



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 3, March 2025

Crop Leaf Disease Detection using CNN and Image Processing Techniques

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ABSTRACT: Agriculture plays a crucial role in sustaining the growing global population, with crops like corn, potato, rice, sugarcane, and wheat being essential for food security and economic stability. However, many farmers, particularly in remote areas, lack accurate knowledge and reliable disease detection methods, relying on manual observation, which often leads to significant crop losses. To address this issue, this study proposes an AI-driven crop leaf disease detection technique using image processing and the Convolutional Neural Network (CNN) model AlexNet. The method is applied to Kaggle datasets of diseased and healthy crop leaves, where image processing techniques enhance and analyse the dataset, followed by feature extraction and classification. The experimental results demonstrate high accuracy, achieving 96.5% and 95.3% with AlexNet for detecting healthy and diseased leaves, respectively. Additionally, a graphical layout provides preventive measures for identified diseases, offering practical solutions for farmers. This research highlights the significance of AI-powered disease detection in agriculture, enabling early intervention, reducing losses, and promoting sustainable farming practices. Index Terms—Disease Detection, Crop Leaf, Image Processing, CNN, AlexNet, Preventive Measures

I. INTRODUCTION

The growing global population relies heavily on a strong economy, where agriculture plays a crucial role in a country's development and GDP. However, various cultivation factors affect the quality and quantity of essential crops such as corn, potato, rice, sugarcane, and wheat. These crops are frequently exposed to different diseases due to varying climatic conditions, leading to severe losses for farmers. Leaf diseases, in particular, significantly impact crop production, making it essential to identify them early to maintain yield and quality. The primary challenge in agriculture is detecting these diseases accurately and efficiently. Many common plant diseases, including *Alternaria Alternata*, Anthracnose, Bacterial Blight, *Cercospora* Leaf Spot, Powdery Mildew, Black Mold, Downy Mildew, and Rust, affect crops at different growth stages. These diseases manifest through changes in texture, color, shape, and size of leaves, many of which are microscopic and beyond human visual capabilities.

To address this issue, an efficient technique is required to detect disease symptoms using advanced scientific methods. This study utilizes crop leaf images from Kaggle datasets, capturing diseased and healthy leaves using digital cameras or high-resolution mobile cameras. Image processing techniques such as acquisition, preprocessing, restoration, segmentation, augmentation, feature extraction, and classification are applied to enhance disease detection. In the preprocessing phase, RGB images are converted to grayscale, and contrast enhancement techniques are used to improve image clarity while eliminating noise. Additionally, augmentation techniques such as flipping, cropping, and rotating ensure the dataset's diversity and improve classification accuracy.

For disease recognition, this paper employs the Convolutional Neural Network (CNN) model AlexNet to classify healthy and diseased crop leaves accurately. While many existing systems detect plant diseases, they often lack preventive measure recommendations. Therefore, this study not only detects diseases but also provides preventive solutions through a graphical user interface, helping farmers take proactive steps in disease management.

The key contributions of this study are as follows: First, image processing techniques are applied to crop leaf datasets for disease detection. Second, the processed leaf images are classified using AlexNet. Third, an analysis of the overall classification accuracy is performed. Finally, a graphical layout is developed for disease detection with preventive measures.

The rest of the paper is structured as follows: Section II discusses related literature review, Section III presents the proposed methodology, Section IV describes the experimental results and classification accuracy, and Section V concludes the study.

