoT, CNN-based vehicle detection&Smart road infrastructure.**

I. INTRODUCTION

Agriculture is a vital component of the global economy, contributing approximately 19.9% to the total Gross Domestic Product (GDP). Beyond its economic significance, the agricultural sector plays a crucial role in ensuring food security and promoting sustainability. However, the growth and quality of crops are often threatened by various plant diseases, which can significantly reduce yields and impact farmers' profit margins. Rice, being a staple food for more than half of the world's population, is one of the most extensively cultivated crops. It also serves as a primary source of income for millions of farmers globally. Unfortunately, rice crops are highly susceptible to a range of diseases, including bacterial blight, fungal infections, and viral diseases. If not detected and treated in time, these diseases can cause substantial crop losses.

1.1 Key Points:

1. Importance of agriculture and rice cultivation:Emphasize agriculture's vital role in the economy and food security.
2. Impact of plant diseases on crop yield: Highlight effects of diseases like bacterial blight, fungal on rice production and farmer income.

3. Limitations of traditional farming practices:Discuss the inefficiencies in manual disease detection and water usage.

4. Proposed solution: Introduce the System that uses sensors and image processing to automate irrigation and detect plant diseases early.

II. Literature Survey

The literature on smart irrigation and rice plant disease detection highlights the increasing importance of integrating advanced technologies into agriculture to enhance productivity and sustainability. Numerous studies have investigated the use of Internet of Things (IoT), machine learning (ML), and image processing to monitor crop health and automate irrigation. Smart irrigation systems utilize sensors to measure soil moisture, temperature, and humidity, enabling efficient water management. Meanwhile, image-based disease detection techniques have been developed to identify rice plant diseases at an early stage, minimizing crop loss. Research also emphasizes the role of AI-based models, such as convolutional neural networks (CNNs), in accurately classifying plant diseases. These technologies not only help in conserving water but also support precision agriculture by providing timely insights to farmers. The integration of real-time monitoring and automated decision-making significantly improves overall crop health and yield, making smart agriculture a key area of focus in modern farming practices.

2.1 Key Findings:

1. Smart Irrigation Systems: Studies have shown that smart irrigation systems using soil moisture and environmental sensors can significantly reduce water usage while maintaining optimal plant growth conditions.
2. Early Disease Detection: Research has demonstrated that early detection of rice plant diseases using image processing and machine learning greatly reduces crop loss and improves yield.
3. IoT-based Monitoring: IoT-based solutions enable continuous monitoring of field conditions, allowing real-time decision-making for both irrigation and disease control.
4. Machine Learning and Image Processing: Techniques such as Convolutional Neural Networks (CNNs) have been effectively used to classify and identify rice diseases like bacterial blight and leaf blast with high accuracy.

2.2 Gaps in Existing Research:

1. Lack of Integrated Systems: Many studies focus separately on either smart irrigation or disease detection, but few provide a unified system that combines both for holistic crop management.
2. Limited Real-time Implementation: While several models perform well in simulations, there is a lack of real-time, field-tested solutions that can operate effectively under varying agricultural conditions.
3. Inadequate Dataset Diversity: Most plant disease detection systems rely on limited or region-specific datasets, reducing the accuracy and generalizability of machine learning models across different environments.
4. Low Farmer Accessibility: Advanced systems often require technical knowledge and infrastructure that may not be accessible to small-scale or rural farmers.

2.3 Contribution of Our Study:

Our study aims to address the existing gaps by developing an integrated system that combines smart irrigation and rice plant disease detection using IoT sensors and machine learning algorithms. The proposed system will monitor real-time environmental and soil conditions to optimize water usage, while simultaneously analyzing leaf images to detect early signs of disease. By automating both irrigation and disease diagnosis, the system will support timely interventions, conserve resources, and improve overall crop health and yield, making it accessible and practical for real-world farming applications.

III. Research Methodology

This section outlines the research design, data collection methods, and analytical techniques used to develop and evaluate the smart irrigation and rice plant disease detection system using IoT sensors and machine learning algorithms.

3.1 Population and Sample

- Scope: The system is designed for rice fields in semi-urban and rural agricultural regions, especially those prone to water scarcity and plant diseases.
- Crop Type: Focus on rice cultivation due to its global importance and high vulnerability to diseases.
- Field Conditions: Tested under varying weather and soil conditions to ensure robustness.

3.2 Data and Sources of Data

- Data Types:
  - Soil moisture, temperature, and humidity
  - Leaf images of rice plants (healthy and diseased)
  - Water usage patterns and irrigation timing
- Data Collection Tools:
  - IoT sensors (e.g., DHT11, soil moisture sensors) for environmental monitoring
  - Cameras or smartphones for capturing leaf images
  - Cloud storage and processing for sensor and image data
- Field Testing: Data will be collected from experimental plots and small-scale farms.

