A Comparative Study of Deep Learning Models for Mango Leaf Disease Recognition

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Abstract— **Mango, a tropical fruit of economic importance, is susceptible to various diseases that can severely impact fruit quality and yield. Every year diseases and pests cause great economic loss to the mango industry. The detection of various mango diseases is challenging for the farmers as the symptoms are produced by different diseases of mango and mango leaves. The advent of deep learning has offered promising solutions for automating the detection of plant diseases, including those affecting mango leaves. In this paper, we conduct a comprehensive comparative analysis of deep learning models for the recognition of mango leaf diseases. We explore and evaluate the performance of different convolutional neural network (CNN) architectures, including popular pretrained models. The proposed CNN based model, VGG16 model attains 97.83% of accuracy. Through extensive experiments and rigorous evaluation, we provide insights into the strengths and weaknesses of each approach, shedding light on the most effective techniques for mango leaf disease recognition.**

Keywords: Convolution Neural Network (CNN), Deep Learning, Mango Leaf Disease, Image Recognition

I. INTRODUCTION

Mango, MangiferaindicaL., belongs to the family Anacardiaceae of the total 62 species, about 16 are edible and cultivated commercially, while the remaining are either wild species or are non-edible. Mango is the biennial habit, irregular flowering and the pre-mature drop. Mango originated from the Indo-Burma region, northeast India, and northern Burma, and in the foothills of the Himalayas. In 2016, Myanmar Agriculture Department reported that Myanmar has 198 varieties of mango grown in the whole country.Off-season fruit production of mango required the soil drenching of paclobutrazole and then spraying of KNO3. Growing of mango is only for its large colorful and delicious fruit but also for home landscape. Crop diseases are a major threat to food security, but their rapid identification remains difficult in many parts of the world due to the lack of the necessary infrastructure.

A significant barrier to mango cultivars producing their maximum production potential is insect infestations. Mangoes are reported to be infested by 400 distinct kinds of insect pests worldwide. When the temperature rises, the metabolic rate of insects increases, driving them to consume more food and inflict more damage. The different diseases affecting mango leaves cannot get acknowledged by the farmers which cause less production of mango fruit. Different diseases [6] cause different effects on mango crops. Some cause white patches and some cause black and all these patches seem over the surface of the leaf or early grown fruits as well while some other diseases cause white fungal powder on leaves and some affect the young leaves and shoots also. The traditional method of detecting and identifying plant diseases involves naked eye observation by experts. This takes time and talent, and is not a practical solution for monitoring large farms. Therefore, to overcome the limitations of manual detection, with the advent of computational methods, automated methods for crop and plant monitoring and forecasting are required [3].

A very promising area of research and innovation is the application of deep learning models for detecting plant diseases from leaf image. In the case of mango leaves; there are various types of diseases present like Anthracnose, Bacterial Canker, Cutting Weevil, Die Back, Gall Midge, etc. In this study, the proposed system is to predict the labels of instances of a dataset containing 4000 images with 240x320 mango leaf images using a deep learning model, the instances belonging to different classes pertaining to the dataset must have distinctive traits so that the model can effectively distinguish among the inter-class feature vectors during the prediction phase. The distinct traits of various diseases were analyzed that found in the mango leaf images dataset. In the present work, we aim to perform a comparative analysis of various deep learning models to assess their suitability for mango leaf disease recognition.

II. LITERATURE REVIEW

Conventional ways to identify leaf diseases is time consuming and expensive as it needs the expertise, knowledge and continuous monitoring. Still, it lacks correct recognition of disease because of the complex structure and pattern of the leaf. With the advent of computational methods in the field of image recognition [13] this problem can be solved with greater accuracy. By using technology one can detect diseases on a large scale. In the case of mango leaves; there are various types of diseases present like powdery mildew, anthracnose, red rust etc.