II. LITERATURE REVIEW

This section highlights various approaches from previous studies that have been used to identify and classify plant leaf diseases. Zhou et al. proposed the K-Means clustering algorithm and Faster R-CNN Fusion algorithm to detect rice diseases while addressing issues such as blurred image edges, noise, large background interference, and low detection accuracy. The study utilized 3,010 images captured by a camera, and a faster 2D-Otsu algorithm was employed to classify the rice disease images for better output. Sharma et al. introduced image pre-processing techniques combined with K-Means clustering, segmentation, and four classifiers, including logistic regression, SVM, KNN, and CNN, to detect and classify leaf diseases automatically. Logistic regression performed well in specific cases, but CNN provided the highest accuracy in classification and disease detection using 20,000 images from GitHub and Kaggle. Another study suggested an integrated approach using Normalized Difference Vegetation Index (NDVI) data, IoT sensors, machine learning models such as SVM and Naive Bayes, and drone technology to assess wheat crop health comprehensively. Sardogan et al. presented a CNN model with the Learning Vector Quantization (LVQ) algorithm to identify and classify leaf diseases in 500 tomato leaf images from the PlantVillage dataset. The model employed various convolutional filters to enhance recognition accuracy. Ozguven et al. developed an improved Faster R-CNN architecture by modifying CNN parameters to detect leaf spot diseases in sugar beet using 155 images. The study aimed to achieve the highest accuracy while minimizing processing time and human error. Lu et al. proposed a CNN-based rice disease identification model with image pre-processing techniques, utilizing 500 natural images from rice fields. The model demonstrated higher accuracy due to a 10-fold cross-validation scheme, greater feasibility, efficiency, faster convergence rates, and better recognition capabilities compared to traditional machine learning models. A novel disease detection model based on CNN techniques with image pre-processing was presented by Kawasaki et al., which automatically diagnosed plant diseases using a 4-fold cross-validation approach. The study utilized 800 cucumber leaf images captured by digital cameras and achieved high accuracy. Jiang et al. introduced a new deep-learning model called INAR-SSD, applied within the Caffe structure of GoogLeNet Inception, utilizing Rainbow Concatenation on a GPU platform. The model used deep CNNs to detect apple leaf diseases in real time, leveraging a dataset containing 26,377 images from both laboratory and real-field environments. This approach provided high accuracy and a feasible solution for disease detection. Pallagani et al. developed a smartphone application, dCrop, which utilized a deep-learning-based approach to predict crop diseases accurately using a public dataset of 54,306 plant leaf images. For real-time disease prediction, the trained PyTorch model was converted into a TensorFlow-compatible format and integrated into the dCrop app, demonstrating its practical feasibility.

Another study used a CNN model with a transfer learning method to diagnose plant diseases and identify crop pests based on leaf images from the PlantVillage database. This approach significantly reduced processing time and human effort while achieving high classification accuracy. These studies highlight the growing importance of AI-based approaches in plant disease detection and the potential for deep learning models to provide accurate and scalable solutions for modern agriculture.

III. PROPOSED METHODOLOGY

Fig. 1 depicts the suggested structure for detecting leaf diseases and taking preventative action. This framework illustrates the ideas of the suggested method for gathering leaf images. The potato and tomato leaf photos were extracted from the Kaggle dataset. The dataset of leaf images is processed using image processing techniques such as image preprocessing, image augmentation, feature extraction, feature selection, and classification. After that, a supervised machine learning system is created [18] that uses the dataset image to train and extract data. This study presents a method for detecting leaf illnesses that makes use of two CNN architectures: AlexNet and Residual Neural Network-50 (ResNet-50). Additionally, it has created a leaf disease prevention measures scheme. The following are controlled by the suggested method:

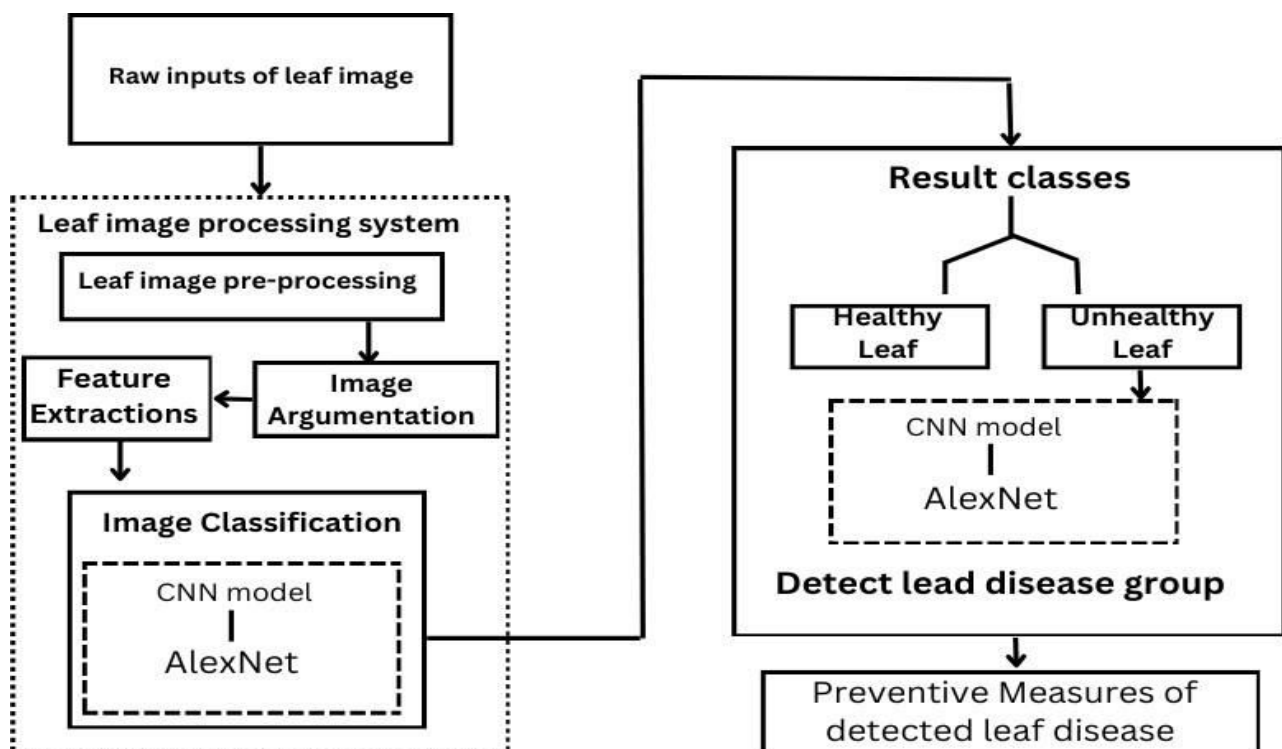
A. Leaf Image Dataset:

