



# International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

*(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)*



**Impact Factor: 8.699**

**Volume 14, Issue 4, April 2025**

# Plant Leaf Disease Detection and Classification in Precision Agriculture using CNN

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**ABSTRACT:** Agriculture is one of the fundamental elements of human civilization. Crops and plant leaves are susceptible to many illnesses when grown for agricultural purposes. There may be less possibility of further harm to the plants if the illnesses are identified and classified accurately and early on. Plant leaf diseases are typically predicted and classified by farmers tediously and inaccurately. Manual identification of diseases may take more time and may not accurately detect the disease. There could be a major drop in production if crop plants are destroyed due to slow detection and classification of plant illnesses. Radiologists used to segment leaf lesions manually, which take a lot of time and work. It is established that deep learning models are superior to human specialists in the diagnosis of lesions on plant leaves. Here, the “Deep Convolutional Neural Network (DCNN)” based encoder-decoder architecture is suggested for the semantic segmentation of leaf lesions. A proposed semantic segmentation model is based on the Dense-Net encoder. The LinkNet-34 segmentation model performance is compared with two other models, SegNet and PSPNet. Additionally, the two encoders, ResNeXt and InceptionV3, have been compared to the performance of DenseNet-121, the encoder used in the LinkNet-34 model. After that, two different optimizers, such as Adam and Adamax, are used to optimize the proposed model. The detection and classification of leaf disease with deep learning models gives better results in comparison with other models.

**KEY WORDS:** Precision Agriculture, Plant Disease Detection, CNN, Deep Learning, Image Processing, Crop Health Monitoring, Leaf Disease Classification, AI in Farming, Transfer Learning, Automated Diagnosis.

## I. INTRODUCTION

India heavily relies on its agricultural sector, with over 60% of the population engaged in farming activities. As a result, the country's economy is largely dependent on agriculture. Unfortunately, India has been facing various challenges that have negatively impacted the agricultural sector. The change in weather patterns and the increasing incidence of plant diseases have led to a reduction in crop yields. This has had devastating consequences for farmers who are facing economic hardships. One of the biggest challenges in managing plant diseases is the difficulty in detecting them at an early stage. Typically, diseases are only noticeable when they have spread widely, making it challenging to implement effective control measures. To address this issue, technology can be used to provide solutions that aid in the early detection of plant diseases. Plant diseases can be caused by various factors such as bacteria, fungi, or viruses, and can range in severity from mild leaf or fruit damage to crop destruction. There are several types of plant diseases such as black spot, powdery mildew, Fusarium Wilt, Gray Mold, Leaf Blight, White Mold, Scab, and Fire Blight. For this project, we collected leaf images from Kaggle and performed image preprocessing to remove noise and convert RGB images to gray scale. To classify these images, we used convolutional neural networks (CNNs), which have proven to be effective in image classification tasks. By leveraging technology to detect and diagnose plant diseases, we can help farmers take appropriate control measures to mitigate the spread of the disease and prevent significant crop losses. This, in turn, can contribute to improving the livelihoods of farmers and boosting the country's economy.



## II. LITERATURE SURVEY

[1] Sannakki & Rajpurohit (2021) Developed a classification system for pomegranate diseases using a **Back Propagation Neural Network (BPNN)**. Emphasized a straightforward neural network architecture to achieve accurate classification based on extracted image features. Demonstrates how even simple neural networks can effectively detect diseases in specific crops.

[2] Rothe & Kshirsagar (2020) Applied **pattern recognition techniques** to identify cotton leaf diseases. Used image processing to extract relevant patterns and textures to distinguish between healthy and diseased leaves. Highlights classical approaches before the dominance of deep learning.

[3] Rastogi, Arora & Sharma (2020) Introduced a **hybrid model** using **computer vision** and **fuzzy logic** for detecting and grading leaf diseases. Combined rule-based logic with image features to improve classification reliability and interpretability. Bridges traditional AI with modern vision techniques for precision agriculture.

[4] Owomugisha et al. (2021) Designed an **automated vision-based system** for diagnosing banana diseases using mobile ICT tools. Utilized deep learning in mobile-friendly formats to detect **Banana Bacterial Wilt** and **Black Sigatoka**. Pioneered **field-deployable AI solutions** in African agriculture.

[5] Tian et al. (2017) Developed an **SVM-based multiple classifier system** for wheat leaf diseases. Combined handcrafted features with machine learning classifiers for robust detection. Provides a multi-class classification strategy without requiring deep learning.

[6] Yun et al. (2019) Proposed a **PNN-based crop disease recognition system** incorporating meteorological data. Showcased how external variables like weather can improve plant disease diagnostics. Useful for **context-aware systems** that adapt to environmental changes.