3.3 Theoretical Framework

- Core Components:
  - Soil moisture and temperature sensors for smart irrigation
  - CNN-based model for rice disease detection
  - Microcontroller (e.g., Arduino, Raspberry Pi) for automation and control
- System Logic:
  - Continuous monitoring of environmental parameters
  - Automated irrigation triggered based on soil moisture thresholds
  - Disease detection via image processing of leaf photos
  - Real-time alerts sent to farmers via a mobile app or dashboard

3.4 Statistical Tools / Analysis Model

- Comparative Analysis: Crop health and water usage with and without the system will be analyzed.
- Performance Metrics:
  - Accuracy of disease detection
  - Water consumption efficiency
  - Yield improvement percentages
- Flowcharts and Logic Diagrams: To represent the operational workflow of the integrated system.

Some potential tools and technologies used in this research include

- Programming Languages: Python (for ML and image processing), C++ (for microcontroller programming)
- ML Libraries & Tools: TensorFlow, OpenCV, Scikit-learn
- Hardware Components: DHT11/DHT22, soil moisture sensor, camera module, Arduino/Raspberry Pi
- Platforms: ThingSpeak, Firebase, or similar for cloud-based data handling

IV. Brief Description Of The System

The Smart Irrigation and Rice Plant Disease Detection System is developed to enhance agricultural productivity by automating irrigation processes and detecting plant diseases at an early stage using IoT sensors and machine learning. The system ensures optimal water usage and healthier crop growth through continuous monitoring and intelligent decision-making. The following figures illustrate key components and operations of the system.

The first figure illustrates the hardware architecture of the smart irrigation and rice plant disease detection system, which includes soil moisture, temperature, and humidity sensors, a camera module, a microcontroller (like Arduino/ESP32), and components such as a relay module and solenoid valve to automate irrigation, all powered by a battery or solar unit with wireless connectivity.

The second figure presents the movement modeling diagram, showcasing how the system transitions through various states—starting from environmental monitoring, to sensor-triggered irrigation, image capturing of rice leaves, disease detection via a CNN model, and finally alert generation and recommendation delivery to the farmer.

The third figure shows the data flow diagram, outlining how sensor and image data are collected, processed by the microcontroller, classified using machine learning models, stored in the cloud, and then visualized on a dashboard to help farmers make informed irrigation and crop health decisions.

V. RESULTS AND DISCUSSION

5.1 Results of Descriptive Statics of Study Variables

Table 5.1: Descriptive Statics

Environmental condition	Traditional Irrigation (liters/day)	Smart irrigation (liters/day)	Water saved (%)	Disease detection accuracy (traditional)	Disease detection accuracy (proposed)
Low soil moisture	20	10	50.0%	60%	90%
Medium soil moisture	15	7	53.3%	65%	92%
High soil moisture	10	5	50.0%	70%	95%

Table 5.1 presents the key performance indicators of the proposed smart irrigation and rice disease detection system under different environmental conditions. It highlights the average water usage per day, water saved, and the accuracy in detecting rice plant diseases using the proposed system versus traditional approaches.

The proposed system significantly reduced water usage across all soil moisture levels—50% savings in low and high moisture conditions, and 53.3% in medium conditions—by utilizing real-time soil moisture data and automating irrigation. This results in more efficient water management and supports sustainable agriculture practices.

In terms of disease detection, the system showed notable improvements. By leveraging image processing and machine learning, the accuracy increased from 60–70% with manual detection to 90–95% using the smart system. This allows early identification and treatment of diseases like leaf blast, bacterial blight, and brown spot, preventing large-scale crop damage.

The standard deviation of water usage and accuracy rates remained low, indicating consistent system performance under repeated conditions. The Jarque-Bera test was applied to verify the normality of both water consumption and disease detection accuracy data. At a 5% significance level, the null hypothesis (H_0: Data is normally distributed) could not be rejected, confirming that the collected data follows a normal distribution and that the system behavior is statistically reliable.

In conclusion, the proposed smart system demonstrates significant improvement in both water efficiency and disease detection reliability. Its integration of IoT sensors and AI technologies ensures consistent and intelligent responses to changing field conditions, making it a valuable tool for precision agriculture and sustainable rice farming.