To maintain the integrity of research, improve field study performance, and direct data-driven decision-making, both quantitative and qualitative datasets play a crucial role. Smart cameras or high-resolution digital cameras can be used to

gather leaf photos for datasets. We used a Kaggle dataset for this study that included leaf photos of the five main crops: wheat, corn, potatoes, rice, and sugarcane. The dataset classifies both healthy and sick leaves into 17 distinct classifications. More than 4,000 photos in the dataset document several plant diseases, including corn leaf blight, rice bacterial blight, wheat rust, sugarcane red rot, potato early blight, and potato late blight. In order to build an effective model for classifying and detecting leaf diseases, 2,000 photos of healthy leaves are also included. This dataset plays a crucial role in developing and evaluating AI-based models for plant disease identification. B. Leaf Image Dataset The user's graphical layout is created after the leaf disease classification system is used so that it may show the leaf disease message and offer preventive measures for a rich awareness of plant health to farmers. Using AlexNet and ResNet-50 pre-trained network models for potato early blight, potato late blight, tomato early blight, and tomato late blight, Fig. 4 shows how to detect leaf diseases and set out user preventive procedures.

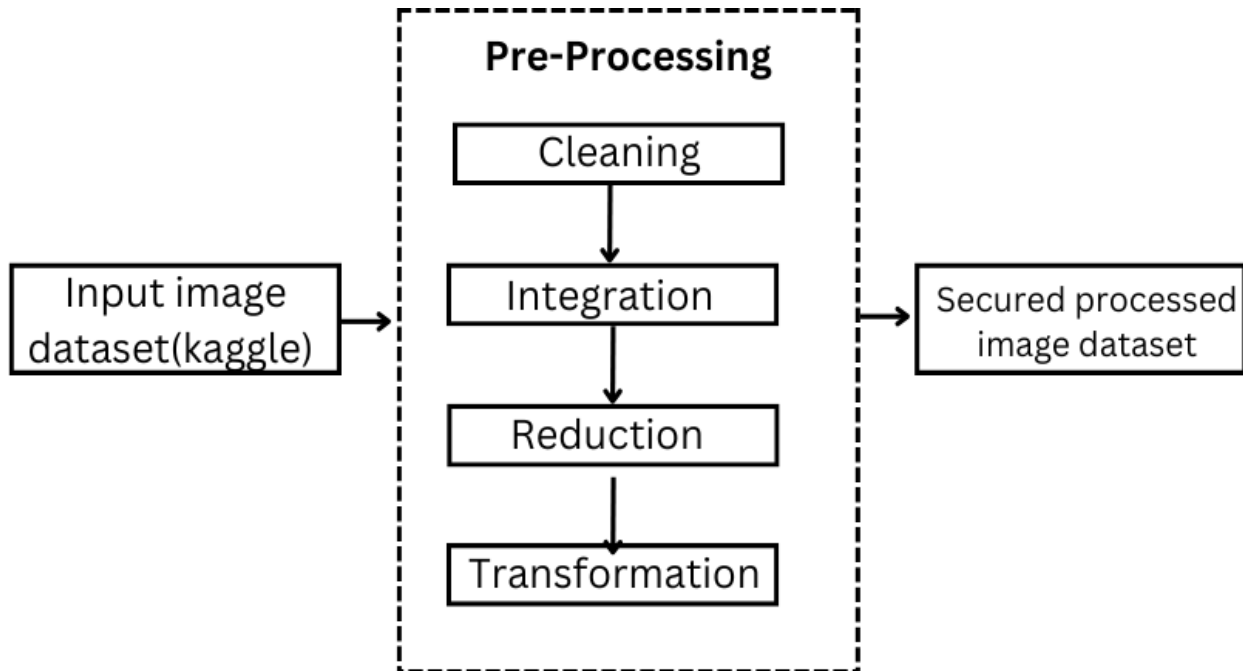
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C. Image Preprocessing:

