AI Based Real-Time Crop Image Analytics for Crop Insurance – PMFBY

[1]M. Sarada, [2]M. Thanmai Gayatri, [3]P. Monika, [4]M. Rupa Venkata Naga Lakshmi

[1] Assistant Professor, Dept of CSE-AI&ML, St. Ann's College of Engineering and Technology Chirala-523187, India.

[2,3,4]U. G Student, Dept of CSE-AI&ML, St. Ann's College of Engineering and Technology Chirala-523187, India.

ABSTRACT -AI Based Real-Time Crop Image Analytics for Crop Insurance – PMFBY is an intelligent web application developed to support farmers in the early detection of crop diseases while providing guidance related to crop insurance. In traditional farming, disease identification mainly depends on manual field inspection, which is time-consuming, labor-intensive, and often delays timely treatment. Such delays may reduce crop productivity and result in financial losses for farmers. To overcome these challenges, the proposed system enables farmers to upload crop leaf images and receive real-time disease analysis along with suitable recommendations. A ResNet50-based Convolutional Neural Network (CNN) is used to accurately classify crop diseases from leaf images, while OpenCV is employed to estimate the visible affected leaf area and determine the severity of infection. Based on the severity level, the application provides preventive measures, treatment recommendations, and guidance to consult agricultural experts. For crops showing severe visible damage, the system also provides information about the Pradhan Mantri Fasal Bima Yojana (PMFBY) and directs farmers to official crop insurance resources. The application is implemented using Python, Flask, TensorFlow, Keras, OpenCV, HTML, CSS, JavaScript, and SQLite, providing a simple and user-friendly platform for real-time crop disease analysis. The proposed system supports timely decision-making, improves crop health management.

KEYWORDS: ***Crop Disease Detection, Crop Image Analytics, Deep Learning, ResNet50, OpenCV, Computer Vision, Crop Insurance, PMFBY, Flask Web Application***

INTRODUCTION

Agriculture plays a vital role in ensuring food security and supporting the economy of many countries. The productivity and quality of agricultural crops are significantly affected by plant diseases, which can spread rapidly if they are not detected at an early stage. In many farming regions, disease identification is still performed through manual field inspection. This traditional approach requires considerable time, experience, and continuous monitoring, making it difficult for farmers to identify diseases at the right time. Delayed detection often results in reduced crop yield, increased cultivation costs, and financial losses.

Recent advancements in artificial intelligence, deep learning, and computer vision have created new opportunities for developing intelligent agricultural applications. Convolutional Neural Networks (CNNs) have demonstrated excellent performance in image classification tasks, making them suitable for automatic crop disease detection. In this work, a ResNet50-based CNN is employed to classify crop diseases from leaf images, while OpenCV is used to estimate the visible affected leaf area and determine the severity of infection. Based on the estimated severity, the application provides preventive measures, treatment recommendations, and guidance to consult agricultural experts. For crops with severe visible damage, the system also provides information about the Pradhan Mantri Fasal Bima Yojana (PMFBY) and directs farmers to official crop insurance resources. The application is implemented using Python, Flask, TensorFlow, Keras, OpenCV, HTML, CSS, JavaScript, and SQLite, offering a simple and user-friendly platform for real-time crop disease analysis and farmer assistance.

RELATED WORK

Research in crop disease detection has advanced significantly with the adoption of artificial intelligence, deep learning, and computer vision techniques. Earlier approaches mainly relied on traditional image processing methods such as color feature extraction, texture analysis, shape identification, and edge detection for recognizing plant diseases. Although these methods provided satisfactory results under controlled conditions, their performance was often affected by variations in lighting, background, and environmental conditions. With the emergence of deep learning, Convolutional Neural Networks (CNNs) such as AlexNet, VGG16, VGG19, InceptionV3, MobileNet, and ResNet50 have demonstrated remarkable performance in automatic crop disease classification using benchmark datasets like PlantVillage. Several studies have also incorporated OpenCV-based image processing techniques to identify infected regions and estimate the visible affected area of crop leaves. More recent research has focused on transfer learning models to improve classification accuracy while reducing training time and computational complexity. However, many existing systems are limited to disease classification and do not provide severity estimation, farmer-oriented recommendations, or crop insurance guidance. In addition, most available applications are developed for controlled datasets and offer limited support for real-time agricultural decision-making. These limitations motivated the development of the proposed AI Based Real-Time Crop Image Analytics for Crop Insurance – PMFBY system, which integrates ResNet50-based disease classification, OpenCV-based affected area estimation, severity-based recommendations, and PMFBY guidance through a user-friendly Flask web application.

