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Classification of Apple Plant Leaf Diseases Using Deep Convolutional Neural Network

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Abstract

Food production is one of the main sources of income and livelihood in the world. Various agricultural products are grown as essential food in the largest areas of World. According to various research, many agriculture sectors face loss due to crop diseases Plant anthologists find new methods for diagnosing plant diseases perfectly and reliably. Classification of crop diseases is done by using machine learning techniques. Now a day largest no of plant diseases is identified by using deep learning methods. In this work, we use an effective approach that is based on Otsu's thresholding method in preprocessing whereas plant diseases classify by using deep CNN. In this research, we use a benchmark dataset of apple leafs from Kaggle. The method that we use in this research is not applied to apple plants in previous studies. The dataset contains three classes first we apply preprocessing on the dataset which applies three models on these images named 19 layer CNN, AlexNet, and Inception V3 model. Apple dataset preprocesses by applying to resize, background removal, and cropping functions. In the first experiment, we did not preprocess the dataset and directly apply deep CNN on original images and show the behavior of this method on the unclean dataset. On the other hand, in the second experiment first, preprocess datasets and then apply deep CNN for the classification of these diseases. apple leaf diseases are also classified by using AlexNet and the inception V3 model lastly 19 layer CNN is compared with two other models named Alexnet and Inception V3 model both are transfer learning models Results of the AlexNet model is quietly better than the CNN and Inception V3 model is not perform well as compare to both algorithms.

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Keywords: Convolution Neural Network, Inception V3, Alex Net, apple, classification.

INTRODUCTION

More than half of the population is dependent on agriculture. With the passage of time and the increase in population, we must take some action against plant diseases. Worldwide farmers are facing significant challenges in protecting crops against various harmful bacteria like fungi, viruses, insects, and protozo (Chen, 2022). A large amount of apple production is affected by apple leaf diseases due to this we face economic losses. Automated methods play a beneficial role in apple garden monitoring also used for the detection of disease symptoms (Hashan et al., 2022). Many living and non-living things can affect how well biocontrol agents work. They can change how the agents do their jobs or how different living things interact with each other, like plants, pathogens, and bacteria (Bonaterra, 2022). Farming is vital for a country's growth. Smart farming now helps farmers make better decisions. Instead of using old methods, farmers usually check their crops for diseases in a smarter way (WAKHARE, 2023). Apple black rot is an apple disease that affects apple trees and fruit that happens due to warm and humid weather also caused by fungus. Fruits that are affected by this disease have black fringes and spores. Apple cedar rust is a fungal disease that affects apple trees and leaves.it is caused by the pathogen Gymnosporangium juniperi-virginianae(PGJV). Apple scab is a fungal disease that affects apple leaves and trees the appearance of Dark, scaly lesions on leaves shows that the leaf has scab disease. In this work, we will use an effective approach that is based on Otsu's thresholding method in preprocessing whereas plant diseases are classified by using deep CNN. DCNNs, a type of neural network, are commonly used in deep learning to analyze visual information. They are also known as Shifting Invariant or Spatial Invariant neural networks (Cai, 2023). Apply multiple methods of preprocessing on the leaf datasets to get quality and background noise removed from the image. The main objective of the study is to apply the DCNNs method to the apple plant dataset and examine the behavior of this method.

Apple dataset preprocesses by applying to resize, background removal, and cropping functions. First, resize all images 64*64 then apply the preprocessing method for background removal first convert the whole dataset into a blue channel then the resultant images convert into grayscale images in the last step of background removal applying another method is Otsu's method (Hong, 2022) for covering the grayscale images into the binary mask. Then crop function on the datasets. These steps are applied to all images for cleaning images so applying these methods on the leaf diseases dataset. In the first experiment, we will not preprocess the dataset and directly apply deep CNN on images and show the behavior of this method on the unclean dataset. On the other hand, in the second experiment first, preprocess the dataset and then apply deep CNN classification of leaf diseases so these experiments show how much results are affected by using image preprocessing or not. we effectively use preprocessing based on Otsu's thresholding along with CNN for diagnosing and classifying the diseases. Apply preprocessing methods to get a clear image by removing the background of the image. whereas we perform two experiments with this dataset first which we apply to preprocess and the second experiment without applying to preprocess CNN applies on both and checks the behavior of both methods. We mainly focus on using a dataset of an apple plant and show the behavior of 19-layer CNN also compare CNN with two other models named Alexnet and Inception V3 model (Ujawe, 2023) both are transfer learning models Results of the AlexNet model is quietly batter than CNN and Inception V3 model is not perform well as compare to both algorithms.

LITERATURE REVIEW

Scientists have developed numerous methods for the classification and identification of plant diseases. For these significant purposes, scientists use machine and deep learning methods. Mahamudul Hashan utilizes a multilayer convolution neural network for the classification of apple leaves consisting of three diseases named black rot, cedar, and scab. In this study author uses two types of transformation to increase dataset size such as perspective and affine transformation. As a result, system achieves training accuracy is 98.40 and 98.47% of testing accuracy (Hashan et al., 2022). The study develops a learning-based pipeline to solve the problem of a limited dataset. The methodology is divided into two parts first using Cycle-consistent adversarial networks(CycleGAN) to improve the learning of data distribution to solve the problem of small datasets and data imbalance. Secondly, train ResNet for apple leaf disease classification as a baseline of convolution neural network. (Chen et al., 2023) Ding J and Zhang C developed an apple disease recognition model named RFCA ResNet, which has a multi-feature extraction capacity. The result shows that this approach significantly increases the results of the model and outperforms the convolution neural network. (Ding et al., 2023). The study utilizes a model for early diagnoses of apple disease.ad convolution replaces standard convolution making smaller no of parameters and calculations.LAD is built to enhance the ability to extract multi-disease spots. LAD-Net significantly achieves 98.58% accuracy with a size of 1.25MB(Zhu et al., 2022). This study presents a transfer learning model for the classification and identification of diseases of apple leaves. That system uses pretrain EfficientNetV2S architecture for extraction of features and passes to the classifier block for effective prediction.

