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CNN-Based Crop Disease Detection and Soil Recommendation

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ABSTRACT

Identification of the crop diseases is the key to prevent the losses in the yield and quantity of the agricultural production. The study of the crop diseases detection mean the studing of visually observable patterns seen on the crop. Health monitoring and disease detection on crop is very critical for sustainable agriculture. It is very difficult to monitor the crop diseases manually. It requires tremendous amount of work, expertise in the crop diseases, and also require the excessive processing time. Hence, image processing is used for the detection of crop diseases by capturing the images of the leaves and comparing it with the data sets. The data set consist of different images of diseased leaves of the crop.

The proposed (Convolutional Neural Networks) CNN-based model utilizes deep learning to automatically extract features from crop images for disease detection. A diverse dataset of healthy and diseased crops enhances generalization. The CNN architecture captures intricate patterns, while transfer learning improves efficiency and accuracy. Experimental results confirm the model's effectiveness, outperforming traditional methods and demonstrating robustness across various diseases and soil recommendation. Additionally, the model's real-time applicability highlights its potential for on-site disease detection.

Keywords: Convolutional Neural Networks, crop disease detection, soil recommendation, agriculture, crop productivity

1. Introduction

The proposed system aims to develop a comprehensive crop disease detection system utilizing advanced technologies in image processing and deep learning. The primary objective is to address the challenges associated with manual monitoring of crop health, ultimately preventing losses in agricultural yield and quantity. This system encompasses several key components, starting with the collection of a diverse dataset containing images of both healthy crops and crops affected by various diseases. These images are sourced from multiple sources, including farms, research institutions, and online repositories, to ensure the dataset's richness and representativeness across different agricultural contexts. Once the dataset is compiled, preprocessing techniques are applied to enhance the quality and consistency of the images. This includes tasks such as resizing, normalization, and augmentation to improve the robustness of the deep learning model during training.

The core of the this system lies in the development and training of a convolutional neural network (CNN)-based model, specifically designed for image analysis tasks. CNNs have shown remarkable capabilities in automatically learning and extracting relevant features from images, making them well-suited for crop disease detection. The model is trained on the preprocessed dataset, adjusting its parameters iteratively to minimize the difference between detected and actual disease labels. Evaluation of the trained model is conducted using various performance metrics, including accuracy, precision, recall, and F1-score. This assessment ensures the effectiveness of the model in accurately detecting and classifying crop diseases across different crops and diseases. Throughout this system, a strong emphasis is placed on collaboration and knowledge sharing with relevant stakeholders, including farmers, agricultural experts, and technology providers. Their input and feedback play a crucial role in shaping the development and deployment of the crop disease detection system, ensuring its relevance and effectiveness in real-world agricultural settings. Overall, the proposed system represents a concerted effort to harness the potential of cutting edge technologies to address pressing challenges in agriculture.

2. Literature Review

Review of various research articles focusing on crop disease detection using machine learning techniques were given below.

The study [1] addresses the critical role of agriculture in global economies and the challenges posed by plant diseases to food security. Leveraging the "PlantVillage" dataset, the researchers employed deep learning architectures—AlexNet, GoogleNet, ResNet50, and InceptionV3—to identify plant diseases. They explored two training approaches: 'training from scratch' and 'transfer learning.' GoogleNet achieved the highest accuracy of 99.9% for color images and 99.6% for segmented images. These findings underscore the potential of deep learning methods to enhance the efficiency and accuracy of disease diagnosis in agriculture.

The research [2] focuses on the early detection of plant diseases to prevent reduced crop yields and economic losses. The authors developed a framework combining Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) models. The CNN component demonstrated remarkable accuracy, achieving a 98.4% success rate in identifying plant diseases from static images. The study highlights the effectiveness of deep learning models in enhancing plant disease detection and classification.