LITERATURE SURVEY

Several researchers have proposed deep learning techniques for automatic crop disease detection using plant leaf images. Mohanty et al. (2016) introduced one of the earliest CNNbased approaches using the PlantVillage dataset and achieved an accuracy of 99.35% under controlled laboratory conditions. However, the study reported that the model's performance decreased when evaluated on real-field images due to differences in lighting conditions, background complexity, and image quality. Ferentinos (2018) evaluated deep convolutional neural networks, including VGGNet architectures, for plant disease recognition and demonstrated that deep learning models can effectively distinguish healthy and diseased crop leaves. The study also highlighted the advantages of transfer learning for improving classification accuracy with limited training effort. Too et al. (2019) compared several pretrained deep learning models, including ResNet50, DenseNet121, MobileNet, InceptionV3, and VGG16, and concluded that transfer learning significantly improves classification performance while reducing computational cost. Several recent studies have also incorporated OpenCV-based image processing techniques to segment infected leaf regions and estimate the visible affected area for disease severity assessment. Although these approaches have achieved high classification accuracy, many existing systems primarily focus on disease identification and lack practical features such as recommendation generation, severity-based decision support, and crop insurance guidance. Motivated by these research gaps, the proposed work integrates ResNet50-based disease classification, OpenCV-based severity estimation, and PMFBY information within a real-time Flask web application to provide comprehensive decision support for farmers.

EXISTING METHOD

One of the widely recognized approaches for crop disease detection was proposed by Mohanty et al. (2016), who utilized deep Convolutional Neural Networks (CNNs) such as AlexNet and GoogLeNet on the PlantVillage dataset to classify plant diseases. The proposed model achieved high classification accuracy under controlled laboratory conditions, demonstrating the effectiveness of deep learning for automatic disease recognition. However, the system was primarily designed for disease classification and did not estimate the severity of infection or provide recommendations to farmers. In addition, the model relied on images captured in controlled environments with clean backgrounds, making its performance less reliable when applied to real agricultural conditions where variations in lighting, leaf orientation, and background noise are common. The existing approach also lacked a user-friendly web interface and did not include support for crop insurance or decision-making assistance after disease detection. As a result, farmers were required to depend on external sources for treatment recommendations and insurance-related information. These limitations reduce the practical usability of the existing system in real-world farming applications and highlight the need for a more comprehensive solution that combines disease classification, severity estimation, recommendation generation, and crop insurance guidance within a single intelligent platform.

PROPOSED METHOD

The proposed AI Based Real-Time Crop Image Analytics for Crop Insurance – PMFBY system is designed to overcome the limitations of existing crop disease detection methods by integrating disease classification, severity estimation, recommendation generation, and crop insurance guidance into a single web-based platform. Unlike earlier approaches that focused only on disease recognition using laboratory-based datasets, the proposed system provides additional decision support to farmers after disease detection. A ResNet50-based Convolutional Neural Network (CNN) is employed to accurately classify crop diseases from uploaded leaf images by utilizing transfer learning, which improves classification performance while reducing training time. After disease prediction, OpenCV is used to estimate the visible affected leaf area and determine the severity of infection. Based on the severity level, the application generates appropriate preventive measures, treatment recommendations, and advises farmers to consult agricultural experts whenever necessary. For crops showing severe visible damage, the system also provides guidance about the Pradhan Mantri Fasal Bima Yojana (PMFBY), including official crop insurance resources and application information. The entire application is implemented using Python, Flask, TensorFlow, Keras, OpenCV, HTML, CSS, JavaScript, and SQLite, providing a simple, interactive, and user-friendly interface. By combining disease detection with severity analysis, recommendation generation, and crop insurance support, the proposed system offers a more practical and comprehensive solution.

SYSTEM ARCHITECTURE

Fig. 1. Architecture of the AI Based Real-Time Crop Image Analytics Web Application

MODULE DESCRIPTION

1.User Sign Up Module

The User Sign Up Module allows new farmers to create an account by providing details such as name, username, email address, phone number, and password. The entered information is validated and securely stored in the SQLite database. After successful registration, users can access the application by logging in with their credentials. This module ensures that only registered users can use the crop disease analysis system.

2. User Sign In Module

The User Sign In Module authenticates registered farmers using their username and password. After successful verification, users are redirected to the dashboard, where they can upload crop leaf images and view disease analysis results. This module provides secure access to the application while protecting user information and preventing unauthorized access.

3. Admin Sign In Module

The Admin Sign In Module provides secure access for the administrator using predefined login credentials. After successful authentication, the administrator can access the admin dashboard to monitor registered users, view prediction history, analyze graphical visualizations, and manage the overall system. This module ensures that administrative operations are restricted to authorized personnel.