Runtime argumentation is used for tackled to imbalance classes. The proposed pipeline evaluated by using the plant Village dataset it achieved 99.21% accuracy(Ashmafee et al., 2023) Khan and Asif Iqbal Quadri utilize 9000 images and apply deep learning-based apple disease detection methods on these images that accurately identify symptoms of diseases. The system is categorized into two stages the first stage classifies disease, damage, and healthy images by using a tailor-made lightweight classification model second stage is the detection stage in which we perform the actual identification of sick-nesses from leaf pictures. Moreover, developed a CNN model for calcification and detection of apple leaf diseases. That is a comparative study that utilizes three deep learning techniques named as VGG16 model, the VGG19 model, and the Inception V3 model to analyze their performance. By using a machine learning model determine whether the image is infected or not.VGG16 model obtained 98.5% accuracy. We introduced a progressive multivariate logistic regression algorithm for assessing apple leaf disease grades and subsequently developed an enhanced evaluation model using PCA-logistic regression analysis.

This study focused on three prevalent apple leaf diseases—black rot, scab, and rust—comprising 4,500 images sourced from open datasets. To validate the model's effectiveness, an object detection algorithm is employed. Results indicated the loss curve stabilized at approximately 70 during training epochs. In comparison to Faster R-CNN, Mask R-CNN demonstrated a notable 4.91% increase in average accuracy for recognizing apple leaf disease type and grade, along with a 5.19% rise in average recall rate. Furthermore, the optimized model for evaluating apple leaf disease grades achieved an impressive average accuracy of 90.12%, marking a significant overall enhancement of 20.48%. These findings strongly affirm the efficacy of innovative model (Bingqian Xing, 2023). This paper introduces an innovative approach for classifying apple leaf diseases within complex backgrounds. It leverages a BF-MSRCR algorithm for image preprocessing and a BAM- Net with ACAM and MFRM for accurate classification. In dataset, the method achieved an impressive 95.64% accuracy, 95.62% precision, 95.89% recall, and a 95.25% F1-score, surpassing existing methods. Notably, BAM-Net also demonstrated strong generalization when identifying diseases in other crops. This research holds promise for modern agriculture and crop disease identification (Yuxi Gao, 2023). To enhance data distribution learning and address issues related to small datasets and class imbalance, an improved CycleGAN is employed to generate synthetic samples. Additionally, a baseline convolutional neural network classifier, ResNet, is trained for apple leaf disease classification. Experimental findings demonstrate that ResNet achieves the highest recognition accuracy on the test set, reaching 97.78%, with a significant classification accuracy improvement of approximately 14.7% due to the use of synthetic samples. Moreover, results from t-distributed stochastic neighbor embedding (t- SNE) and a visual Turing test visually validate that the images produced by the enhanced CycleGAN exhibit notably higher quality and are more convincing (Yiping Chen1, 2023).

This study introduces an automated framework for apple fruit leaf disease detection using CNN and a hybrid optimization algorithm. The process begins with data augmentation to balance the Apple dataset. Subsequently, two pre-trained deep models undergo fine-tuning and transfer learning. A fusion technique called Parallel Correlation Threshold (PCT) is then proposed to combine feature vectors, which are further optimized using a hybrid optimization algorithm. Finally, machine learning algorithms are used to classify the selected features. The experiments conducted on the augmented Plant Village dataset achieved an outstanding accuracy of 99.8%. Furthermore, the proposed framework's accuracy surpasses that of several neural networks, making it a superior choice for disease detection (Samra Rehman Muhammad Attique Khan, 2023).

The study utilized the publicly available PlantVillage dataset, comprising four classes: Scab, Black Rot, Cedar Rust, and Healthy Leaves. The results from experiments involving ten prominent CNN models, including DenseNet201, DenseNet169, InceptionV3, InceptionResNetV2, MobileNet, MobileNetV2, ResNet50, VGG16, VGG19, and Xception, demonstrated the effectiveness of deep learning techniques in accurately distinguishing between apple diseases. Notably, DenseNet201 outperformed the other models, achieving an impressive accuracy of 98.75%. This high accuracy underscores the potential of CNN-based methods as a valuable alternative to traditional approaches for apple disease classification (Mohan, 2022). This paper introduces an innovative apple leaf disease recognition model, MSO-ResNet (multistep optimization ResNet), built upon the foundation of ResNet50. The model's advancements include convolution kernel decomposition, identity mapping method enhancement, a reduction in the number of residual modules, and the replacement of batch normalization layers. These improvements result in enhanced model accuracy and speed, along with a reduction in model parameters. Experimental results reveal that the proposed model achieves impressive average precision, recall, and F1-score for leaf disease identification at 0.957, 0.958, and 0.957, respectively. Notably, the model has a modest parameter memory size of 14.77 MB and rapid image recognition times of only 25.84 ms per image. Overall, the performance of this model surpasses that of other competing models (Chen, 2021).