The article [3] proposes a method for crop disease detection using preprocessing and segmentation processes with filtering and neural network techniques. The dataset was created using historical cultivation data and live images from the field. The images were preprocessed using convoluted Gaussian filtering and segmented using an active contour neural network (ACNN). A 2D Convolutional Neural Network (CNN) was then employed to classify and detect crop diseases. The results indicate that the proposed method is robust for crop disease detection, effectively segmenting major plant leaf diseases such as Cercospora Leaf Spot, Bacterial Blight, Powdery Mildew, and Rust.

Paper [4] uses machine learning (Random Forest, Decision Trees, SVM) to predict soil fertility based on parameters like pH, nitrogen, and potassium. Random Forest showed the highest accuracy, proving ML’s effectiveness in guiding crop selection and fertilization.

A ML-based crop recommendation system [5] analyzes soil properties (pH, moisture, nutrients) to suggest suitable crops. KNN performed best, showing ML's potential to optimize agricultural productivity through data-driven crop selection.

3. Proposed Methodology

Traditional crop disease detection methods include visual inspection, where experts identify symptoms like discoloration and lesions, but this approach is subjective and prone to errors. Manual sampling and laboratory testing provide accurate results through techniques like PCR and microscopy, yet they are time-consuming and expensive. Spectral and hyperspectral imaging analyze crop spectral signatures for real-time disease detection, but their effectiveness depends on environmental conditions and requires advanced equipment.

Challenges in disease detection include dependency on environmental conditions, as spectral imaging needs proper lighting and clear weather for accuracy. Additionally**,** high equipment costs and technical expertise make it difficult to implement these methods, especially in rural or resource-limited areas. These limitations highlight the need for a more accessible and automated solution.

The proposed system uses image-based analysis for efficient disease detection. It captures high-resolution images via cameras, drones, or UAVs, followed by preprocessing techniques to enhance quality. Feature extraction helps identify disease patterns, and machine learning models like CNNs classify images as healthy or diseased, improving accuracy with transfer learning. This approach offers a scalable and automated solution for modern agriculture.

The proposed system has five modules. They are

- Login module
- Register module
- Home page
- Detection module
- Soil recommendation module

Register Module

Users can create an account by providing necessary information such as name, email username, password, and mobile number.

Login Module

Using the information from register page user can login to their accounts.

Home Page

After executing the url, as output screen Home page is being displayed then it consists of two important module namely detect and soil recommendation