[7] Barbedo (2021) Conducted a **comprehensive review** of digital image processing in plant pathology. Analyzed methods for disease detection, quantification, and classification using imaging techniques. A foundational review for researchers exploring classical image-based approaches.

[8] Caglayan et al. (2021) Used **shape and color features** for plant recognition and classification. Demonstrated that simple morphological features are still effective in some use cases. Alternative to deep learning for **low-resource environments**.

[9] Lu, Tan & Jiang (2021) Provided a review of **CNN applications** in plant disease classification. Compared architectures and datasets, evaluating performance across different tasks. Helps identify optimal CNN variants for plant diagnostics.

[10] Monigari (2021) Built a **CNN-based disease prediction model** using image classification. Demonstrated a practical deep learning system with high detection accuracy. Shows CNNs' potential in real-world agricultural applications.

[11] Sujatha et al. (2021) Compared **deep learning and machine learning** methods for disease detection. Concluded that deep learning, particularly CNNs, outperformed traditional approaches. Validates DL's superiority with empirical evidence.

[12] Jasim & Al-Tuwaijari (2020) Integrated **image processing with deep learning** for plant disease detection. Combined edge detection, segmentation, and CNNs for effective classification. Exemplifies a **hybrid approach** that blends traditional and modern techniques.

[13] Ramkumar et al. (2021) Proposed a **deep learning model with IoT integration** for real-time detection. Allowed real-time monitoring and alerts using smart agricultural tools. Advances the trend toward **smart farming and precision agriculture**.

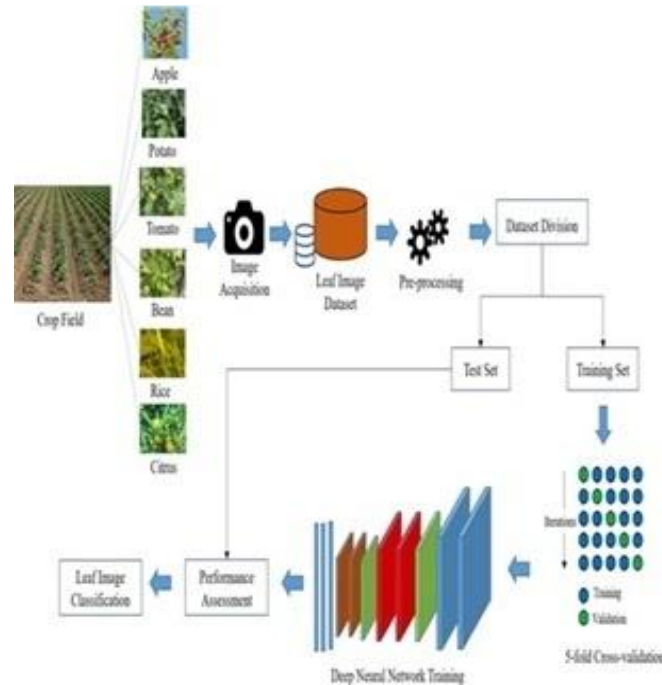
- [14] Sharma, Hans & Gupta (2020) Used **machine learning and image preprocessing** for disease classification. Focused on improving the feature quality before feeding into ML models. Highlights the importance of **data quality** in ML accuracy.
- [15] Ajra et al. (2020) Developed a CNN-based model with **preventive suggestions** for plant diseases. Not only detected disease but also recommended **control measures**. Adds actionable insight to AI predictions.
- [16] Deepa & Shetty (2021) Employed traditional machine learning for identifying plant leaf diseases. Reinforced the practicality of classical approaches in certain applications. Serves as a **benchmark for comparing ML and DL** techniques.
- [17] Mustofa et al. (2023) Reviewed various deep learning techniques including **CNN, YOLO, and ViT**. Compared performance across models for leaf disease detection. Useful for selecting state-of-the-art architectures.
- [18] Sharma & Bansal (2024) Surveyed both **machine learning and deep learning** models. Evaluated SVM, DT, CNN, RNN in terms of effectiveness and usability. Comprehensive for readers seeking an overview of both paradigms.
- [19] Ahmed et al. (2021) Utilized **color and texture features** to identify diseases from leaf images. Focused on traditional image features rather than AI or DL. Simple but effective for constrained settings.
- [20] Ferentinos (2018) Applied CNNs to a large dataset for plant disease diagnosis. Achieved **over 99% accuracy**, validating deep learning's robustness. One of the most **widely cited works** in this domain.

### III. METHODOLOGY

The research methodology involves collection plant leaf images from dataset like PlantVillage or field sources, followed by data preprocessing (resizing, augmentation, and normalization). A CNN model (such as VGG1 or ResNet) is trained for disease classification using labelled images, with hyperparameter tuning for optimization. The model's performance is evaluated using accuracy, precision, recall, F1-score, and a confusion matrix. Finally, the trained model is deployed in precision agriculture applications, with considerations for dataset imbalance and real-world variations.

