Plantex: Plant Recommendations and Leaf Disease Detection Using IOT and Machine Learning

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Abstract – In modern agriculture, optimizing crop yield and managing plant health are crucial for sustainable farming practices. This research explores the development of a robust system that leverages machine learning to provide intelligent crop recommendations and accurate leaf disease detection. The system integrates environmental factors, such as soil quality (Nitrogen, phosphorus, potassium, temperature, humidity and PH level) and historical crop dataset, to recommend the most suitable crops for a given region. Concurrently, it employs advances image processing techniques and machine learning algorithms to identify and classify leaf diseases from plant images. By automating these processes, the system aims to assist farmers in making informed decisions, reducing crop losses, and enhancing overall productivity. The results demonstrate the potential of machine learning in transforming traditional agriculture into a data-driven industry, improving food security, and promoting sustainable farming practices.

1.INTRODUCTION

Agriculture faces a complex set of challenges including selecting suitable crops for varying local conditions, managing crop diseases, and adapting to climate change. These issues affect food production, farmer income, and sustainability. Precision agriculture tools, such as soil sensors and satellite imagery, provide real-time data to help farmers choose the best crops for their environment. AI models can further predict optimal crops based on local conditions. Drones and AI-driven image recognition can detect diseases early, allowing for timely intervention. Mobile apps and sensors can also alert farmers to potential issues, while predictive analytics can forecast outbreaks based on weather and disease patterns. Climate-resilient crops, smart irrigation systems, and climate prediction models can help farmers adjust to changing weather patterns, ensuring better resource management and crop resilience. Data-driven solutions can guide sustainable practices like crop rotation and reduced pesticide use, while smart farming technologies optimize water usage and reduce environmental impact.

2. LITERATURE REVIEW

[1] Plant diseases threaten food security, and traditional detection methods are slow and error-prone. Deep learning, particularly convolutional neural networks (CNNs), offers an automated solution by accurately identifying diseases from plant leaf images. CNNs can recognize subtle differences in color, texture, and shape, enabling early disease detection. Transfer learning also helps reduce the need for large datasets. Challenges include the difficulty of collecting high-quality labelled datasets, real-world factors affecting model performance, and the lack of interpretability in deep learning models. Future research should focus on improving data collection, model robustness, and interpretability to enhance plant disease detection and support sustainable agriculture.

[2] This study presents a novel K-nearest Neighbours Random Forest Ridge Regression (KRR) model for forecasting crop production in Bangladesh, focusing on five major crops: Aus rice, Aman rice, Boro rice, potato, and wheat. The KRR model outperforms traditional machine learning models like Support Vector Regression, Naïve Bayes, and Ridge Regression, as well as ensemble methods like Random Forest and CatBoost, based on metrics like Mean Squared Error (MSE) and R-squared. The Diebold-Mariano test confirms its statistical significance.To assist farmers, a recommender system is developed to suggest suitable crops based on predicted yields and environmental factors, optimizing crop choices and improving returns. However, the model's performance is dependent on data quality, and issues like missing values or outliers could affect accuracy. Additionally, the model's adaptability to future conditions, such as climate change or pest outbreaks, needs further refinement. Future research should focus on improving data handling and model robustness to enhance its applicability in dynamic agricultural environments.

[3] Climate change is affecting plant growth, making it essential to choose suitable plants for specific locations. This article introduces a user-friendly system that recommends plants based on a user's geographical location and climate conditions. The system uses the OpenWeatherMap API to gather weather data, including average temperature, humidity, and precipitation for the current month, which are crucial for plant growth. A ranking algorithm evaluates these factors and assigns ratings ranging from "Extreme" to "Very Low," with "Moderate" being ideal. Based on this data, the system recommends plants that thrive in similar conditions, helping users make informed planting choices.However, the system has limitations. Its recommendations depend on the quality and completeness of weather data, and it doesn't account for other factors like soil composition or sunlight. Additionally, its reliance on historical data may not capture unpredictable weather patterns. Future updates could integrate more environmental factors and real-time weather data for better accuracy.

[4] Plant diseases threaten global food security and agricultural sustainability. Traditional detection methods, relying on visual inspection, are time-consuming, labour-intensive, and prone to errors. Machine learning and deep learning offer efficient alternatives by analysing image data to identify disease patterns

with high accuracy. However, challenges remain, including limited high-quality labelled datasets, varying real-world conditions, and the interpretability of deep learning models. Future research should focus on efficient data collection, enhancing model robustness, and improving interpretability. Addressing these challenges will advance plant disease detection and support sustainable agriculture.