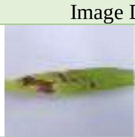
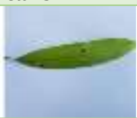
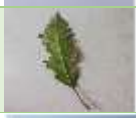
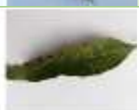
(S. P. Mohanty et.al., 2016) was demonstrated the technical feasibility using a deep convolutional neural network utilizing 54,306 images of diseased and healthy plant leaves collected under controlled conditions, to identify 14 crop species and 26 diseases made openly available through the project Plant Village. The trained model achieves an accuracy of 99.35% [13]. Md. Rasel Mia et al. [4] collected a training dataset comprising various photos of mango leaves with four different illnesses. They developed a machine learning method using an SVM classifier that could automatically recognize symptoms of mango leaf diseases and achieved an average detection and classification score of 80%. In the study of Mango Leaf Diseases Detection using CNN based model for detection and classification. Data augmentation techniques like rotation, translation has been applied. CNN model has been trained on the augmented data for detection and classification of mango leaf diseases and it attains 90.36% of accuracy [1]. (S. Gowrishankar, et.al., 2023) proposed a work that includes finding a solution to the problem on the application of

ConvNeXt models for the diagnosis of pathogen and pest caused illnesses in mango plants. The study intends to investigate the variety in how these illnesses emerge on mango leaves and assess the efficiency of ConvNeXt models which was achieved98.79% for mango pests, 100% for mango pathogens, and 99.17% for the combined dataset [7].
(S. Kumar, et.al., 2021) proposed the DL based approach for image recognition and examined the three main architecture of the Neural Network: Faster R-CNN, R-CNN and SSD. System proposed can detect the different types of disease efficiently the accuracy of 94.6% was attained [8]. (J. Liu, et.al., 2021) were built a model for plant diseases and pests detection that includes finding a solution to the problem of 38 different classes of plant diseases detection using the simplest approach while making use of minimal computing resources to achieve better results compared to the traditional models [2]. VGG16 training model is deployed for detection and classification of plant diseases (R. Rinu, etl.al., 2021) [5] . Neural network models employ automatic feature extraction to aid in the classification of the input image into respective disease classes.

III. Methodology

Data Collection and Preprocessing

We compiled a dataset comprising high-resolution images of mango leaves, including both healthy and diseased samples based on dataset of 4000 images collected from Mango Leaf Disease dataset. The dataset was carefully annotated to classify diseases accurately. Standard preprocessing techniques, such as image resizing, normalization, and data augmentation, were applied to prepare the data for training and evaluation.

Mango Leaf Disease Dataset			
Class Name	Image Details		
Anthracnose	500		
Bacterial canker	500		
Cutting weevil	500		
Die back	500		
Gall midge	500		
Powdery mildew	500		
Sooty mold	500		
Healthy	500		

Deep Learning Models

Deep learning (DL) is a branch of machine learning (ML) that mimics the human brain's ability to process data and derive patterns for decision-making. Deep learning, autonomously learns features from extensive data, eliminating manual intervention. This capability holds great potential in the field of plant disease and pest image recognition. In our study, we explored a range of deep learning models for mango leaf disease recognition, encompassing custom-designed convolutional neural networks (CNNs) and pretrained five models that were fine-tuned on our mango leaf dataset using transfer learning techniques. DenseNet121 model with 121 layers, where each layer directly receives input from all previous layers. It excels at extracting intricate image features and its compact design and efficient parameter utilization and seeking both accuracy and computational efficiency. InceptionV3, efficiently capturing multi-scale image features and employs various convolutional filter sizes (1x1, 3x3, and 5x5) and architectures, including max-pooling, to create a deep network. It allows to extract rich hierarchical features at multiple abstraction levels. VGG 16, with 16 weight layers, including 13 convolutional and 3 fully connected layers, it's deeper than many of its peers. Its uniform design, featuring 3x3 convolutional filters and max-pooling layers and remains a benchmark for deep learning. VGG19, an extension of VGG16, boasts 19 weight layers, including 16 convolutional and 3 fully connected layers. It relies on 3x3 convolutional filters and max-pooling layers, maintaining a deep and uniform structure. Due to its capacity to capture intricate visual patterns and hierarchies. Xception, reimagines inception modules by using depth-wise separable convolutions, replacing standard convolutional layers. This reduces computational complexity while potentially enhancing model performance, achieving exceptional results with fewer parameters.