4. Crop Image Upload Module

The Crop Image Upload Module enables farmers to enter crop details such as farmer name, crop name, district, and insurance policy information before uploading a crop leaf image.

The uploaded image is stored in the server and prepared for further processing. This module acts as the input stage of the proposed system for real-time disease analysis.

5. Crop Disease Detection Module

The Crop Disease Detection Module is the core component of the application. It utilizes a ResNet50-based Convolutional Neural Network (CNN) to analyze uploaded crop leaf images and identify the corresponding disease.

The trained deep learning model predicts the disease class with high accuracy and also provides the confidence score, enabling reliable and efficient disease diagnosis.

6. Severity Analysis Module

The Severity Analysis Module employs OpenCV image processing techniques to estimate the visible affected area of the crop leaf.

It highlights the infected regions, calculates the percentage of damaged leaf area, and categorizes the infection into Healthy, Mild, Moderate, or Severe levels. This information helps farmers understand the seriousness of the disease.

7. Recommendation and PMFBY Guidance Module

Based on the predicted disease and severity level, this module generates suitable preventive measures and treatment recommendations.

It also advises farmers to consult agricultural experts when required. If severe damage is detected, the system provides information about the Pradhan Mantri Fasal Bima Yojana (PMFBY), including official crop insurance guidance and useful resources.

8. Admin Dashboard Module

The Admin Dashboard Module enables the administrator to monitor and manage the entire application through a centralized interface. It provides access to registered users, prediction history, graphical visualizations, and system reports.

This module helps in tracking user activities, analyzing disease prediction records, and maintaining the overall performance of the application.

RESULTS AND DISCUSSION

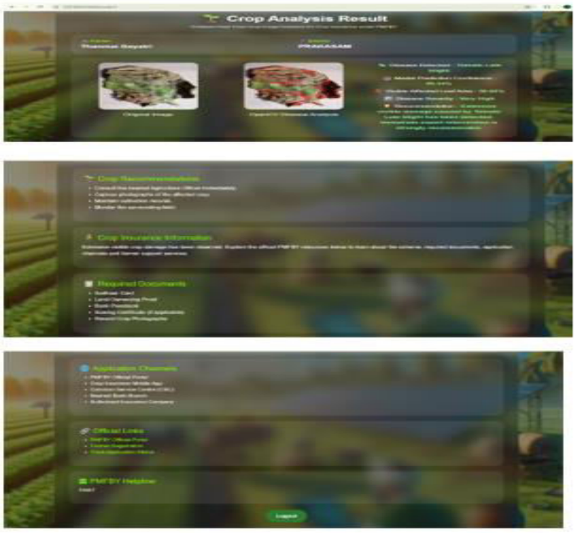

Fig. 2. Crop Disease Analysis Result with Very High Severity, Recommendations, and PMFBY Insurance Guidance

Figure 2 presents the complete output of the proposed AI-Based Real-Time Crop Image Analytics for Crop Insurance – PMFBY system for a crop affected by Tomato Late Blight. After the farmer uploads a crop leaf image, the fine-tuned ResNet50 model accurately identifies the disease with a prediction confidence of 99.34%. The OpenCV module highlights the infected regions of the leaf and estimates that 50.83% of the visible leaf area is affected, classifying the disease as Very High severity. Based on this analysis, the application generates suitable crop management recommendations and provides complete PMFBY crop insurance guidance, including the required documents, application channels, official PMFBY resources, and helpline details. This output demonstrates the system's capability to support farmers by combining disease diagnosis, severity estimation, treatment recommendations, and crop insurance assistance within a single web application.

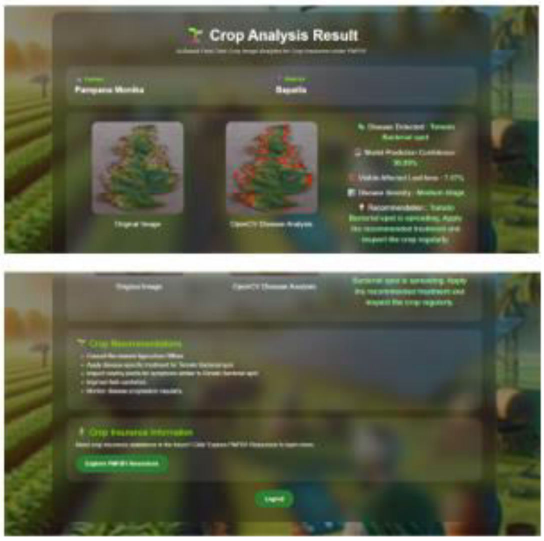

Fig. 3. Crop Disease Analysis Result with Medium Stage Severity, Recommendations, and PMFBY Resource Guidance

Figure 3 presents the complete output of the proposed AI-Based Real-Time Crop Image Analytics for Crop Insurance – PMFBY system for a crop affected by Tomato Bacterial Spot. After the farmer uploads the crop leaf image, the fine-tuned ResNet50 model accurately classifies the disease with a prediction confidence of 99.99%. The OpenCV module identifies the infected regions of the leaf and estimates that 7.07% of the visible leaf area is affected, categorizing the disease as Medium Stage.