[5] Plant diseases threaten global food security and agricultural sustainability. Traditional detection methods, relying on visual inspection, are slow, labour-intensive, and error-prone. Deep learning, particularly convolutional neural networks (CNNs), offers a powerful alternative for automated plant disease detection.CNNs effectively extract intricate features from plant leaf images, enabling accurate disease classification. Transfer learning further enhances efficiency by leveraging pre-trained models, reducing data requirements and training time.Despite advancements, challenges remain, including limited high-quality labelled datasets, varying real-world conditions, and the lack of model interpretability. Addressing these issues will enhance deep learning's effectiveness in plant disease detection.

[6] Crop recommendation systems leverage technology to assist farmers in selecting optimal crops based on soil, climate, and market factors. By integrating machine learning, GIS, and remote sensing, these systems enhance productivity and sustainability.Hybrid approaches combine sensor data, satellite imagery, and expert knowledge for accurate recommendations, adapting over time through user feedback. Personalized suggestions cater to individual farm conditions, improving decision-making.Challenges include data availability, infrastructure limitations, and environmental unpredictability. Overcoming these barriers is essential to maximizing the impact of crop recommendation systems in global agriculture.

[7] Selecting the right crop each season is crucial for farmers, impacting income, food security, and sustainability. Traditional methods rely on experience but struggle with dynamic agricultural conditions.Machine learning (ML) transforms crop selection by analyzing data from soil sensors, weather stations, and satellite imagery. Models like decision trees, KNN, neural networks, and random forests provide accurate, location-specific recommendations. ML also supports yield prediction, pest detection, and soil mapping, enhancing efficiency.Challenges include data quality, infrastructure gaps, and environmental variability. Ethical concerns, such as fair access and reliance on technology, must also be addressed to maximize ML's impact in agriculture.

[8] Smart farming leverages machine learning (ML) to detect crop diseases early, preventing severe yield losses. Models like Support Vector Machines (SVM), K-Nearest Neighbours (KNN), and Convolutional Neural Networks (CNN) automate disease classification through image analysis.A study on soybean leaf diseases found CNN most effective, achieving 96% accuracy, compared to 76% for SVM and 64% for KNN. CNN's strength in image recognition enables precise, rapid disease detection for timely interventions.Challenges include high computational demands and sensitivity to real-world conditions like lighting and occlusions. Refining these models will enhance their scalability and field applicability.

[9] Agriculture faces significant threats from plant diseases, making early detection crucial. Traditional manual inspection is slow, labour-intensive, and error-prone.Deep learning, particularly convolutional neural networks (CNNs), has revolutionized disease detection by enabling precise image-based classification. However, challenges remain, including the need for large, diverse datasets like PlantVillage and real-world variability.
Limitations include high computational demands, model interpretability issues, and reliance on controlled data. Addressing these challenges will enhance deep learning's role in safeguarding agricultural productivity and food security.

[10] The Crop Recommendation System automates crop selection using IoT devices, including Arduino microcontrollers and sensors, to collect environmental data. Machine learning models—Naïve Bayes and Support Vector Machine (SVM)—analyze factors like temperature, humidity, soil moisture, pH, and sunlight to recommend optimal crops with over 92% accuracy.The system adapts through farmer feedback, refining predictions over time. Its user-friendly mobile app provides accessible guidance, enabling informed decisions without expert knowledge, enhancing farming efficiency.

3. PROBLEM STATEMENT

With a growing population and environmental challenges, sustainable agriculture is essential for food security. Traditional crop selection is labour-intensive and often inaccessible to farmers in developing regions. Climate change, soil degradation, and water scarcity further complicate this process. This research aims to develop a machine learning-based crop recommendation system that analyzes soil nutrients, climate, temperature, humidity, and rainfall to suggest optimal crops. By evaluating various models, the system seeks to maximize yield, maintain soil health, and promote sustainable farming, providing an accurate and scalable solution for data-driven decision-making in agriculture.

4. PLANTEX: THE PROPOSED SYSTEM

The proposed system comprises two modules—Crop Recommendation and Leaf Disease Detection—leveraging machine learning and deep learning to optimize farming practices, enhance yields, and promote sustainability.

6.1.1 Crop Recommendation System

This system helps farmers select optimal crops based on soil and environmental conditions. Using a **Random Forest** model, it analyzes sensor data (temperature, humidity, soil parameters) to predict the best crop choices. The model undergoes data preprocessing, training, and evaluation (using R^2 score and MSE) to ensure accuracy. Farmers receive tailored crop recommendations, minimizing risks and maximizing productivity.

