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Leaf Diseases Recognition from Images Using Deep Learning

Mithun V P, Dr. ShreeKumar. T

Department of Computer Engineering, MITE College, Mijar, Moodabidri, Karnataka, India

Associate Professor, Department of Computer Engineering, MITE College, Mijar, Moodabidri, Karnataka, India

ABSTRACT: This paper discusses the challenge of accurately classifying leaf diseases in apple trees utilizing Convolutional Neural Network (CNN). The dataset used for this investigation is composed of images belonging to four different categories, with three categories representing different diseases and one category representing a healthy leaf. This work follows a systematic methodology, including dataset preprocessing, model architecture design, training, validation, and testing phases. Precision, recall, the F1 score, & accuracy will be used to evaluate the CNN model's performance. The findings will highlight the efficacy and practicality of learning-based techniques to foliar disease classification. The fundamental purpose of this project is to develop a dependable framework for deep learning system algorithm able to attaining an outstanding precision rate, with a target accuracy rate of more than 90%, and this method achieved 95% accuracy.

KEYWORDS: Deep Learning, leaf diseases, CNN

I. INTRODUCTION

The health & production of crops for agriculture is critical to the global population's survival and food security. Crop diseases, on the other hand, constitute a substantial threat to agricultural productivity, generating significant economic losses & impacting food security. Apple trees are prone to a range of illnesses that can impair fruit quality, production loss, & even tree mortality in a variety of crops. Effective disease management requires identification of diseases affecting apple- straighten leaves quickly and accurately so farmers can apply the correct measures and prevent further spread. Historically, experienced agricultural scientists or plant pathologists have used visual inspection to diagnose plant diseases. However, this manual method is labor and time intensive and prone to human error. Automated diagnostic systems are now recognized as viable methods for fast and accurate diagnosis due to advances in computer vision & deep learning techniques. A specific part of machine learning known as deep learning has gained prominence in diverse computer vision tasks, notably in areas like image classification. Some deep learning model convolution neural networks (CNNs), specially designed to capture spatial dependencies and hierarchical features in data well. The focus of this paper is harnessing the capabilities of deep learning and CNNs to create an automated system for categorizing leaf diseases in apple trees. The main goal is to establish a strong deep learning model that can precisely differentiate and classify leaf pictures into four distinct groups: three portraying diverse diseases and one signifying a healthy leaf. Utilizing deep learning algorithms offers a substantial boost in disease detection accuracy, allowing for timely actions and improved disease control strategies.

The paper's structure is outlined as follows: Section I introduces the topic. In Section II, previous research is discussed. The design of the proposed system is explained in Section III. Section IV showcases the experimental findings. Lastly, Section V provides the conclusion.

II. RELATED WORK

Iqbal et al., [1] proposed a model aimed at classifying three different diseases affecting potato plant leaves. They employed seven machine learning (ML) algorithms for this purpose. The process began with preprocessing 450 images, which were resized and then subjected to image segmentation. This segmentation phase involved extracting the diseased portions of the images using a color threshold segmentation method. The segmented images were then used to extract characteristics such as Humoment, Haralic, and Histogram. These collected features were then fed through seven ML algorithms for classification, namely Random Forest (RF), Logistic Regression (LR), KNN, DT, NB, linear

discrimination analysis (LDA), & SVM. The Random Forest (RF) classifier has the greatest accuracy of all the classifiers, reaching an amazing 97%. D. Aparajita et al., [2] detailed a model designed to categorize three distinct diseases affecting soybean leaves by utilizing Support Vector Machine (SVM). They began the procedure by using preprocessing filters to remove unnecessary features from the photos. They detected the affected area on the leaves using the k-means technique. They collected four color characteristics & seventeen texture features from these segmentation images, which they then sent into the SVM. Finally, the SVM performed the classification task, with a significant accuracy of 95% in differentiating various soybean illnesses.

M. Suresha et al., [3] presented a model for detecting and classifying Brown Spot and Leaf Blast diseases in paddy leaves. Initially, they employed the Global threshold method to segment the image and isolate the affected portion of the leaf image. Following this, they extracted four geometric features from the segmented images and input them into the K-Nearest Neighbors (KNN) classifier. The model was evaluated using 198 images for training and 132 images for testing, achieving a disease classification accuracy of 76.59% through KNN. Similarly, E. Hossain et al., [4] introduced a technique to classify diseases in various plant leaves. They extracted four texture features and two color features from diseased leaf images, which were then utilized as input for the KNN classifier. This approach achieved successful disease classification with a high accuracy of 96.76% using KNN.