MATERIALS AND METHODS

Architecture of Proposed Methodology

The architecture of the proposed methodology is shown in Figure 1. It consists of the following modules

- Data Collection
- Preprocessing
- Experiments
- Visualization

PROPOSED METHODOLOGY

In this study, we propose a deep convolution neural network for classification of leaf diseases using benchmark datasets. As seen in Figure 1, the proposed work consists of following three stages: where preprocessing increase the lesion and clarity of the image. Leaf disease classification is performed by using 19 layers CNN, AlexNet and Inception V3 The overview of proposed framework is given in figure 2.

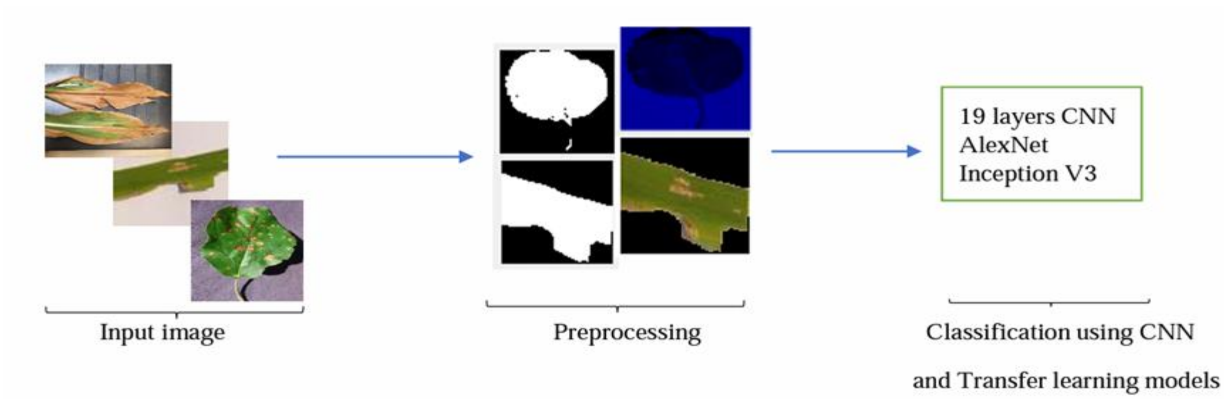

Figure 1.
Proposed Methodology

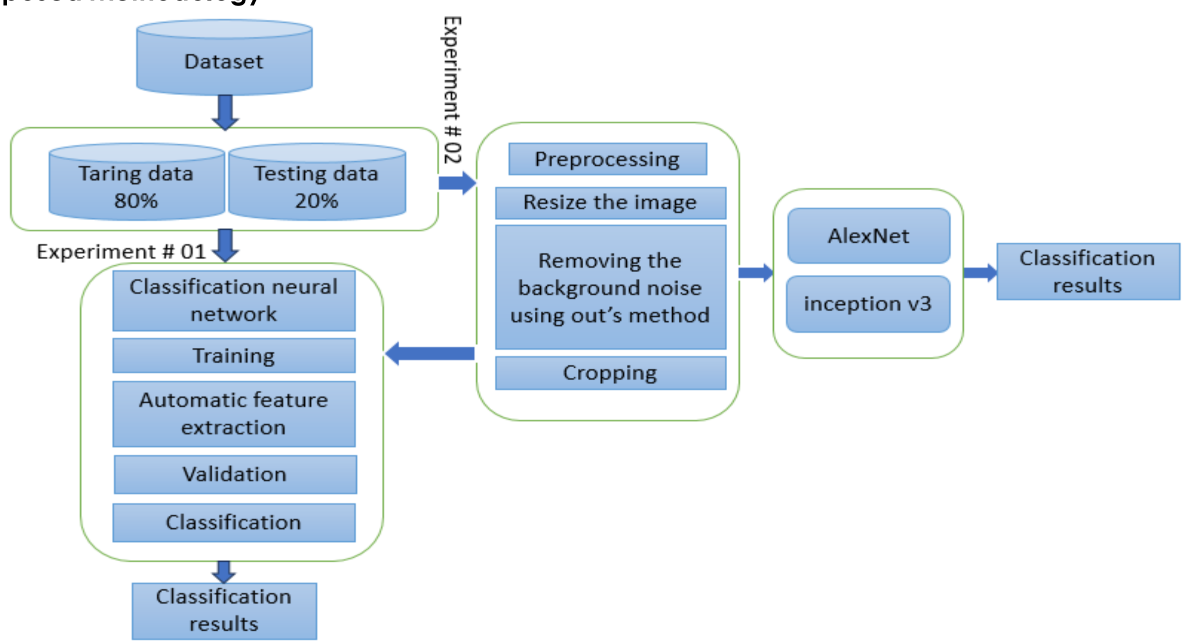

Figure. 2.
Basic Architecture of Proposed Methodology

In this section, a methodology is proposed for classifying diseases in apple plants by following multiple steps, starting with the acquisition of the dataset after applying different preprocessing techniques on acquired datasets then next applying a Classification neural network (CNN) for extraction of automatic features. Bunch mark datasets of apple plants were gathered. The quality of the image is enhanced by utilizing image preprocessing multiple steps. Pre-processing consists of multiple steps: Change the size of the image and eliminate background noise using Otsu's method. In this step, all RGB images are transformed into blue channel images by setting the red and green channels to zero. The resulting images are then turned into grayscale images by averaging the values of the red, green, and blue elements. After that applying global thresh holding Otsu's method the d then finds an area of interest by multiplying the original and masked image and cropping. After preprocessing apply CNN 19 layers on preprocessed data and get classified diseases on different plant datasets. AlexNet and Inception v3 are utilized for the classification of diseases. Finally, the classification of the disease is done this methodology is detailed in multiple subsections.

