

# A Transparent Deep Learning Approach for Mango Leaf Disease Classification

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**Abstract** - Mango leaf diseases pose a significant threat to crop yield and quality, directly impacting agricultural productivity and farmer livelihoods. Accurate and timely detection of these diseases is essential for effective disease management and sustainable farming practices. This project proposes a deep learning-based approach for automated mango leaf disease classification using the Xception (Extreme Inception) model, a state-of-the-art convolutional neural network (CNN) architecture. Xception leverages depthwise separable convolutions to efficiently capture fine-grained patterns such as texture, color variations, and lesion shapes in leaf images, enabling high accuracy in disease classification. To ensure data privacy and scalability, the system incorporates federated learning, allowing multiple agricultural institutions or farmer cooperatives to collaboratively train the model without sharing raw data. This decentralized approach prevents unauthorized access to sensitive datasets while continuously improving model performance across diverse environments. The proposed system thus combines advanced deep learning techniques with privacy-preserving collaborative learning, offering a robust, secure, and scalable solution for early detection and classification of mango leaf diseases. Its implementation can contribute significantly to precision agriculture, reducing economic losses and supporting sustainable crop management.

**Key Words:** Mango Leaf Disease Detection, Deep Learning, CNN, Xception Model, Federated Learning, Precision Agriculture.

## 1. INTRODUCTION

Agriculture plays a crucial role in sustaining the global economy, particularly in tropical regions where mango cultivation is a major source of income for farmers. However, mango production faces significant challenges due to the widespread occurrence of leaf diseases such as

anthracnose, bacterial canker, and powdery mildew, which severely affect yield quality and quantity. Traditional methods of disease detection rely on manual inspection by experts, which is time-consuming, subjective, and often impractical for large-scale monitoring. With the rapid advancements in artificial intelligence and computer vision, deep learning-based models have emerged as powerful tools for automated plant disease diagnosis. This project focuses on developing an intelligent system for mango leaf disease classification using the Xception (Extreme Inception) model, a highly efficient convolutional neural network capable of extracting intricate visual features from leaf images. To enhance security and data privacy, federated learning is integrated into the framework, enabling collaborative model training across multiple sources without sharing sensitive data. By combining accuracy, scalability, and privacy-preserving capabilities, the proposed system provides an effective solution for early disease detection and precision agriculture, ultimately helping farmers mitigate losses and improve crop productivity.

## 2.LITERATURE REVIEW

Plant disease detection is an important area in agriculture because early identification of plant diseases helps improve crop yield and reduce economic loss. Traditionally, farmers identify plant diseases through manual inspection of leaves, which requires experience and expert knowledge. However, this process is time-consuming and sometimes inaccurate due to human error. To overcome these limitations, researchers have applied image processing and machine learning techniques to automate plant disease detection. Early approaches used algorithms such as Support Vector Machines (SVM), Decision Trees, and K-Nearest Neighbors (KNN). In these methods, features like color, shape, and texture were manually extracted from leaf images and then used for

classification. Although these techniques achieved moderate accuracy, they required complex feature engineering and were not very efficient when dealing with large datasets. With the advancement of artificial intelligence, deep learning techniques have significantly improved plant disease classification systems. Convolutional Neural Networks (CNNs) have become one of the most widely used approaches because they automatically extract important features from images without manual intervention. Several studies have applied CNN architectures such as AlexNet, VGGNet, ResNet, and EfficientNet to detect diseases in crops including mango, tomato, and potato. These deep learning models have demonstrated higher accuracy and better performance compared to traditional machine learning techniques. Recently, researchers have also started focusing on explainable or transparent deep learning models that provide visual explanations of predictions. These models help users understand how the system identifies diseased regions in leaf images, thereby improving reliability and trust in the system.

### 3. RELATED WORK

Several research studies have explored automated systems for plant disease detection using machine learning and deep learning techniques. Earlier works mainly relied on traditional image processing methods combined with classifiers such as SVM and KNN. These systems extracted features like color distribution, edge patterns, and texture characteristics from leaf images to classify diseases. Although these approaches showed reasonable performance, they were limited by the need for manual feature extraction and were sensitive to environmental factors such as lighting conditions and background noise.



Recent research has focused on deep learning approaches, particularly Convolutional Neural Networks, which automatically learn hierarchical features from image data. Many researchers have applied pre-trained deep learning models using transfer learning to improve classification accuracy when the dataset size is limited. Models such as VGG16, ResNet50, and MobileNet have been widely used for plant disease detection tasks. These models have shown promising results in identifying different plant diseases with high accuracy. In addition, some studies have introduced explainable artificial intelligence techniques to improve the transparency of deep learning models by highlighting the affected regions in leaf images. However, most existing systems mainly focus on disease classification and do not provide practical recommendations or remedies for farmers. Therefore, there is a need for an integrated system that combines disease detection, visual explanation, and treatment suggestions.