F Ahmed [5] emphasized a significant concern in agricultural systems: reducing the growth of unwanted plants. Often, chemical herbicides are used to control these plants, but they can have negative effects on the environment and human health, even though they increase productivity. Detecting and classifying plants in digital photographs, even undesired ones, could lead to the development of automated agricultural equipment directed by vision, specifically tailored for targeted herbicide administration. Suhaili Beeran Kutty [6] investigated a neural network-based approach for classifying watermelon leaf diseases such as Downey Mildew and Anthracnose. This method used color features from RGB images and achieved 75.9% accuracy in disease classification. Machine learning's applicability in agriculture, including crop disease detection, was highlighted by Godliver Owomugisha [7].

Mrunmayee Dhakte [8] concentrated on pomegranate crops, offering an image processing & neural network method to phytopathology problems. This system employed GLCM feature extraction & k-means machine learning to detect diseases with 90% accuracy. Arti Singh [9] noted the increase in high-resolution plant photos and sensor data, which necessitated the use of machine learning algorithms to extract patterns and features. Machine learning phases such as identification, categorization, quantification, & prediction were investigated. In 2016, Sharada P. Mohanty [10] tackled the problem of quick crop disease identification using smartphone-assisted diagnosis. The combination of widespread smartphone use and breakthroughs in deep learning prepared the ground for trained models to achieve outstanding disease diagnosis accuracy.

III. METHODOLOGY

The proposed system for precise classification of leaf diseases in apple trees via Convolutional Neural Networks (CNN) involves crucial steps. A diverse dataset of apple leaf images representing various disease categories and healthy leaves is collected and preprocessed for quality enhancement.

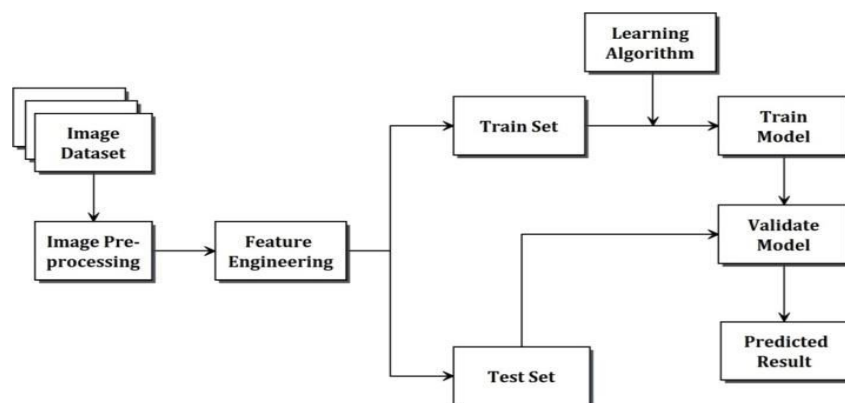


Fig 1: Proposed system



Using image processing techniques enhances dataset quality even more. After that, the data is divided into training & testing subsets. A CNN model with convolutional and fully linked layers is created and trained. Validation is carried out, during which parameters such as accuracy, precision, recall, & F1 score are examined. The technology outperforms the target accuracy of 90% with an amazing 95% accuracy. This displays the system's capacity to classify apple leaf diseases effectively using deep learning techniques.

IV. EXPERIMENTAL RESULTS

CNN - REPORT ON CLASSIFICATION

The classification report is a complete summary of a classification model's performance. It includes a number of measures that assess how successfully the model classified distinct classes in the data set. Metrics such as precision recall, F1 score, accuracy, & support for every class are often included in the report.

	precision	recall	f1-score	support
Apple__Apple_scab	0.89	0.96	0.92	125
Apple__Black_rot	1.00	0.92	0.96	125
Apple__Cedar_apple_rust	0.98	0.98	0.98	125
Apple__healthy	0.98	0.97	0.97	125
accuracy			0.96	500
macro avg	0.96	0.96	0.96	500
weighted avg	0.96	0.96	0.96	500

Fig 2: Classification Report for CNN

The Fig 2 offers a concise overview of classification performance metrics across various classes in a classification task, encompassing overall accuracy and macro/micro averages. The precision, recall, & F1 score for each class are displayed. Notably, "Apple__Apple_scab" achieves a precision, recall, and F1 score of 0.89. Similarly, "Apple__Black_rot" exhibits impeccable precision (1.00), a recall of 0.92, and an impressive F1 score of 0.96. "Apple__Cedar_apple_rust" demonstrates outstanding values of 0.98 for precision, recall, and F1 score. "Apple__healthy" showcases strong performance with precision, recall, and F1 scores of 0.98, 0.97, and 0.97, respectively. The classifier's overall accuracy stands at 0.96, indicating 96% accuracy in class label predictions.

CNN - Confusion MATRIX

The confusion matrix is a table that is used to assess the effectiveness of a classification model. It gives a clear picture of how successfully the model identified cases from various classes.