Data Collection

We have utilized a dataset of apple plant leaf diseases. That dataset consists of three (Hashan A. M., 2021) diseases namely black rot, cedar rustand and scab. The dataset was taken from Kaggle website are benchmark dataset.

Table 1: Specification of Apple Dataset

Plant	*Classes*	*No of images*
Apple	Black rot	170
	cedar rustand	160
	scab	150

In table 1. Apple dataset consists of three diseases such as black rot, cedar rustan,d, and scab (Palanisamy, 2023). Mostly these leaves are damaged due to fungus and bacteria (Upadhyay, 2022). The 19-layer CNN, Inception V3, and AlexNet is applied on the apple dataset to classify leaf diseases.

Data Preprocessing

The preliminary phase of this study encompasses a crucial pre-processing stage aimed at enhancing the quality of apple leaf images. This phase consists of three key operations: resizing, background removal, and cropping. The first operation, resizing, aims to standardize the dimensions of the rice leaf image samples. Each image is resized to a uniform dimension of 64x64 pixels, facilitating consistent input dimensions for subsequent analyses. Following resizing, the process of background removal is executed. This step involves a series of transformations to isolate the apple leaf's distinct features while eliminating unwanted background elements. Initially, Each RGB image is modified in a way that eliminates the green and red components, leaving only the blue channel. This technique effectively reduces the impact of background features and brings out the main characteristics of the rice, corn, and apple leaves. Following this, the blue channel image is further converted into a grayscale image by calculating the average values of the blue, red, and green elements for each pixel. The resultant grayscale image encapsulates the essential structural features of the apple leaf, serving as a foundation for subsequent analysis. The grayscale image produced in the background removal phase is then subjected to Otsu's method, a well-established global thresholding technique for image banalization. Otsu's method operates by determining a threshold value that optimally separates the image's pixel intensity values into two classes: background and foreground. This threshold is chosen based on the maximization of between- class variance and the minimization of within-class variance calculated from the image histogram. By segmenting the grayscale image into binary regions, Otsu's method creates a binary mask that distinguishes between background and foreground pixels. This binary mask acts as a filter that highlights the relevant features of the rice leaf while suppressing the noise and irrelevant background information. Overall, these pre-processing steps collectively contribute to enhancing the quality and relevance of the apple leaf images, enabling more accurate and effective analysis in subsequent stages of the study.

Automatic features extraction and classification

In this research, we have utilized CNN for the classification of apple plant deceases and also for improving the efficiency of the model that is the best model as compared to other traditional learning models and is widely used for classification. In a CNN setup, the input layer takes in the data. Then, several hidden layers work together to figure out the important stuff in the data. Finally, the last layer gives us the result we need. Each of these layers does specific jobs that are really important for the task we're doing. The convolution layer is the most important layer in the CNN that performs feature extraction of the hidden layer depending on the nature of the research problem. Automatically and optimally features are mapped by using the pooling layer convolution layer and fully connected layer. Strides are the steps in which the kernel slides on input data. A CNN is a type of deep-learning setup that can maintain and uncover important patterns in visual data while it learns. It achieves this using tools like filters, which create maps highlighting different features in the data. By examining these feature maps from various perspectives, CNNs reveal the data's complex characteristics (Ahmed, 2023). That CNN consists of 19 layers applying this model to an apple leaf dataset that performs well and outputs results significantly good.

RESULTS AND DISCUSSION

Experimental Tools

To execute the proposed methodology, we initially gathered the benchmark dataset from Kaggle. After obtaining the dataset, it was stored in a designated folder. Subsequently, the acquired data underwent preprocessing using MATLAB. Data loading in MATLAB was facilitated through the utilization of the"Image Batch Preprocessor" feature, which processes data from folders through a series of distinct steps. The AlexNet model is executed within the MATLAB software environment, where it is loaded using a specific command. Simultaneously, Jupiter notebook is used to process the inception v3 model in the Python programming language, and various built-in libraries, including pandas, NumPy, TensorFlow, and Keras, were utilized to conduct experiments.

Observation of Experiment One

In experiment one the performance of the classification model is analyzed by applying 8 epochs, each epoch contains 100 iterations on an individual dataset total of 800 iterations are executed, and performance of experiment one is observed. The same no of epochs were used for the training and validation of each plant. Set the no of iterations per epoch is 100 by changing the value of Minimum Bach Size from the model. If the dataset size decreases the minimum is decreased on the other hand if the dataset size increases the minimum Bach size increases. So the dataset is processed with 8 epochs in each iteration. Apple dataset achieves 99.9% training accuracy and 97.92% of validation accuracy. The accuracy and loss graph of each disease leaf is shown in figure 3 and 4 which depicts the results of the classification in the accuracy graph

On the apple plant leaf disease dataset that model runs 768 maximum iterations, 94 iterations per pouch. So Apple dataset achieved 99.9% training accuracy and 97.92% validation accuracy which is significantly good accuracy.