Based on the severity level, the system generates appropriate crop management recommendations, including disease-specific treatment, regular monitoring, and improved field sanitation. Since the crop damage is moderate, the application provides an option to explore PMFBY crop insurance resources for future assistance instead of displaying complete insurance claim details. This output demonstrates the system's ability to provide accurate disease diagnosis, severity estimation, and timely farmer guidance through a single integrated web application.

CONCLUSION

This paper presented an AI-Based Real-Time Crop Image Analytics for Crop Insurance – PMFBY system that assists farmers in the early detection and management of crop diseases. The proposed system integrates a fine-tuned ResNet50 deep learning model for accurate disease classification with OpenCV for visible affected area estimation and disease severity analysis. Based on the severity level, the application provides appropriate treatment recommendations and PMFBY crop insurance guidance when required. Developed as a user-friendly Flask web application, the system supports timely decision-making, improves crop health management, and enhances farmers' awareness of crop insurance services, contributing to smarter and more sustainable agriculture.

FUTURE SCOPE

The proposed system can be further enhanced by expanding the dataset to include a wider variety of crops and diseases collected from real-field environments, thereby improving model robustness and prediction accuracy. A mobile application can be developed to enable farmers to capture crop images and receive instant disease analysis using smartphones. Integration of weather information, IoT sensors, and satellite data can support early disease prediction and preventive alerts. The application can also be extended with multilingual support to improve accessibility for farmers across different regions. Cloud deployment and continuous model updates can further enhance scalability, real-time performance, and practical adoption in smart agriculture.

REFERENCES

[1] S. P. Mohanty, D. P. Hughes, and M. Salathé, "Using Deep Learning for Image-Based Plant Disease Detection," *Frontiers in Plant Science*, vol. 7, p. 1419, Sept. 2016. doi: 10.3389/fpls.2016.01419.

[2] K. P. Ferentinos, "Deep Learning Models for Plant Disease Detection and Diagnosis," *Computers and Electronics in Agriculture*, vol. 145, pp. 311–318, 2018.

[3] E. C. Too, L. Yujian, S. Njuki, and L. Yingchun, "A Comparative Study of Fine-Tuning Deep Learning Models for Plant Disease Identification," *Computers and Electronics in Agriculture*, vol. 161, pp. 272–279, 2019.

[4] K. He, X. Zhang, S. Ren, and J. Sun, "Deep Residual Learning for Image Recognition," in *Proc. IEEE Conf. Computer Vision and Pattern Recognition (CVPR)*, Las Vegas, NV, USA, 2016, pp. 770–778.

[5] S. Sladojevic, M. Arsenovic, A. Anderla, D. Culibrk, and D. Stefanovic, "Deep Neural Networks Based Recognition of Plant Diseases by Leaf Image Classification," *Computational Intelligence and Neuroscience*, vol. 2016, Article ID 3289801, 2016.

[6] A. Fuentes, S. Yoon, S. Kim, and D. S. Park, "A Robust Deep-Learning-Based Detector for Real-Time Tomato Plant Diseases and Pests Recognition," *Sensors*, vol. 17, no. 9, p. 2022, 2017.

[7] M. Tan and Q. V. Le, "EfficientNet: Rethinking Model Scaling for Convolutional Neural Networks," in *Proc. 36th Int. Conf. Machine Learning (ICML)*, 2019.

[8] OpenCV Team, *OpenCV: Open Source Computer Vision Library*. Available: https://opencv.org

[9] TensorFlow Developers, *TensorFlow: An End-to-End Open Source Machine Learning Platform*. Available: https://www.tensorflow.org

[10] F. Chollet, *Keras: The Python Deep Learning API*. Available: https://keras.io

[11] Pal Szilard, *Flask Web Development*, 2nd ed. Sebastopol, CA, USA: O'Reilly Media, 2018.

[12] SQLite Consortium, *SQLite Documentation*. Available: https://www.sqlite.org

[13] S. P. Mohanty, *PlantVillage Dataset*. GitHub Repository. Available: https://github.com/spMohanty/PlantVillage-Dataset

[14] W. J. Jiao *et al.*, "A ResNet50-DPA Model for Tomato Leaf Disease Identification," *Frontiers in Plant Science*, vol. 14, 2023