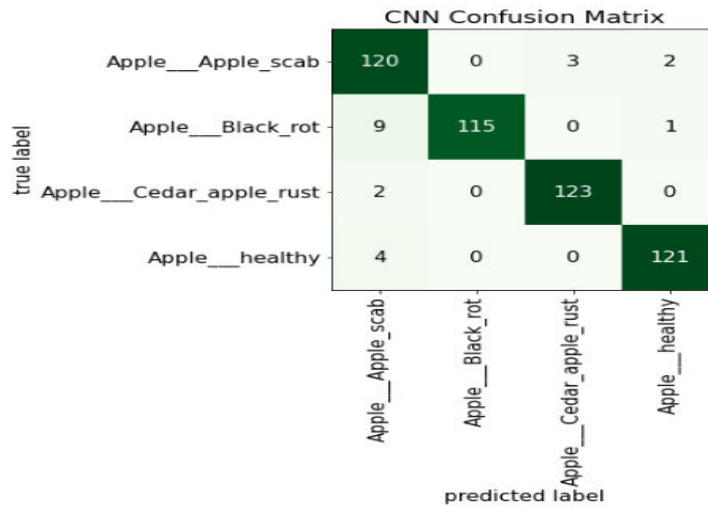


Fig 3: Confusion Matrix for CNN

Fig 3 displays the confusion matrix for the complex CNN. Examine the model's performance using this chart to gain insights into its effectiveness. The dataset comprises 500 images, and the model achieves a commendable accuracy of 96%.

Accuracy plot-graphs and Loss plot-graphs

An accuracy plot is a graphical representation that illustrates the performance of a machine learning model in terms of its accuracy across different iterations or epochs during the training process. It is a common visualization used to monitor how well the model is learning and improving over time.

A loss plot is a graphical representation that illustrates the behaviour of the loss function during the training process of a machine learning model. The loss function quantifies the difference between the predicted values generated by the model and the actual target values in the training dataset.

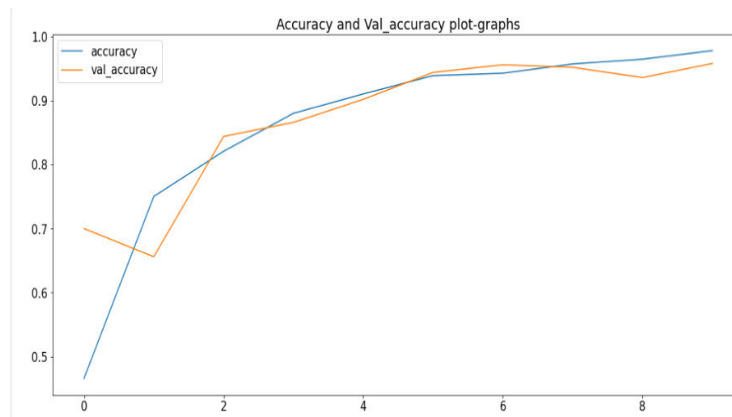


Fig 4: Accuracy Plot-graph

A total of 10 epochs were employed, with training accuracy depicted in blue and validation accuracy in red. Notably, both training and validation accuracies surpassed more than 90%.

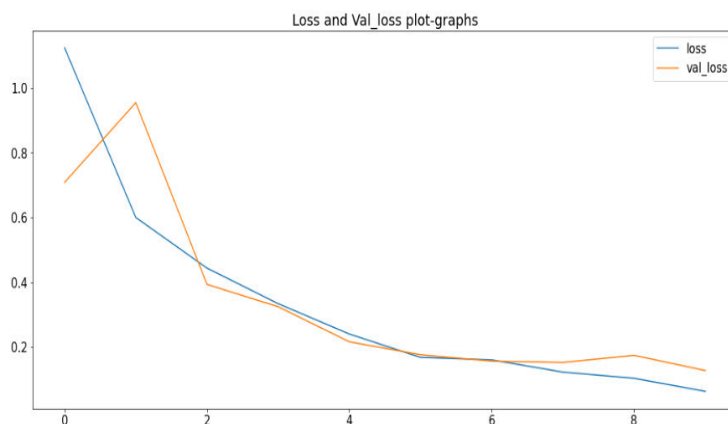


Fig 5: Loss Plot-graph

Ten epochs were utilized, illustrating training accuracy in blue and validation accuracy in red. Encouragingly, both training and validation loss exhibited a consistent downward trend over the course of training.

V. CONCLUSION

The goal of this research was to use sophisticated technology to develop a smart system that can effectively recognize & classify diseases in apple tree leaves. Using an advanced Deep Learning Algorithm named Convolutional Neural Networks (CNN), the system was able to recognize these diseases from images of the leaves with a 96% accuracy. This demonstrates that the intelligent system is capable of detecting faults in apple trees. This accomplishment is significant because it shows that such technology may be used to automatically detect and manage problems in apple orchards, resulting in a significant step forward in tree care.

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