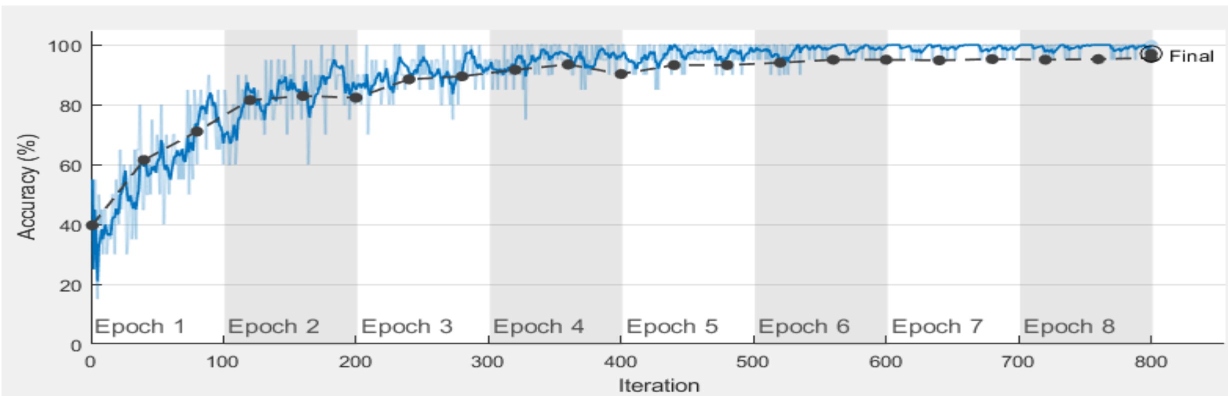

Figure 3.
Apple observation of experiment one (19 layer CNN)
The accuracy graph of the apple disease leaf is shown in figure 3, and clearly indicates the results of classification accuracy dataset that model run 768 maximum iterations,94 iterations on per pouch. So Apple dataset achieve 99.9% training accuracy and 97.92% of validation accuracy that is significantly good accuracy.

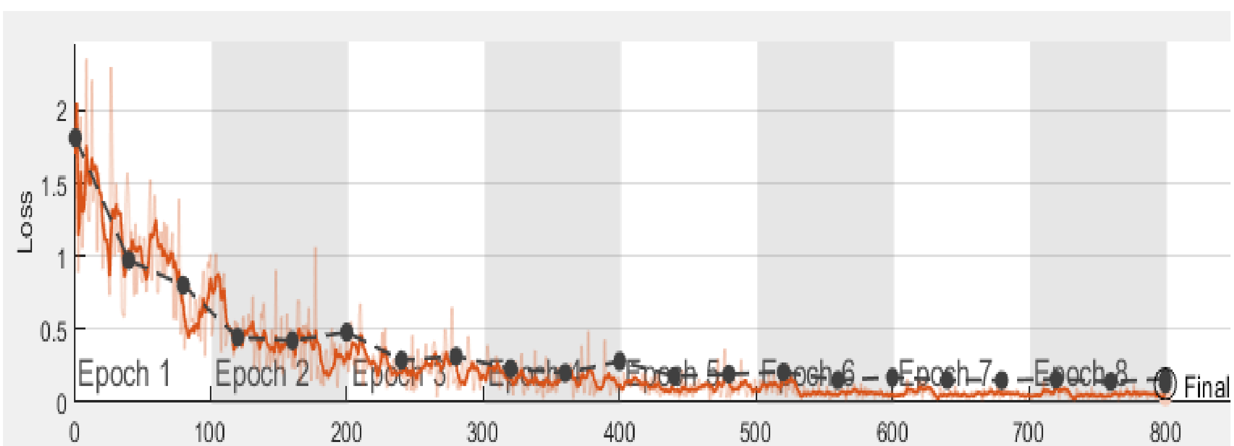

Figure 4.
Observation of experiment one apple loss graph
In figure 4, the loss graph of apple disease leaf show the results of classification loss of

apple disease dataset.

Observation of Experiment Two

In the experiment number Two, a pre-process dataset is used of three plants named apple to analyze the performance of the classification model by applying 8 epouches with 100 iterations on an individual dataset total of 800 iterations are executed to observe the performance of experiment. This study utilizes four hidden layers for the classification of apple plant leaf diseases this model effectively uses Otsu's thresholding preprocessing method for background removal to apply multiple image preprocessing steps for quality images. The quality of the image is enhanced by utilizing image preprocessing multiple steps. The pre-processing involves a series of actions: resizing the image and eliminating background noise using Otsu's method. In the initial step, all RGB images are turned into blue channel images by setting the red and green channel values to zero. These resulting images are then transformed into grayscale by averaging the values of red, green, and blue elements. After that apply global thresh holding Otsu's method then finds an area of interest by multiplying the original and masked image and cropping. After preprocessing apply CNN 19 layers on preprocessed data and get classified diseases on different plant datasets.

AlexNet and Inception v3 are utilized for the classification of diseases. Finally, the classification of the disease is done this methodology is detailed in multiple subsections. We have developed two experiments in the first experiment we apply CNN on the original dataset and in the second experiment first apply preprocessing on the benchmark dataset and then apply CNN. Furthermore, compare that model to two other algorithms named Alex net and transfer learning algorithms. The quality of the Apple image dataset is enhanced by utilizing image preprocessing multiple steps. The pre-processing involves a series of actions: resizing the image and eliminating background noise using Otsu's method. In the initial step, all RGB images are turned into blue channel images by setting the red and green channel values to zero. These resulting images are then transformed into grayscale by averaging the values of red, green, and blue elements. After that apply global thresh holding Otsu's method the d then finds an area of interest by multiplying the original and masked image and cropping. After preprocessing CNN 19 layers is applied on preprocessed data to get classified diseases on the apple plant dataset, the training and validation accuracy in figure 5 and loss graph in figure 6 is shown. The model runs 768 maximum iterations and each epoch contains 96 iterations so as a result that model achieves 99.9% training accuracy and 92.71% validation accuracy.