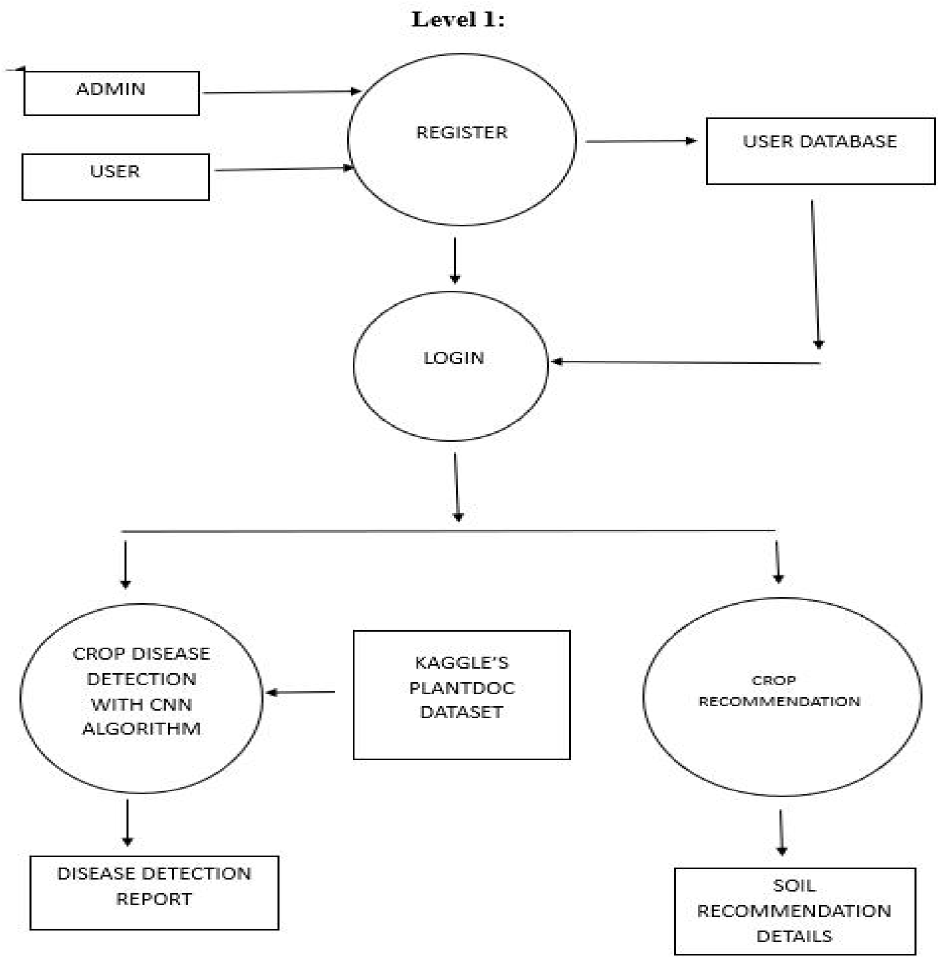
Detection Module

The **Detection Module** is a key part of a machine learning system designed to identify crop diseases. It allows users to select and upload crop images, which are then processed and analyzed by a pre-trained model. Once the image is submitted, the user simply clicks a button to initiate detection. The model evaluates the input and provides the desired output, such as identifying whether the crop is healthy or diseased and, if applicable, specifying the type of disease. This module simplifies the disease detection process, making it user-friendly and efficient.

Soil Recommendation Module

The Soil Recommendation Module is designed to suggest the most suitable soil type for a selected crop, helping optimize agricultural productivity. Users begin by selecting the appropriate category and crop from the available options. Once selected, they click on the soil recommendation button, and the system analyzes the input to provide tailored soil type suggestions. This module ensures that crops are matched with optimal soil conditions, supporting better growth and yield.