6.1.2 Leaf Disease Detection System

The Leaf Disease Detection System employs **VGG-16**, a CNN model, for automated disease identification via image analysis. Farmers upload leaf images, and the system classifies them as healthy or diseased, identifying specific diseases if present. Early detection enables targeted treatments, reducing pesticide use and improving crop health.

6.1.3 Integration and Benefits

Together, these systems optimize crop selection and provide early disease detection, enabling farmers to make informed, data-driven decisions. By integrating machine learning and deep learning, the solution enhances efficiency, minimizes resource waste, and supports sustainable agriculture.

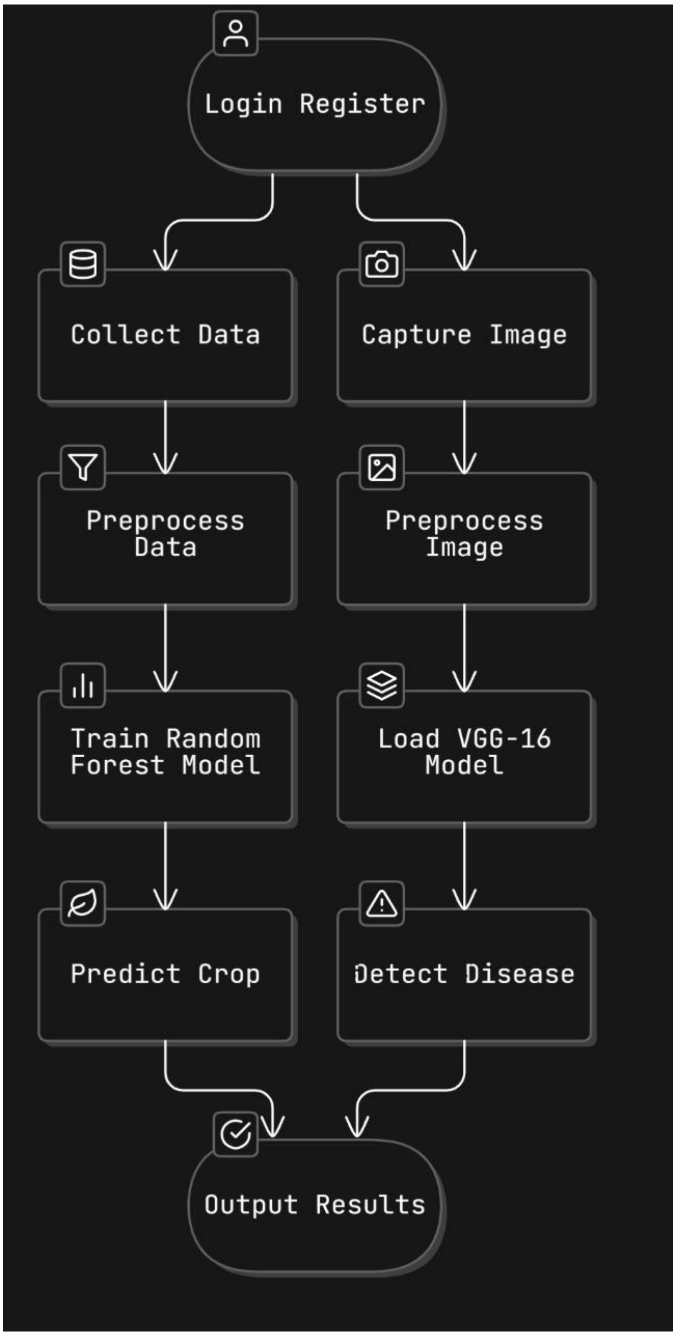

Fig 1: System Architecture

5. RESULTS AND DISCUSSION

The implementation of the Crop Recommendation and Disease Detection System has shown great potential in improving agricultural productivity through real-time monitoring and data-driven insights. By integrating sensors, machine learning, and deep learning, the system helps farmers select suitable crops based on soil and climatic conditions while enabling early disease detection through image analysis. This proactive approach minimizes crop losses, optimizes resource use, and promotes sustainable farming. Its user-friendly interface and cloud-based infrastructure ensure accessibility for farmers of all scales. Despite challenges like data inconsistencies and hardware limitations, continuous improvements in AI models and sensor integration can further enhance its effectiveness, making it a crucial tool for future agricultural advancements.