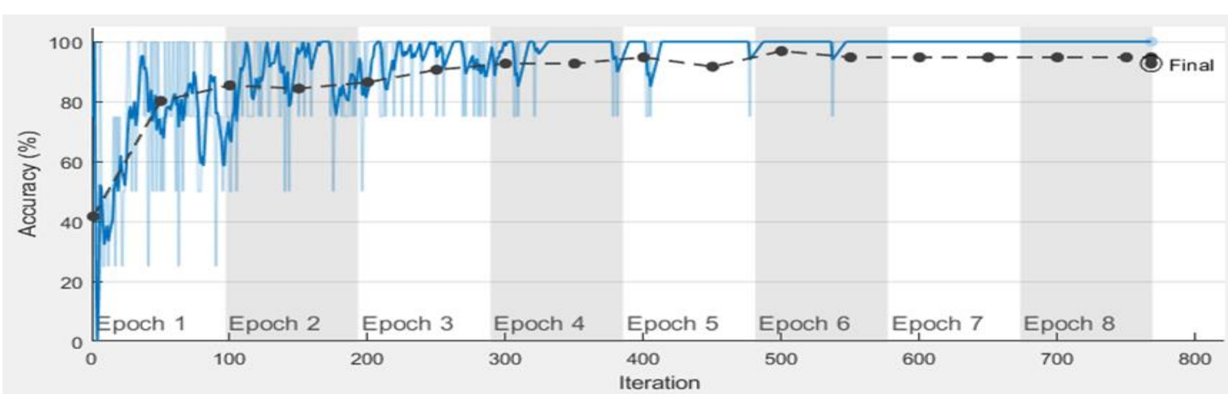

Figure 5.
Observation of experiment two (19 layer CNN) apple accuracy graph

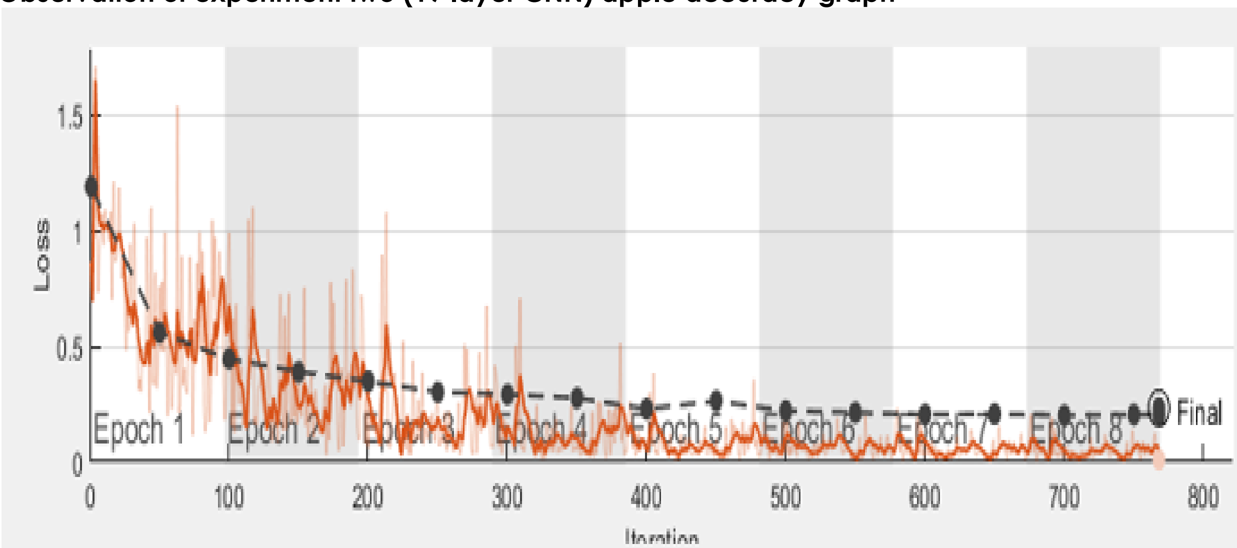

Figure 6.
Observation of experiment two apple loss graph

Classification Results Using AlexNet

AlexNet, which is a modified type of convolutional neural network, was developed by Alex Krizhevsky. This model has been trained using over a million images from a dataset called ImageNet, and its ability to classify images extends our learning by trying out diverse approaches. Interestingly, AlexNet acquired knowledge from an extensive collection of images. This accumulation of knowledge through practice is akin to honing a skill. This accumulation enabled AlexNet to excel at recognizing the content of images. Thanks to AlexNet, we now possess more advanced computer brains capable of superior image comprehension. Its impact transformed the way these digital cognitive systems are constructed, thus providing a fresh perspective on how to perceive the world that model run 672 maximum iterations and each epoch contain 84 iterations so as a resulted that model achieve 99.9%training accuracy and 91.67% validation accuracy obtained from Figure 7 and 8.