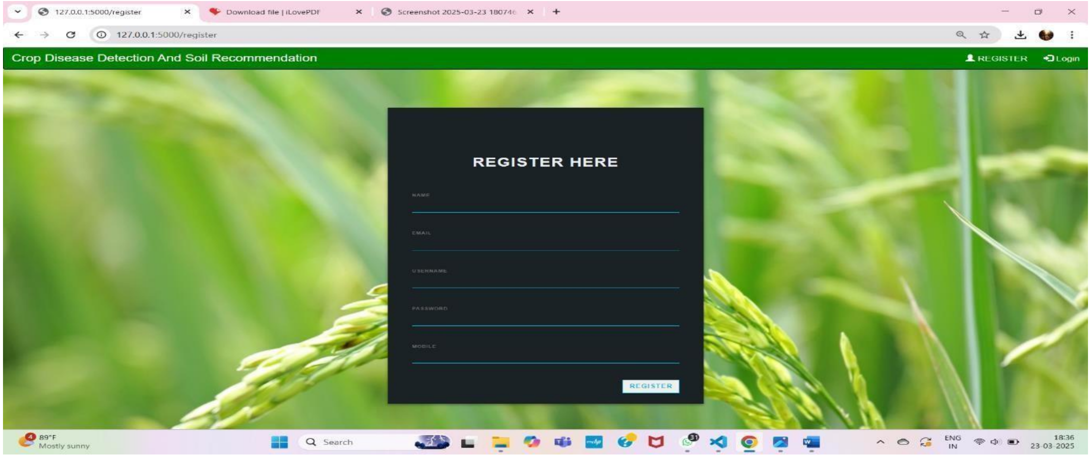
Data Flow Diagram



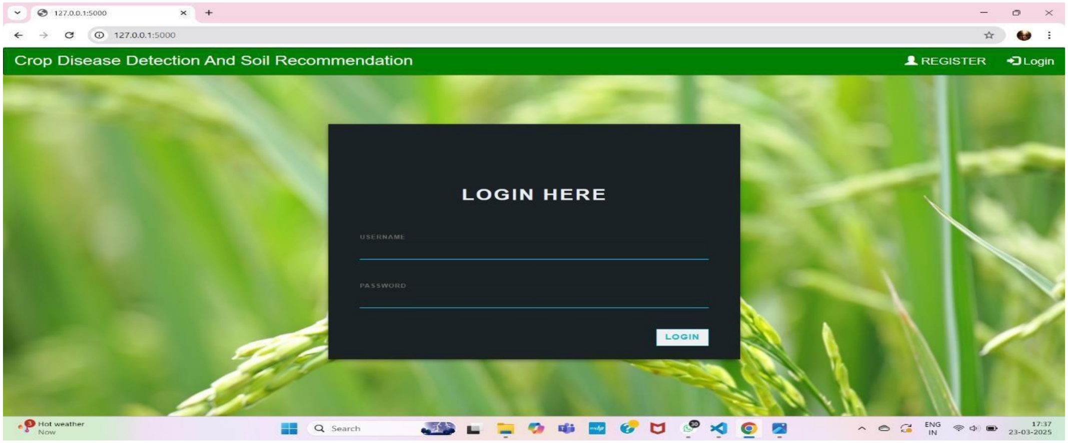
4. Results and Discussions

Convolutional Neural Networks (CNNs) are deep learning models designed for image analysis. They consist of layers like convolutional layers for feature extraction, pooling layers for reducing dimensionality, activation functions to introduce non-linearity, and fully connected layers for classification. CNNs learn patterns such as edges and textures to detect and classify visual data, making them highly effective for tasks like crop disease detection.

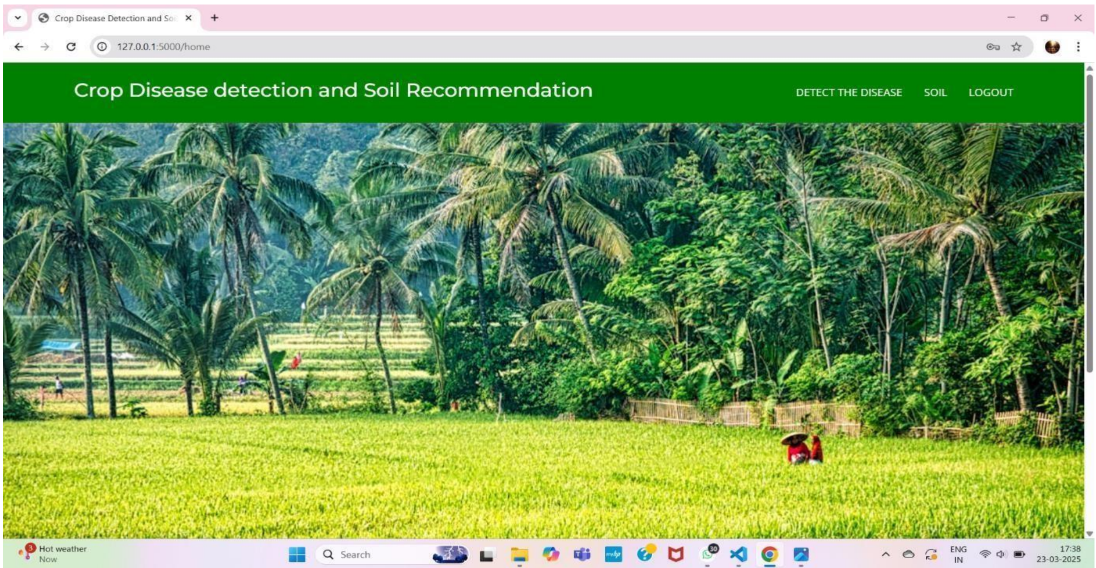
The **PlantDoc dataset**, introduced in 2019 by IIT Gandhinagar researchers, supports the development of CNN models for plant disease detection. It contains 2,598 real-world images covering 13 plant species and 17 disease types. Captured in natural settings with diverse backgrounds and lighting, the dataset helps train robust models capable of handling real-world agricultural challenges. The detection results are given below in the screenshots.



