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Detect Plant Diseases with Convolutional Neural Network

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Abstract: *Agricultural productivity is an important factor in the Indian economy. Therefore, the contribution of food and cash crops is very important to both the environment and people. Each year, crops succumb to several diseases. The diagnosis of such diseases is inadequate, and many plants die due to ignorance of the symptoms of the disease and its treatment. This is done using image processing techniques. A total of 15 cases were fed to the model, 12 of which were Bell Paper Bacterial Spot, Potato Early Bright, Potato Rate Bright, Tomato Target Spot, Tomato Mosaic Virus, Tomato Yellow Leaf Curl Virus, and Tomato Bacteria. Three cases of Spot, Tomato Early Bright, Tomato Late Bright, Tomato Leaf Mold, Tomato Septoria Leaf Spot and Tomato Spider Mite and Healthy Leaves: Bell Paper Healthy, Potato Healthy and Tomato Healthy. The test accuracy is 94.80%. Different performance matrices are derived for the same thing.*

Background*: This study provides insights into an overview of plant disease detection using various algorithms. Here, a CNN-based method for detecting plant diseases was proposed. Simulation studies and analysis are performed on sample images in terms of time complexity and area of infected area.*

Key Word*: Convolutional Neural Network (CNN), Leaf Disease, etc.*

I. INTRODUCTION

Crop growth and yield are essential aspects that influence the field of agriculture as well as farmer economically, socially, and in every possible way. So, it is necessary to have close monitoring at various stages of crop growth to identify the diseases at right time. But, humans naked may not be sufficient and sometimes it would be misleading scenarios arise. In this aspect, automatic recognition and classification of various diseases of a specific crop are necessary for accurate identification. In this chapter, I will provide a tour d'horizon for the proposed methodology of my research work. This chapter consists of the background, problem statement, objectives, and scope of the proposed methodology.

One of the severe causes of increased microbial infection is illiteracy among farmers in India. Once a crop is infected by some disease it is difficult for farmers to find out the real cause of diseases. pathogens and pests are affecting the crops badly. The crop produces for 5 main food crops by 10

-40%, This data is in reference to a study report which is published by UC Agriculture and Natural Resources.

In the Indian context where agriculture contributes to 16% of GDP and engages almost 60% of the population requires great measures to be taken to avoid plant diseases. According to the Ministry of Food Processing Industries in the year 2016 agricultural loss was 13 billion dollars. One of the helpful measures in plant disease detection methods can be done with the help of image processing and neural network. Neural network and deep learning in some recent research have proved its worth in doing such classification tasks efficiently.

Agriculture is an essential sector in countries like India as those countries' economy directly or indirectly dependent on agriculture. It indicates the necessity of taking care of plants from seedling until the expected crop obtains. Through this process, the crop needs to cross a lot of phases to obtain the expected crop such as weather conditions, the survival of the crop from various diseases, and the survival of the crop from various animals. Of these major phases, the crops can be protected from the various animals by providing proper protection for the field and this issue can be solvable. The next major issue is weather conditions which will not be in the control of humans, humans can only pray for better weather conditions to obtain a better crop. Finally, The major issue is very crucial to protect the crop from various diseases as these diseases can impact the complete growth and yield of the crop. If one can able to identify these diseases in time, then the crop can be protected using appropriate fertilizers. If this process of identification and classification of diseases able to digitalize which would be helpful for the agriculturists. It will decrease the time for the identification of diseases and precision in classifying the diseases.

II. RELATED WORK

1. Sardogan, M., et al. in 2018 [1] presented a model with a combination of convolutional neural networks (CNN) along with learning vector quantization(LVQ) for the identification and categorization of diseases of tomato plant leaves. The presented framework was implemented on the data size of 500 images with the four categories of diseases considered for tomato plant leaves. The convolutional neural network is utilized for the extraction of vital attributes from the images as well as for the classification.
2. Wallelign, S., et al. in 2018 [2] discussed the viability of convolutional neural network architecture for the classification of various plant diseases with the aid of leaf images. The mentioned framework is implemented by utilizing the LeNet, one of the popular CNN architecture, for disease classification in the aspect of soybean plants. The soybean plant leaf images of 12,763 samples are obtained from the standard database called PlantVillage. The mentioned framework able to achieve an accuracy of 99.32% indicating the viability of CNN with plant disease classification utilizing the leaf images.
3. Sladojevic, S., et al. in 2016 [3] concerned the generation of the new-age model for the identification of various diseases of 13 plant diseases out of the healthier plant leaf images. The deep learning architecture called Caffe was utilized for training the data. The results were obtained from the mentioned framework with a precision of 91percent to 98percent.
4. Fuentes, A., et al. in 2017 [4] proposed a framework and can be applied in two stages. At first, the meta architectures of Faster R-CNN, R-FCN, and SSD will be combined to form a single meta-architecture. Lastly, certain methodologies such as VGG- 16, VGG-19, and ResNet-50 will be attached to extract the features from more depth and these models' efficiency was estimated. When compared to many other models, the proposed framework efficiency is better.
5. Arivazhagan, S. and Ligi, S. V. in 2018 [5] proposed a framework based on automated deep learning for the recognition and classification of various diseases in mango plants. The dataset utilized for this framework consists of 1200 images which include both diseased and healthy leaves of mango. The accuracy obtained from the proposed framework is 96.67%. Oppenheim,
6. D. and Shani G. in 2017 [6] proposed a framework based on convolutional neural network architecture for the recognition and classification of various diseases in potato plants. The dataset utilized for this framework consists of 2465 potato images.