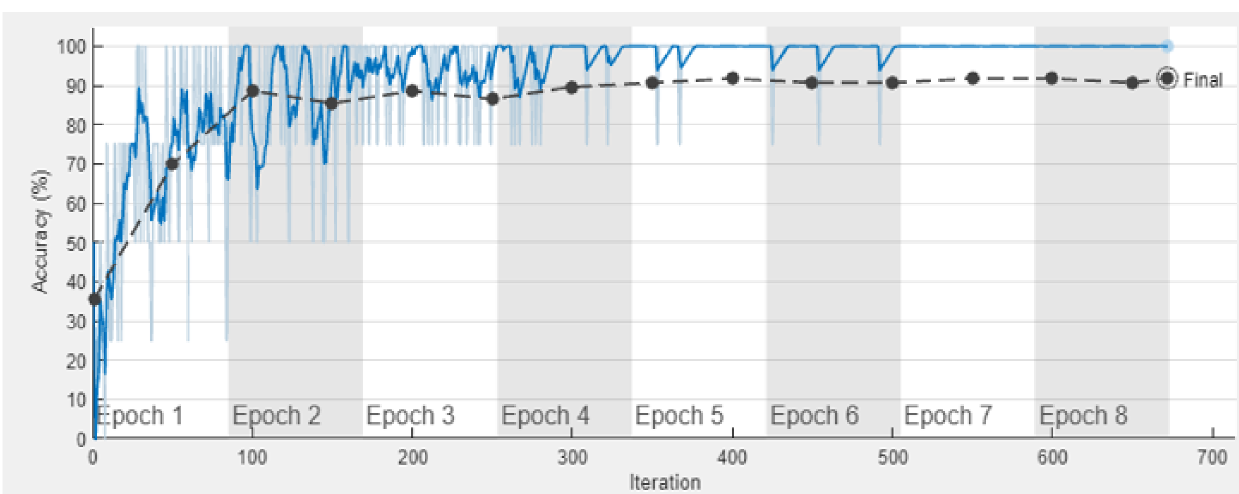

Figure 7.
AlexNet model apple dataset accuracy graph

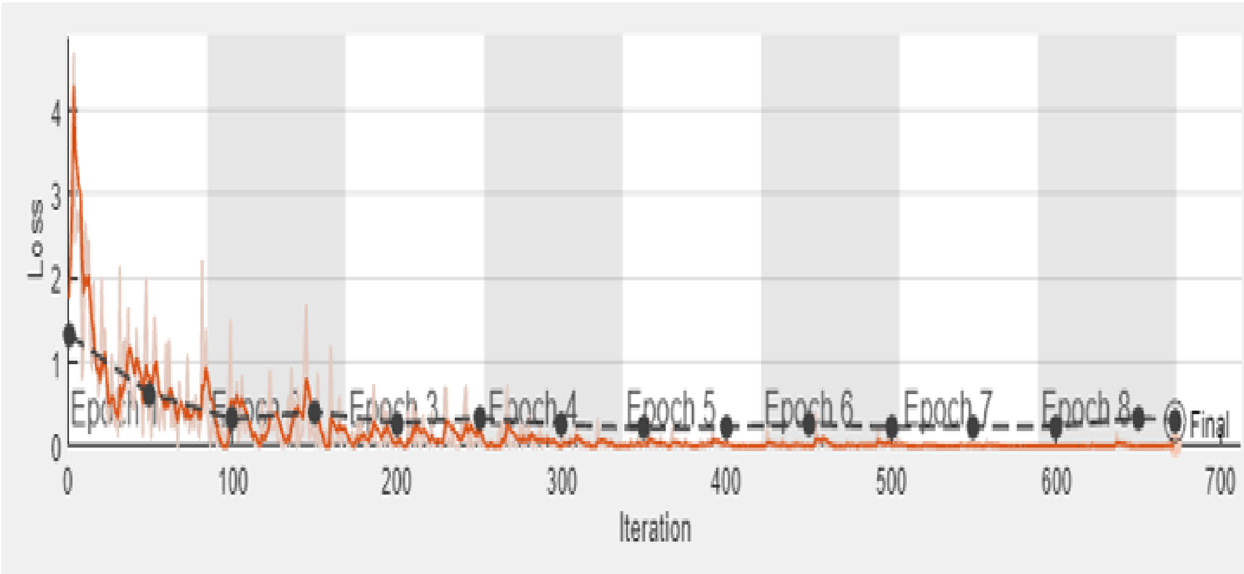

Figure 8.
AlexNet model apple dataset loss graph

Classification Results Using Inception V3

InceptionV3 is an advanced convolutional neural network (CNN) architecture devised for image classification and object recognition. It derives from the lineage of the Inception model, originally introduced in the"Going Deeper with Convolutions" paper by Google researchers. The hallmark of the Inception approach lies in its strategic use of varying filter sizes (1x1, 3x3, and 5x5) within individual layers to capture features of different scales. InceptionV3, the third iteration, refines this design with enhancements aimed at both performance and computational efficiency.InceptionV3's core features encompass: Parallel Architectural Streams: The architecture integrates multiple branches, each concurrently processing the input with different filter sizes. This parallelism enables the network to capture a wide range of features simultaneously. Factorized Convolutional Paradigm: Incep- tionV3 introduces factorized convolutions, decomposing larger filters into smaller convolutions. This reduces computational demands while preserving the model's ability to represent intricate patterns.

The quality of apple image dataset is enhanced by utilizing image preprocessing multiple steps The pre-processing involves a series of actions: resizing the image and eliminating background noise using Otsu's method. In the initial step, all RGB images are turned into blue channel images by setting the red and green channel values to zero. These resulting images are then transformed into grayscale by averaging the values of red, green, and blue elements. After that apply global thresh holding Otsu's method then finds area of interest by multiplying the original and masked image and cropping. After preprocessing apply Inception V3 on preprocessed data and get classified diseases on apple plant dataset. Training operation is set as minimum batch size is 32,10 pouches so as a resulted that model achieve 92.21% training accuracy and 86.84% validation accuracy as shown in figure 9.