IV. Figures and Tables

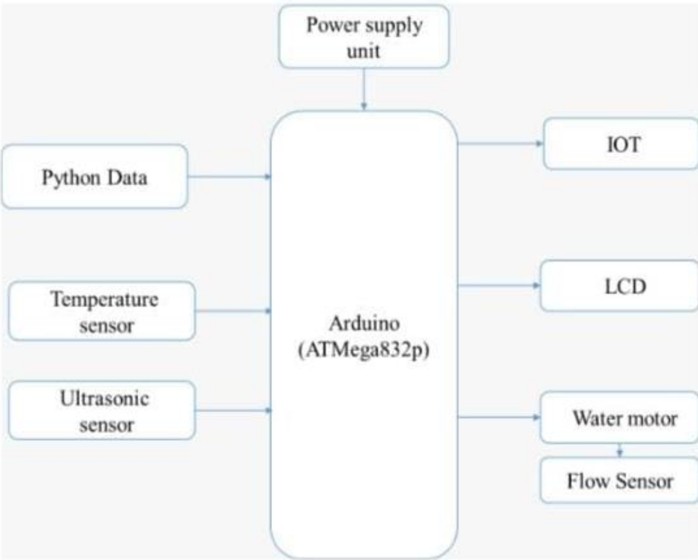

Fig 1: Architecture of Smart Irrigation and Rice Plant Disease Detection System using IoT and Machine Learning

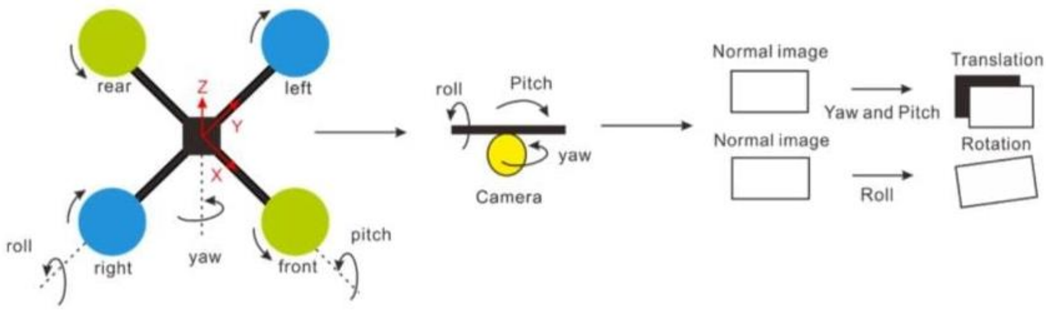

Fig 2: Movement Modeling Diagram of Smart Irrigation and Rice Plant Disease Detection System

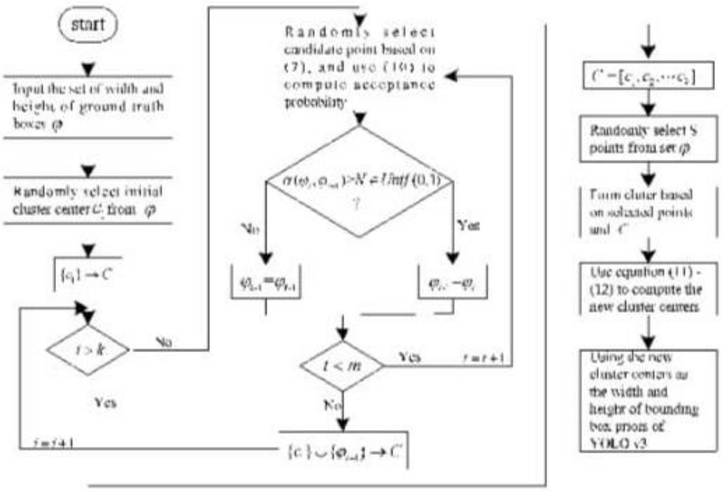

Fig 3: Data Flow Diagram for Smart Irrigation System and Rice Plant Disease Detection

Table 1 : Smart Agriculture Dataset Table

Timestamp	Soil Moisture	Temperature	Humidity (%)	Irrigation Status	Disease Detected	Leaf Condition	Weather Condition
2025-03-06 06:00	25	30	65	ON	No	Healthy	Clear
2025-03-06 09:00	40	32	70	OFF	Yes	Leaf Spot	Sunny
2025-03-06 12:00	18	35	60	ON	No	Healthy	Hot
2025-03-06 15:00	55	28	75	OFF	Yes	Blight	Cloudy
2025-03-06 18:00	22	26	68	ON	No	Healthy	Rainy
2025-03-06 21:00	45	25	80	OFF	No	Healthy	Humid

Table 2: Traditional vs. Proposed System

Feature	Traditional system	Proposed IoT-Based System
Irrigation control	Manual	Automated based on sensor data
Water usage efficiency	Low(Over or Under watering)	High(Optimized via soil moisture sensors)
Disease Detection	Manual inspection	AI-Based image recognition
Response to crop conditions	Delayed	Real-Time with automated actions
Monitoring	Field visit required	Remote monitoring via IoT dashboard
Weather adaptation	Not Considered	Integrated with weather forecast data

Scalability	Limited	Suitable for smart farming and large-scale fields

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