IV. Experimental Results and Discussion

A. Experimental Results

Our comparative analysis revealed interesting insights into the performance of different deep learning models for mango leaf disease recognition. Custom-designed CNNs exhibited high accuracy and fine-grained disease recognition capabilities but required larger amounts of data for training. Pretrained models, on the other hand, demonstrated competitive performance with significantly less training data and reduced computational resources. We discussed the trade-offs between model complexity, training requirements, and recognition accuracy. The proposed study was used a dataset of 4000 images collected from Mango Leaf Disease dataset which consists of 8 classes (including the healthy category) and seven diseases are considered namely Anthracnose, Bacterial Canker, Cutting Weevil, Die Back, Gall Midge, Powdery Mildew, and Sooty Mould that attack the mango trees. Argumentation is performed on the collected dataset to increase the number of images for model training and testing. Then the dataset was divided into train and test the dataset that has been performed to train and test the dataset. The dataset which is used for training – 350 images per class (2800 images), for validation – 75 images per class (600 images) and for testing – 75 images per class (600 images) that is used to test the model. The deep learning models are trained with 8 batch size and 10 epochs. To classify the images, a CNN based model has been developed. These models were DenseNet121, Inception V3, VGG16, VGG19 and Xception. The Table I provides validation loss and testing accuracy for five different models DenseNet121, Inception V3, VGG16, VGG19 and Xception trained on a Mango Leaf Disease Dataset.

TABLE I. MANGO LEAF DISEASE DATASET IMPLEMENTATION RESULTS FOR CNN-BASED MODELS

Model	Loss	Accuracy
DenseNet121	0.1663	0.935
InceptionV3	0.0951	0.9700
VGG16	0.0874	0.9783
VGG19	0.1384	0.9517
Xception	0.1408	0.9667

B. *Discussion*

Our findings emphasize the potential of deep learning in mango leaf disease recognition. While custom-designed CNNs offer fine-tuned disease recognition, pretrained models provide a practical and efficient solution, particularly for resource-constrained environments. The choice of model may depend on the available data and computational resources, and our analysis helps guide decision-making in this regard. Additionally, future research could explore techniques for transfer learning across different crops and diseases. The accuracy of the model on a different validation set is referred to as validation accuracy, and this accuracy is used to assess the performance of the model during training and adjust its hyperparameters. The training process was conducted with the Adam optimization algorithm to adjust the parameters of a neural network to improve its accuracy and speed; and categorical cross-entropy was used for the cost function.

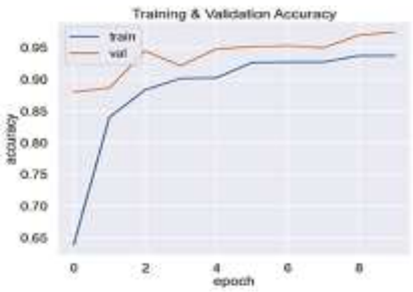


Fig. 1. Training and Validation Accuracy of the Best Model (VGG16)

The testing accuracies of the models are high, with all five models achieving above 90% accuracy. The model has been trained with epochs equal to 10 and the batch size 8. The best accuracy of 97.83% was attained. The training and validation accuracy graph attained by the proposed model is shown below in fig 1. The training and Validation loss graph is shown in fig 2. A generalized model is built in the proposed study as the validation loss is very less and the validation accuracy is more than the training accuracy as shown in fig 2. Overall, the VGG 16 model achieved the highest testing accuracy of 97.83 %, indicating that it is the best performing model on this Mango Leaf Disease Dataset. The difference in

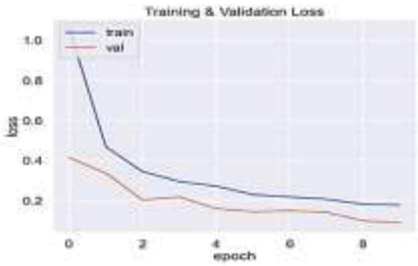


Fig. 2. Training and Validation Loss of the Best Model

testing accuracy between the models is relatively small, which suggests that they are all performing well on this task.

V. CONCLUSION

In this paper, we conducted a comparative analysis of deep learning models for mango leaf disease recognition. Our results highlight the advantages and limitations of custom-designed CNNs and pretrained models, offering valuable insights for researchers and practitioners in the field of agricultural disease recognition. This comparative analysis serves as a foundation for designing effective and efficient solutions to combat mango leaf diseases and contribute to sustainable mango cultivation practices. The application of DL-based techniques has promoted the emergence of projects that have enriched the development and evolution of smart farming. Further research can extend this analysis to cover a broader range of crops and diseases, fostering advancements in the field of precision agriculture.

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