The pre-processing technique plays a crucial role in transforming raw leaf image datasets into a structured format suitable for analysis, enhancing image quality, and removing unwanted elements. This process involves multiple stages, including data cleaning, integration, reduction, and transformation. In the data cleaning phase, unwanted distortions are eliminated, missing data is handled, and inconsistencies are corrected. Data integration ensures a unified representation by resolving conflicts and reducing redundancy from diverse datasets. Given the large size of datasets, data reduction helps minimize storage requirements and computational complexity by optimizing feature dimensions. Data transformation further enhances the dataset by performing smoothing, aggregation, feature extraction, normalization, and discretization, ensuring consistency across data attributes. To standardize the dataset for model training and evaluation, the leaf images are resized to 256×256 pixels for both training and testing. Through these pre-processing steps, the dataset becomes well-prepared for accurately identifying and classifying leaf diseases.



D. Image Augmentation:

In order to accurately identify leaf disease, image augmentation is used to modify and facilitate the leaf picture representation. Therefore, to reduce the possibility of over- fitting and to improve the model's simplicity, the training and testing leaf image datasets are expanded. Using flipping, cropping, and rotating techniques, the augmentation process is used to resize the original leaf picture dataset. Additionally, the colour transformation technique is used to convert the leaf photos into RGB. The augmented leaf photos, on the other hand, are made to preserve the healthy and unhealthy leaf datasets balanced image size and quality. To prevent the dependability of the attributes in the data assessment structures and units for data images, apply data smoothing, aggregation, feature creation, data normalisation, and discretisation.

E. Feature Extraction:

The crucial step in the image processing process that offers the best limitations and an appropriate platform is feature extraction. The picture feature vectors of the leaf disease can be extracted using the CNN based detection framework's feature extractor. In a convenient manner, the feature extraction technique examines a leaf image's colour, shape, and texture. Thus, the correct classification of various leaf disease classes can be aided by this extraction procedure. The feature extraction process for leaf diseases pulls out the characteristics of different lesion colours and forms.

F. Classification based CNN Model:

This paper's main goal is to use a convolutional neural network (CNN) to classify leaf diseases using visual datasets. The AlexNet architecture-based deep learning method is used to detect a variety of illnesses in the leaves of wheat, corn, potatoes, rice, and sugarcane. To classify various disease classes, the CNN-based classification model analyses both tested and training leaf image data. Images of both healthy and ill leaves from 17 different disease groups are included in the dataset.

In this study, leaf photos are automatically classified into healthy and unhealthy categories using the AlexNet pre-trained network model. A dataset of more than 6,000 leaf photos, comprising 2,000 healthy and 4,000 diseased leaf samples, is used to train the model at first. After the initial division into categories for healthy and ill people, In addition, the model categorises infected samples into distinct disease classifications, including potato late blight, wheat rust, corn leaf blight, rice bacterial blight, and sugarcane red rot. This technology offers useful insights for precision agriculture by effectively identifying and classifying plant leaf diseases.

G. Graphical Layout of Preventive Measures:

The user's graphical layout is made to show the identified leaf disease and offer preventative actions once the leaf

disease classification system has been used, assisting farmers in becoming more conscious of the health of their plants. Diseases in crops including corn, potatoes, rice, sugarcane, and wheat are detected by the system. It divides leaf conditions into healthy and unhealthy groups, such as wheat (brown rust, yellow rust), corn (common rust, grey leaf spot, and northern leaf blight), potatoes (early blight, late blight), rice (brown spot, leaf blast, and neck blast), and sugarcane (bacterial blight, red rot). By providing information on diseases and suitable preventative measures, this graphical representation improves agricultural decision-making.

