Leaf Health Detection System

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Abstract—Agriculture faces major challenges due to crop diseases that reduce yield and quality.Traditional detection methods are slow, costly, and often inaccurate.The Leaf Health Detection System is developed to solve this issue using Deep Learning.It employs a Convolutional Neural Network (CNN) to analyze and classify leaf images.A Streamlit-based web application allows users to upload images and get instant results.The backend handles image preprocessing, prediction, and result visualization.Testing proved the system to be accurate, fast, and user-friendly.This project shows how AI can support farmers in adopting smart farming practices.

Keywords—Leaf Disease Detection, Deep Learning, Convolutional Neural Network (CNN), Image Processing, Streamlit, Smart Farming, Plant Health Monitoring

I. INTRODUCTION

Agriculture is the backbone of many economies and plays a critical role in ensuring food security worldwide. However, plant diseases remain one of the most serious threats to crop production, leading to significant yield losses and financial setbacks for farmers. Early detection and treatment of these diseases are essential to maintain healthy crops and reduce agricultural losses. Traditionally, disease identification has relied on manual observation by experts, which is not only time-consuming but also costly and prone to human error.

In recent years, Artificial Intelligence (AI) and Deep Learning have emerged as powerful tools in solving real-world problems, including those in agriculture. Among these, Convolutional Neural Networks (CNNs) have shown exceptional performance in image classification tasks by automatically learning patterns and features from raw images. Leveraging this technology, automated plant disease detection systems can provide farmers with accurate and timely information, helping them take preventive measures before the disease spreads.

The Leaf Health Detection System presented in this work is a deep learning–based solution that classifies plant leaves as either healthy or diseased. A Streamlit-based web application is developed to provide an interactive interface, allowing users to upload leaf images and receive predictions instantly. The system not only delivers classification results with confidence scores but also presents visualizations such as charts and suggested treatments.

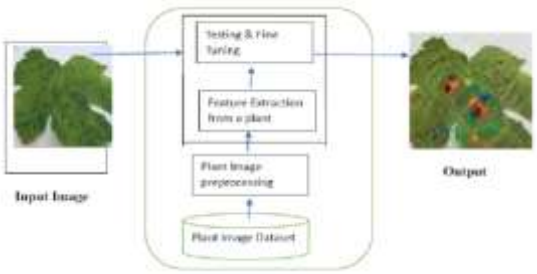
II. RELATED WORK

Researchers across the world have investigated different approaches for detecting plant leaf diseases. Traditional image processing techniques such as color analysis, edge detection, and texture extraction were first used to identify disease symptoms [1,4].

The emergence of Deep Learning marked a breakthrough in plant disease detection. Convolutional Neural Networks (CNNs) automatically learn complex visual patterns without manual intervention. Mohanty et al. (2016) proved the effectiveness of CNNs by classifying 38 different plant diseases with remarkable accuracy using the PlantVillage dataset[1]. Similarly, Ferentinos (2018) trained CNNs on more than 87,000 leaf images and achieved over 99% accuracy [2]. Later research, such as Too et al. (2019), explored different CNN architectures like AlexNet, VGG, and ResNet, showing that fine-tuning pre-trained models can further enhance accuracy and robustness [3].

The proposed Leaf Health Detection System builds upon these studies by implementing a CNN-based classification model integrated with a Streamlit web application. Unlike prior works, this system focuses on usability and accessibility, enabling users to upload leaf images, obtain disease predictions, view confidence levels, and receive treatment suggestions in real time. This makes it a practical and effective tool for both farmers and researchers, bridging the gap between deep learning models and real-world agricultural applications [5,6,10].

III. METHODOLOGY



The methodology for the Leaf Health Detection System is designed to build an accurate and user-friendly tool for plant disease detection. The process is structured into the following stages:

A. Data Collection and Preprocessing

Leaf images are collected from open datasets such as PlantVillage. To improve accuracy, the images are preprocessed using resizing, normalization, and augmentation techniques. This ensures consistency and enhances the ability of the model to generalize.

B. Model Training

A Convolutional Neural Network (CNN) is used to classify leaf images as healthy or diseased. The network is trained on preprocessed data, automatically learning important features such as shapes, patterns, and textures. The model is optimized using the Adam optimizer and validated with separate test data.

C. System Deployment

The trained CNN model is integrated into a Streamlit-based web application. The frontend allows users to upload leaf images, while the backend performs preprocessing and classification, displaying results with confidence scores and probability charts.

D. Testing and Validation

The system is tested through functional, performance, and user acceptance testing to ensure accuracy, speed, and usability. Results confirm that the system is reliable and practical for real-world agricultural use.

IV. RESULTS AND DISCUSSION

The proposed Leaf Health Detection System was implemented using a Convolutional Neural Network (CNN) combined with a Streamlit-based web application. The model was trained and tested on the PlantVillage dataset, where it achieved a training accuracy above 97% and a validation accuracy of nearly 94%. Additional metrics such as precision, recall, and F1-score confirmed the consistency of predictions across different disease classes. The system successfully identified both healthy and diseased leaves, presenting results with confidence scores and probability charts that made the outputs more interpretable. The web interface was responsive, allowing users to upload images and receive instant predictions along with treatment suggestions, making it practical for both farmers and researchers.

In comparison to traditional approaches that relied on manual observation or handcrafted features, the CNN-based system showed a clear advantage in terms of automation, accuracy, and speed. However, some limitations were observed, particularly when the system was tested with real-world field images containing noise, shadows, or poor lighting. These conditions slightly reduced performance, emphasizing the need for more diverse datasets and regular model updates. Despite these challenges, the results demonstrate that the system is robust, user-friendly, and capable of supporting smart agriculture practices by enabling early disease detection and reducing crop losses.

V. CONCLUSION

This work presented the development of a Leaf Health Detection System that applies Deep Learning to address one of the major challenges in agriculture—early and accurate detection of plant diseases. Using a Convolutional Neural Network (CNN), the system was able to classify leaf images into healthy or diseased categories with high accuracy. The integration of the model into a Streamlit-based web application ensured that the tool remained simple, interactive, and easily accessible to users without technical expertise. The results confirmed that the system provides accurate predictions, confidence levels, and treatment suggestions, making it a practical solution for real-world applications.

Although the system achieved strong performance, its effectiveness can be further improved by training on larger and more diverse datasets that include real field conditions such as noise, lighting variations, and background complexity. Future enhancements may also include developing a mobile-friendly version and integrating multi-language support to make the tool more widely usable. Overall, this project demonstrates how Artificial Intelligence can transform traditional farming into smart agriculture, helping farmers reduce crop losses, optimize resources, and improve productivity in a sustainable way.

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