III. PROPOSED METHODOLOGY

A series of steps need to be carefully followed for the process need to be followed in a diseplinedmanner:

Step-1: Image Acquisition for dataset creation: This step involves exploring various data sourcesfrom where data can be extracted for training the model and further how the test image input is tobeprovided.

Step-2:ImagePre-processingandbackgroundremoval:Thisismostimportantphas,asitinvolvesthe quality assurance of the data. In the image pre-processing phase image is processed to desiredcolorformat, resized to desired sizeand imagesaredenoised.

Step-3: Image Segmentation to obtain infected region: Region of interest that is the infected partof the leaf is identified. This is again one of the most crucial step, as entire analysis is dependentonthe infectedrefion identified bythe process ofsegmentation.

Step-4: Extraction of Features from images: On the basis of obtained region of interest which isthe infected part of the leaf various image features like standard deviation, mean of red, blue andgreenchannels, theentropy ofimageis extracted.

Step-5: Evaluate and identification of the affected region: By comparing the extracted region ofinterests & featureswhich areextracted fromtheimage, anefficient modelis derieved.

Step-6:ProcessedDatasetcreation:Thedatawhichareprocessedinpreviousstagesareprocessedand extracted and converted to a csv file format and stored. This stored data is further utilized foranalysispurpose.

Step-7: Training Data Extraction: Randomly the data in csv file is split. The 70% of the split dataisused fortraining the proposed model.

Step-8: Testing Data Extraction: Randomly the data in csv file is split. The 30% of the split dataisused fortraining the proposed model.

Step-9: Classification: Test data has labels such as: Late Blight, Early Blight, and Healthy, basedonwhich classification isperformed.

Step-10: Evaluation of proposed model: Depending on the obtained results from the classifiermodel,theevaluationmetricssuch asprecision,recall,F1-score,andaccuracywillbeobtained.

(1) (2) (3)

Figure.1 The three Sample leaves of potato are (1): leaf affected by Light Blight (2): leaf affected byEarlyBlight(3):leaf unaffected(Healthy)

IV. CONVOLUTIONAL NEURAL NETWORK (CNN)

Convolutional Neural Networks (CNN) is also known as CNNs or ConvNets. They are categories of a neural network that are very effective in the computer vision tasks like image recognition and classification. CNN's are feed-forward neural networks that are used to analyze image data by processing it in the grid-like topology. An image data can be represented digitally as a matrix of pixel values. The series of pixels arranged in a grid-like manner represents pixel values about the color and intensity of the color for each pixel. After seeing the particular image, the human brain processes information related to the image. Each neuron in the brain works as an individual receptive field connected with other neurons to cover the whole visual area. Similarly, each neuron in the CNN is process data only in the receptive field. The layers of the CNN architectures arranged in a manner that processes simple information like lines and curves first. With the CNNs, it is possible to provide sight to the computer. The major four operations that exist in the CNNs are as follows:

- Convolution operation
- Non-Linearity
- Pooling
- Fully Connected layers or Classification

4.1 ConvolutionOperation

One of the basic building blocks of CNN is the convolution layer. The convolution layers carry the main portion of the computational load. This layer does the dot product between the matrix of learnable parameters known as the kernel and matrix with a limited receptive field. The height and width of the kernel will be spatially small. However, the depth of the kernel extends up to three RGB channels of the input image. While performing the forward pass, the kernel slides through the image's height and width, which is responsible for the image representation of a particular receptive region (Smeda, K., 2019).

4.2 Non-Linearity

To achieve the non-linearity in the CNN network, Rectified Linear Unit (ReLU) activation function is used. ReLU stands for a rectified linear unit. Once the feature set is obtained in the next step, they are forwarded to the ReLU layer (Smeda, K., 2019). It operates on each and every element of the feature set and set the value of all negative pixels to zero. It is represented in Figure 4.2.