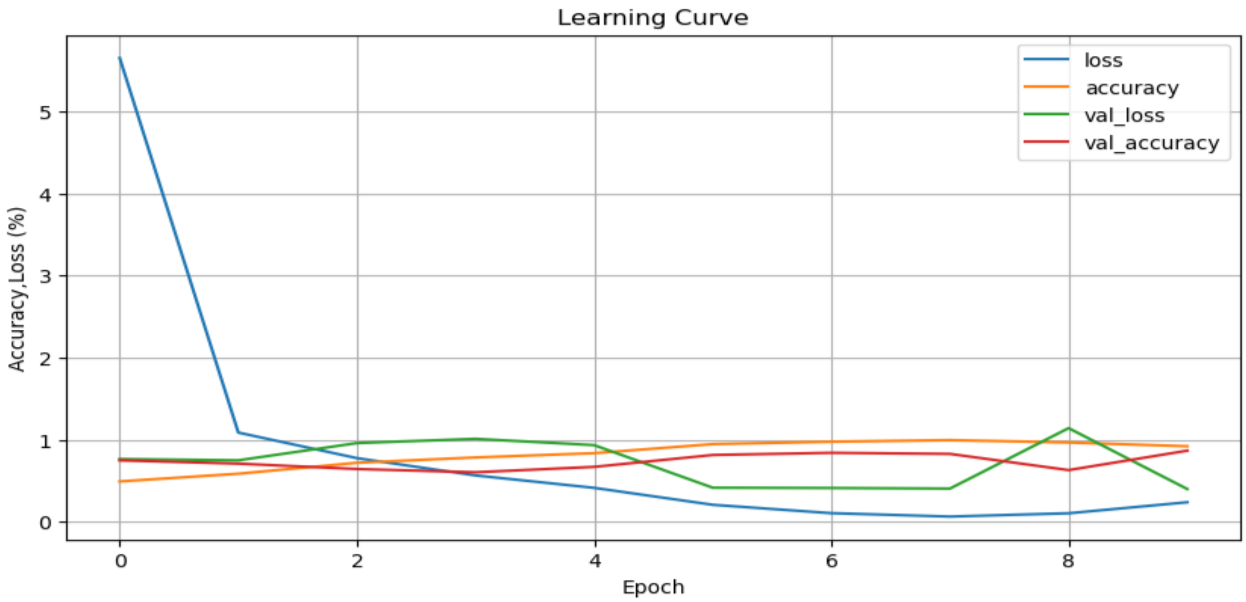

Figure 9.
Inception V3 apple dataset accuracy and loss graph

DISCUSSION AND COMPARISON

As shown in Table 2, the 19 Layer CNN model demonstrates exceptional performance on the apple dataset. With a training accuracy of 99.9%, it indicates a robust learning process on the training data. Moreover, the validation accuracy stands impressively high at 97.92%. This signifies that the model not only learned well from the training data but also generalizes effectively to unseen data, showcasing its potential for real-world applications. Moving on to AlexNet, it also exhibits commendable performance on the apple dataset. It achieves a training accuracy of 99.9%, showing that it effectively captured the underlying patterns in the training data, similar to the 19 Layer CNN. However, the validation accuracy is slightly lower at 92.67%. This suggests that AlexNet might be slightly overfitting to the training data, as it performs better on the training data compared to the unseen validation data.

Table 2.
Comparison of different models results

Author	Classes	Images	Accuracy	Methods
Proposed approach	3	480	99.9%	convolutional neural network
Proposed approach	3	480	99.9%	AlexNet
Proposed approach	3	480	92.21%	Inception V3
(Hashan et al., 2022)	3	480	98.40%	multilayer convolutional neural network
(Khan, 2022)	4	9000	81.1%	Naïve Bayes and Adaboost
(Chen et al., 2023)	3	1977	97.78%	improved CycleGAN and convolutional neural network

Inception V3, while still achieving a high training accuracy of 99.9%, falls behind in terms of validation accuracy, achieving 85.53%. This is notably lower than both the 19 Layer CNN and AlexNet. This indicates that Inception V3 might be struggling to generalize as effectively to unseen data for this particular apple dataset.

In summary, for this specific apple dataset and the applied preprocessing steps, the 19 Layer CNN model appears to be the most effective, closely followed by AlexNet. Inception V3, while still performing well, lags behind in terms of validation accuracy. It's important to note that these results are specific to this dataset and preprocessing approach, and different datasets or preprocessing methods might yield different comparative outcomes.

CONCLUSION AND RECOMMENDATIONS

In this study, the aim is to improve the health of apple plants using advanced computer techniques to detect leaf diseases. Deep learning, a powerful method for understanding images, was employed to enhance the clarity of pictures by removing unnecessary elements. Various computer models were tested to determine the most effective one. The "19 Layer CNN" emerged as the top-performing model, boasting an impressive 99.9% accuracy in both training and validation stages. AlexNet also delivered strong results, with 99.9% training accuracy and 91.67% validation accuracy. However, a slightly lower validation accuracy suggested a potential for mild over fitting.

In contrast, Inception V3 faced challenges in generalizing effectively, achieving 99.9% training accuracy but falling short with an 85.53% validation accuracy. This research is crucial for equipping farmers with a smart tool to protect their apple crops from diseases. Through these cutting-edge computer methods, we take significant steps towards securing our food supply and supporting the livelihoods of those reliant on agriculture. These findings not only benefit apple growers but also contribute to our broader understanding of using technology for global food security. In the future, the proposed method can be utilized for the classification of other Benchmark datasets also compare with other algorithms (Vgg 16, vgg 19, rest net, inceptionv3, and inceptionv4). There is huge difference between training and testing accuracy of each implemented model, hyper parameter tuning can be done to minimize the differences.

DECLARATIONS

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Conflicts of Interests: The authors declare no conflict of interest.

Consent to Participate: Yes

Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

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