### 4. PROPOSED METHODOLOGY

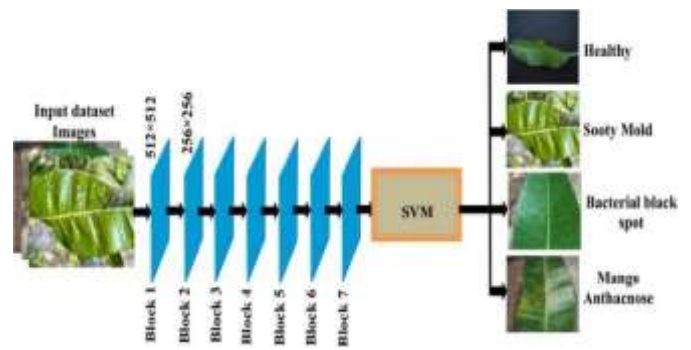
The proposed system implements a transparent deep learning approach to classify mango leaf diseases using image-based analysis. The methodology begins with collecting a dataset of mango leaf images that includes both healthy leaves and leaves affected by various diseases. These images are preprocessed to improve their quality and make them suitable for training the deep learning model. Preprocessing steps include resizing the images, normalization, and removing noise to ensure consistent input for the model. After preprocessing, the prepared dataset is used to train a Convolutional Neural Network (CNN) model for disease classification. The CNN model automatically extracts important features from the leaf images such as color variations, texture patterns, and disease spots. These features help the model learn the differences between healthy leaves and diseased leaves. The trained model is then used to predict the disease category when a new leaf image is uploaded to the system. The system is implemented through a web-based

interface where users can upload mango leaf images for analysis. Once an image is uploaded, the model processes the image and generates a prediction indicating the type of disease present in the leaf. To improve transparency, the system also displays a visual representation highlighting the important regions of the leaf that influenced the prediction. This helps users understand how the deep learning model identifies disease patterns. In addition to disease classification, the system provides remedy suggestions for the detected disease. These suggestions include recommended treatment methods such as applying specific fungicides, removing infected plant parts, and maintaining proper agricultural practices. By combining disease detection, visual explanation, and treatment recommendations, the proposed system provides an effective and user-friendly solution for early detection and management of mango leaf diseases.

### 5. RESULTS AND DISCUSSION

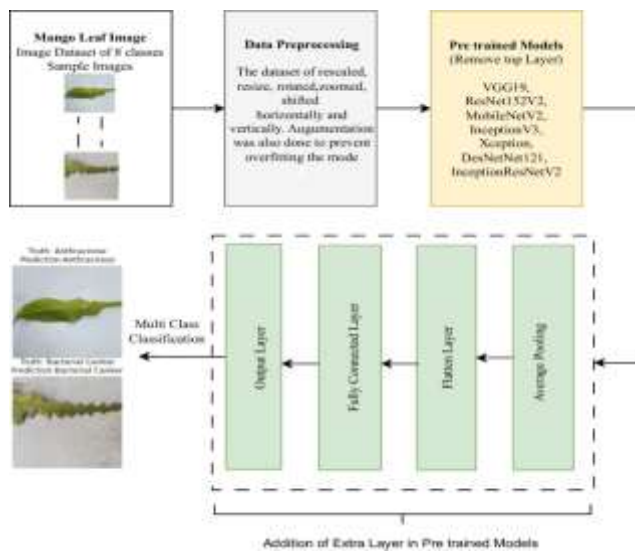
The proposed system successfully detects and classifies mango leaf diseases using a transparent deep learning approach. The system provides a simple web interface where users can upload an image of a mango leaf. After the image is uploaded, the trained deep learning model processes the image and predicts the disease type. The system then displays the predicted disease name along with a brief description. In the experimental results, the system accurately detected diseases such as anthracnose by analyzing the visual patterns and infected regions of the mango leaf.

Another important feature of the proposed system is its transparency. The model highlights the important regions of the leaf image that influence the classification result, which helps users understand how the prediction is made. This visual explanation improves the interpretability of the deep learning model. Furthermore, the system also provides remedy suggestions for the detected disease. For example, when anthracnose is detected, the system recommends using copper-based fungicides, removing infected plant parts, avoiding excessive watering, and maintaining proper air circulation. These suggestions help farmers take preventive actions at an early stage. The results demonstrate that the integration of deep learning classification, visualization, and remedy recommendation provides a useful tool for effective disease management in mango cultivation.



### 6. CONCLUSION

In conclusion, this project successfully demonstrates an intelligent and automated approach for the detection and classification of mango leaf diseases using deep learning techniques. By employing the Xception model, the system effectively captures detailed visual features of mango leaves, enabling accurate identification of diseases such as anthracnose, bacterial canker, and powdery mildew. The integration of federated learning ensures data privacy and facilitates collaborative model improvement across multiple institutions without sharing sensitive information. Through various stages, including data preprocessing, model training, testing, and prediction, the system achieves reliable performance and provides a scalable solution for real-world agricultural use. Ultimately, the proposed model supports precision agriculture by enabling early disease detection, reducing economic losses, and empowering farmers with a practical, technology-driven tool for sustainable crop management.



## 7. FUTURE SCOPE

The proposed transparent deep learning approach for mango leaf disease classification has significant potential for further development and improvement. In the future, the system can be expanded into a mobile application that allows farmers to capture images of mango leaves directly using their smartphones and receive instant disease detection results. This would make the system more accessible and practical for real-time agricultural use. The accuracy of the system can also be improved by collecting a larger dataset of mango leaf images from different environments and growing conditions. Additionally, advanced explainable artificial intelligence techniques can be incorporated to provide more detailed visual explanations of the infected regions in leaf images. The system can also be extended to support disease detection for multiple crops such as rice, tomato, and wheat, making it a comprehensive plant disease diagnosis platform. Integration with cloud computing and agricultural advisory systems can help provide weather-based alerts and preventive recommendations. Furthermore, the use of IoT devices and drone technology could enable large-scale monitoring of agricultural fields for early disease detection. These improvements would make the system more effective in supporting modern smart agriculture practices.

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