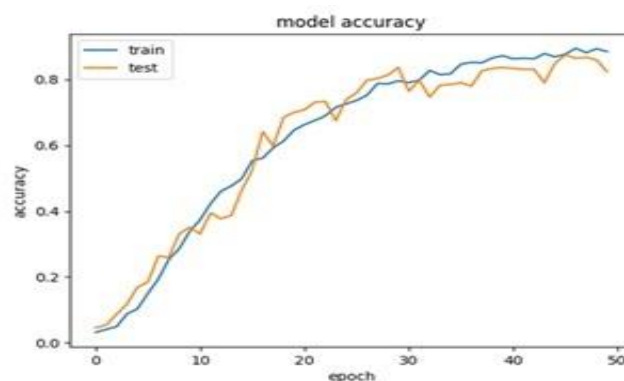
### IV. PROPOSED SYSTEM

This study is focused on the identification of plant diseases. The segmentation, feature extraction, and classification techniques are used to detect plant diseases. Photos of leaves from various plants are taken with a digital camera or similar unit, and the images are used to classify the affected region in the leaves. Then comes extracting features of a preprocessed image which is done with the help of HOG.



**FIGURE 1: EXPECTED OUTCOMES**

The diagram illustrates a deep learning-based plant leaf disease detection system. Leaf images from crops like apple, tomato, and rice are collected and preprocessed. The dataset is split into training and test sets, with 5-fold cross-validation applied for robust model training. A deep neural network learns features to identify diseases accurately. The model is then evaluated and used for classifying new leaf images.



**FIGURE 2 : MODEL ACCURACY**

**X-axis (epoch):** Represents the number of training iterations over the dataset. **Y-axis (accuracy):** Measures the model's performance in terms of accuracy. **Blue Line (train accuracy):** Shows how well the model is learning on the training data. **Orange Line (test accuracy):** Indicates the model's performance on unseen test data.

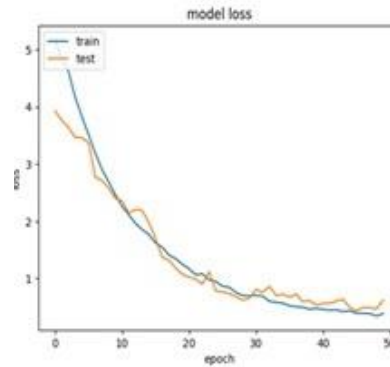


FIGURE 3: MODEL LOSS

**X-axis (epoch):** Represents the number of training iterations over the dataset. **Y-axis (loss):** Represents the model's loss (error) value, which the model tries to minimize. **Blue Line (train loss):** Indicates how the model's loss is decreasing on the training dataset. **Orange Line (test loss):** Shows how the model is performing on the unseen test dataset.

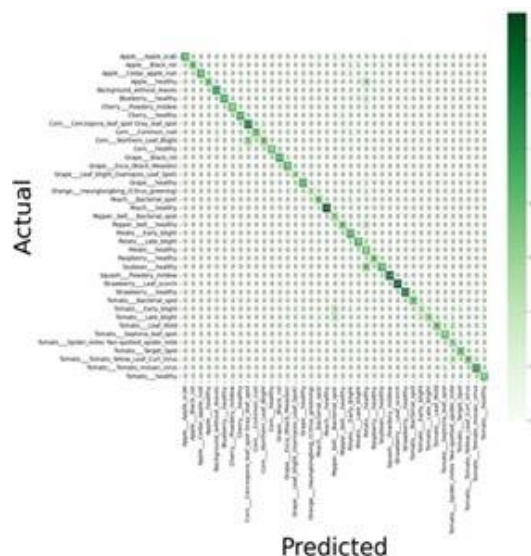


FIGURE 4: PREDICTION

**X-axis (Predicted labels):** Represents the classes predicted by the model. **Y-axis (Actual labels):** Represents the ground truth (correct labels). **Diagonal elements (green shades):** Correct classifications (where predicted = actual). **Off-diagonal elements:** Misclassifications (where predicted  $\neq$  actual). **Color intensity:** Darker shades of green indicate higher values, meaning more samples were classified in that category.

## V. CONCLUSION

In conclusion, the paper demonstrated the effectiveness of deep learning techniques in detecting plant leaf diseases. The paper achieved high accuracy rates in classifying the different types of plant leaf diseases using Convolutional Neural Network (CNN) architecture. The integration of OpenCV for image processing and feature extraction, along with the CNN model, contributed to the paper success. Furthermore, the project's ability to predict suitable medicines for the detected diseases is a valuable addition to the agriculture industry, as it helps farmers make



informed decisions about the most effective treatment for their crops. With further advancements in technology and the integration of precision agriculture techniques, the future of plant leaf disease detection and agriculture can become more efficient, sustainable, and productive.

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