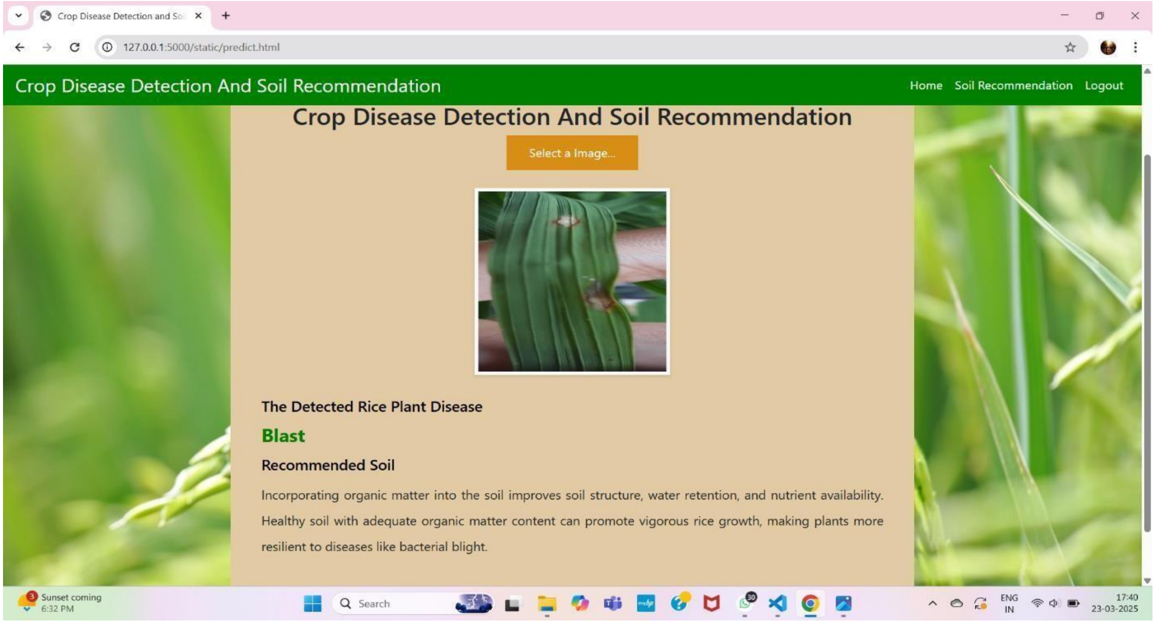
REGISTER



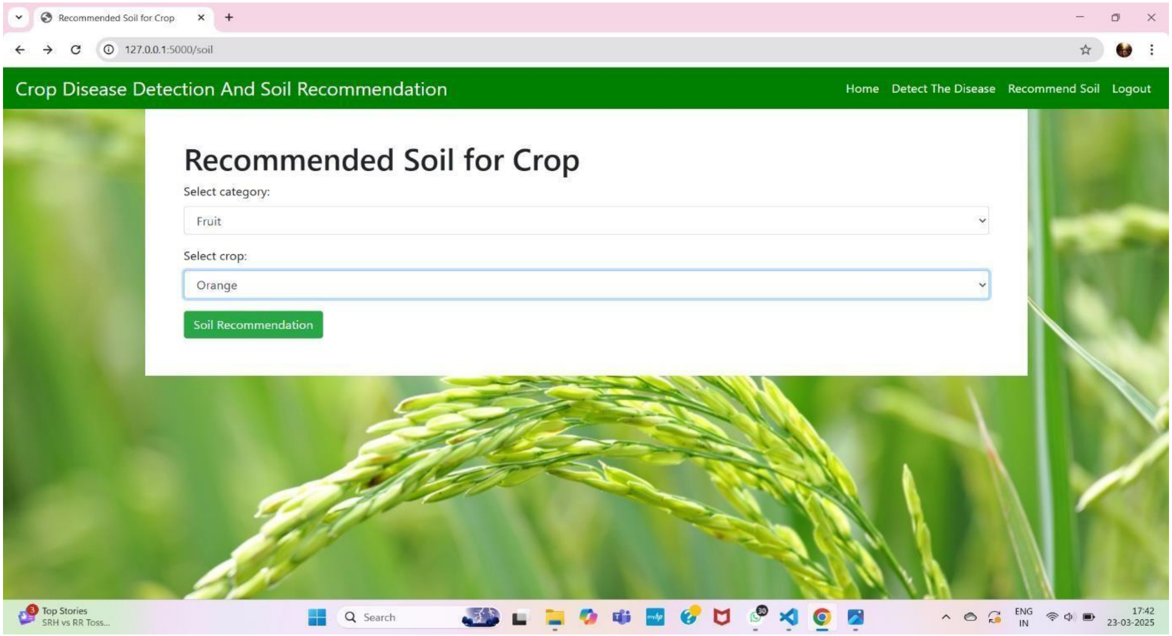
LOGIN PAGE



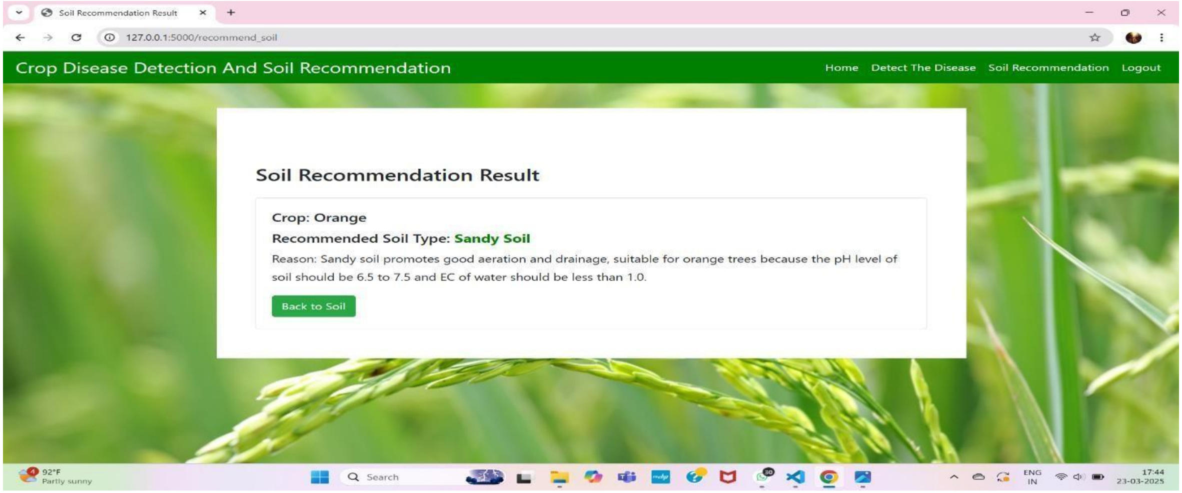
HOME PAGE



DETECTION MODULE



SOIL RECOMMENDATION MODULE



5. Conclusion

The integration of technology into crop disease detection and soil recommendation is transforming agriculture by enabling early disease diagnosis and precise soil analysis through sensors, imaging, and machine learning. These advancements help improve crop yields and reduce environmental impact. However, challenges such as system scalability, affordability, integration with current farming practices, and concerns over data privacy and digital literacy remain. Addressing these issues through continued research, collaboration, and investment will be essential to making agriculture more sustainable, efficient, and accessible for farmers at all levels.

Future technologies in crop disease detection and soil recommendation will enhance farming through AI, sensors, and real-time monitoring. These tools help farmers improve yield, reduce environmental impact, and support sustainable, resilient agriculture.

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