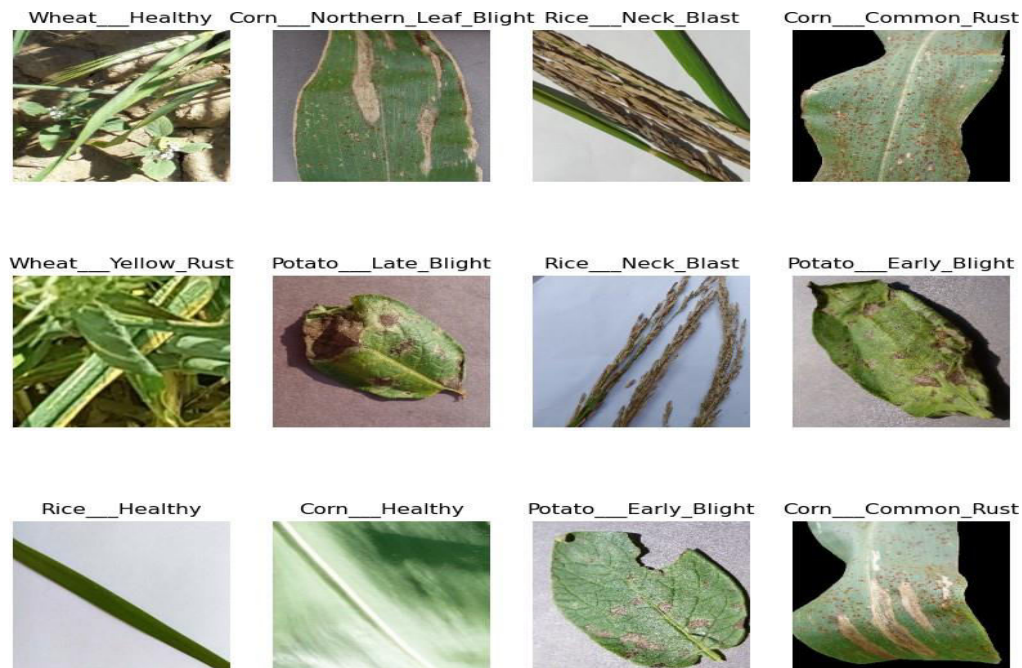


Fig. 3. Leaf disease of potato, rice, wheat, sugarcane and corn.

Disease Detection Result

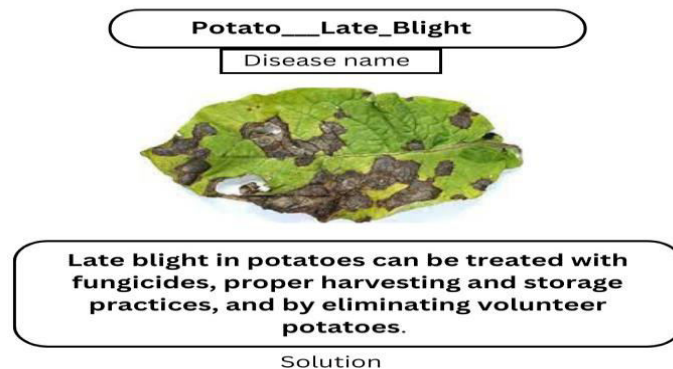


Fig. 4. Preventive measure in a graphical representation

IV. CONCLUSION

This paper addresses the issue of leaf diseases in essential crops such as corn, potato, rice, sugarcane, and wheat, which pose significant challenges for farmers in the agricultural sector. A diagnostic approach using image processing and CNN has been proposed to detect and classify leaf diseases while also providing preventive measures through a graphical layout. The study utilizes Kaggle datasets containing images of healthy and diseased leaves, applying preprocessing, augmentation, and feature extraction techniques to analyse symptoms. The framework classifies diseases

into categories such as Corn (Common Rust, Gray Leaf Spot, Northern Leaf Blight), Potato (Early Blight, Late Blight), Rice (Brown Spot, Leaf Blast, Neck Blast), Sugarcane (Bacterial Blight, Red Rot), and Wheat (Brown Rust, Yellow Rust) using the AlexNet model. The results demonstrate high accuracy in disease classification, making this approach a viable solution for early disease detection and improved agricultural decision-making. The integration of a graphical layout further enhances usability, providing farmers with actionable insights to mitigate crop damage and improve yield quality.

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