The screenshots of the website is given below:

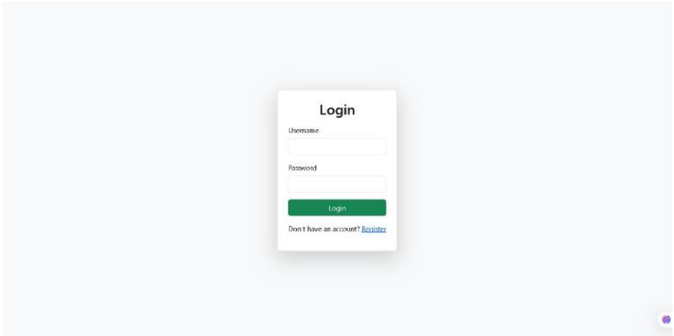

Fig 2: Login page

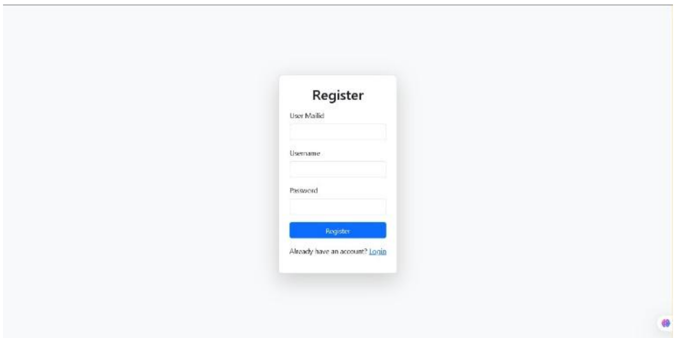

Fig 3: Register Page

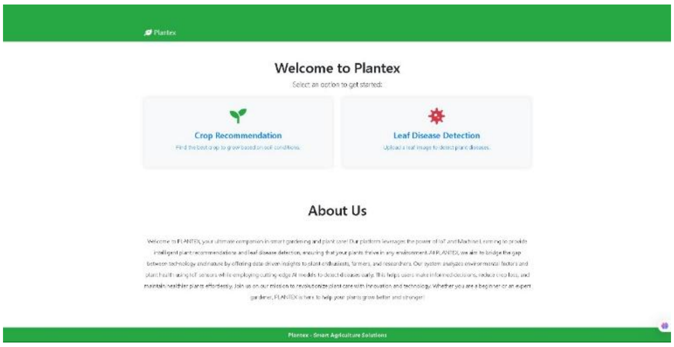

Fig 4: Dashboard Page

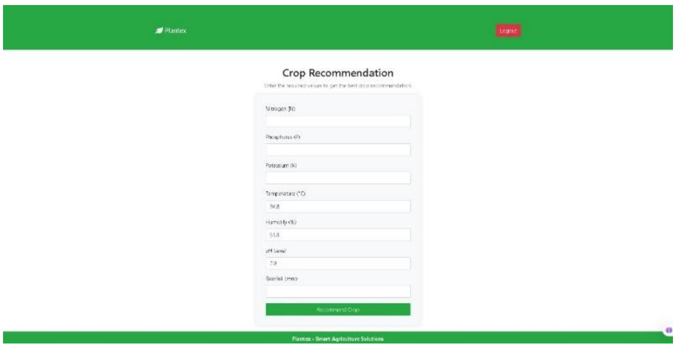

Fig 5: Crop Recommendation Input Page

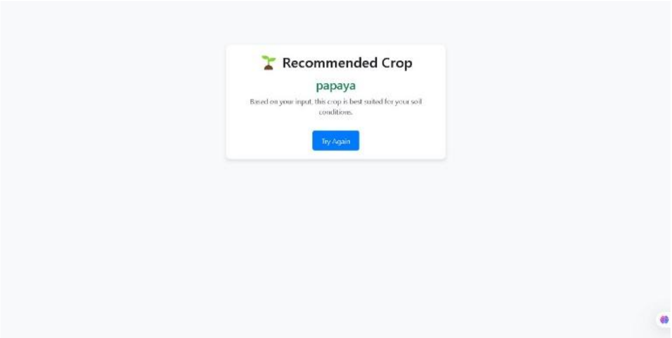

Fig 6: Crop Recommendation Result Page

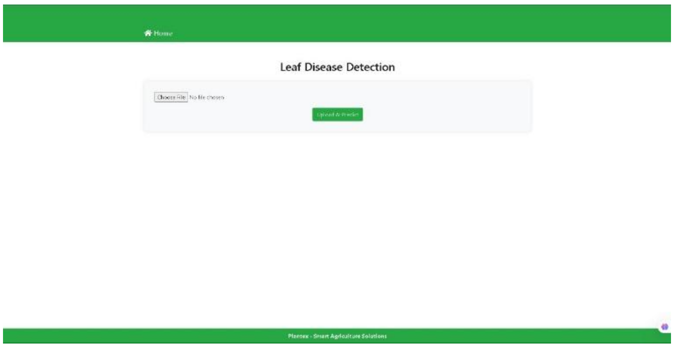

Fig 7: Leaf Disease Detection Input Page

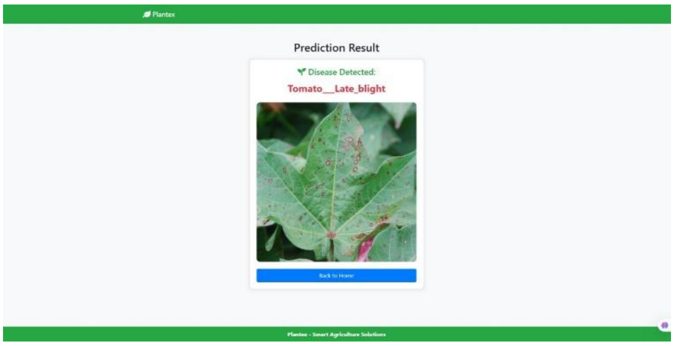

Fig 8: Leaf Disease Detection Result Page

6. CONCLUSION

The Crop Recommendation and Disease Detection System addresses modern agricultural challenges using advanced sensors, machine learning, and deep learning. It provides real-time insights for optimal crop selection and early disease detection, enhancing productivity while reducing resource use and environmental impact.

By integrating temperature, humidity, pH sensors, and cameras with cloud-based computing, farmers can monitor conditions and take proactive measures to minimize crop losses. Its user-friendly, scalable design makes it accessible to farms of all sizes, supporting efficient, sustainable, and profitable agriculture. Intelligent systems like this are key to ensuring food security and climate resilience.

REFERENCES

[1] Pradeepa Bandara, Thilini Weerasooriya, Ruchirawya T.H., W.J.M. Nanayakkara, Dimantha M.A.C, Pabasara M.G.P – "Crop Recommendation System", International Journal of Computer Applications (0975 – 8887) Volume 175– No. 22, October 2020

[2] "Plant Recommendation System with the Use of Weather Forecasting", Maulik Dhamecha,Department of Computer Engineering, VVP Engineering College, Rajkot, Gujarat, India, International Conference on Emerging Technologies: AI, IoT, and CPS for Science & Technology Applications, September 06–07, 2021, NITTTR Chandigarh, India

[3] "Ensemble machine learning based recommendation system for effective prediction of suitable agricultural crop cultivation", Mahmudul Hasan, Md Abu Marjan, Md Palash Uddin, Masud Ibn Afjal, Seifedine Kardy, Shaoqi Ma and Yunyoung Nam, 10 August 2023

[4] "Plant disease detection and classification techniques: a comparative study of the performances", Wubetu Barud Demilie, Journal of Big Data (2024) 11:5

[5] "A comprehensive review on detection of plant disease using machine learning and deep learning approaches", C Jackulin, S. Murugavalli Department of CSE, Panimalar Engineering College, Tamilnadu, India, Measurement: Sensors 24 (2022) 100441

[6] "Smart farming: crop recommendation using machine learning with challenges and future ideas", Devendra Dahiphale, Pratik Shinde, Koninika Patil, and Vijay Dahiphale, journal of ieee transactions on artificial intelligence, vol. 00, no. 0, month 2023

[7] "Crop recommendation system for growing best suitable crop", Yash Gupta and Garima Srivastava, International Journal of Science and Research Archive. Amity School Of Engineering and Technology, Amity University Uttar Pradesh, Lucknow, India

[8] "An Effective Approach for Crop Recommendation with Using Features of Specific Locations and Seasons and Maximize Crop Yield Production by Using Machine Learning", Dr. Pawan, Ms. Deepika Yadav, Mr. Ram Kumar Sharma, Mr. Mukesh Kumar, Ms. Jyoti Rani, Dr. Nidhi Sharma, International Journal of Intelligent Systems and Applications in Engineering

[9] "Leaf Disease Detection and Classification", B V Nikitha, N K S. Keerthanb, Praneeth M.Sc, Dr. Amrita Td, Department of Computer Science, Amrita Vishwa Vidyapeetham, Bangalore-560035, India

[10] J A.; Eunice, J.; Popescu, D.E.; Chowdary, M.K.; Hemanth, J. "Deep Learning-Based Leaf Disease Detection in Crops Using Images for Agricultural Applications", Agronomy 2022

[11] "Plant Disease Detection and Classification Using Machine Learning and Deep Learning Techniques: Current Trends and Challenges", Yasmin M. Alsakar, Nehal A. Sakr, Mohammed Elmogy The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2023