4.3 PoolingLayer

Like the convolutional layer, the pooling layer is used to reduce the spatial size of the convolved features obtained after convolution operation. Applying pooling on the obtained features reduces the computational power required for data processing using dimensionality reduction. Moreover, it helps in effective

4.4 FullyConnected LayersorClassification

The fully connected layer is a typical multi-layer perceptron that uses softmax as an activation function in the output layer. The neurons in the fully connected layer are fully connected with the neurons in the preceding and succeeding layer. For the input RGB image, the output of the convolutional and pooling layer delivers the high-level features. Based on the training dataset provided to the network, the fully connected layer utilizes these features for input classification into different classes (Smeda, K., 2019). Also, fully connected layers are usually used for learning a non-linear combination of the features obtained from the previous layers. The working of fully connected layers is described in Figure 4.4.

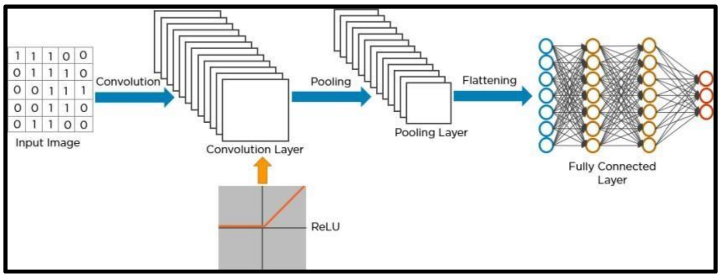

Figure 2 Fully Connected Layers for Classification

V. PROPOSED OUTPUT

Atfirstmachinelearningalgorithmwasimplementedtodetectplantdisease.Thiswasdoneintwophases.I.)ImplementingMLalgorithmonpotatodataset.II)ImplementingMLalgorithmontheentiredataset.

I. Implementing ML algorithm on potato dataset.

The dataset which is considered in the proposed work is an openly accessed dataset & it wasrandomlydividedintothetrainingdatasetconsistsof1820imagesandthetestingdatasetconsistsof 780 images. The otsu algorithm was utilized for the binary image segmentation and infectedregionidentificationthiswasdonewiththehelpofpreparinganimagemask.TheGrayLevelCo-occurrence Matrix is the main tool that implements the concepts learned from extracted features.utilized for feature extraction, & multi-class support vector machine(SVM) methodology wasutilized for the classification of potato leaves. The model derived is evaluated using certainevaluationmetrics: precision, recall, F1-score, and accuracy

4.1.1 Input Image:

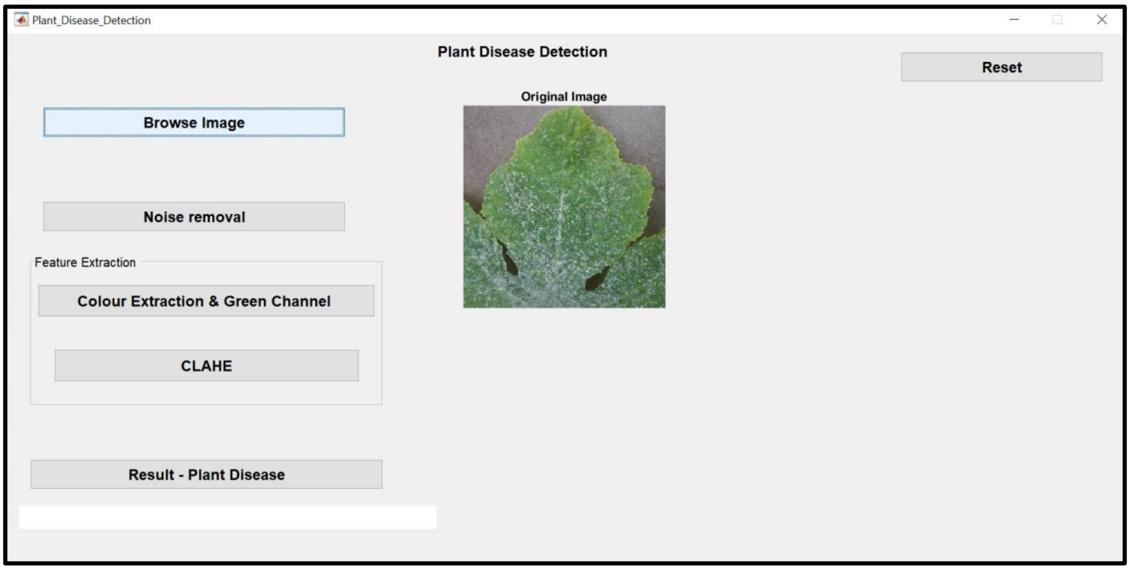

Fig. 3 GUI for Input Image for Plant Disease detection using CNN

4.1.2 Noisy Image :

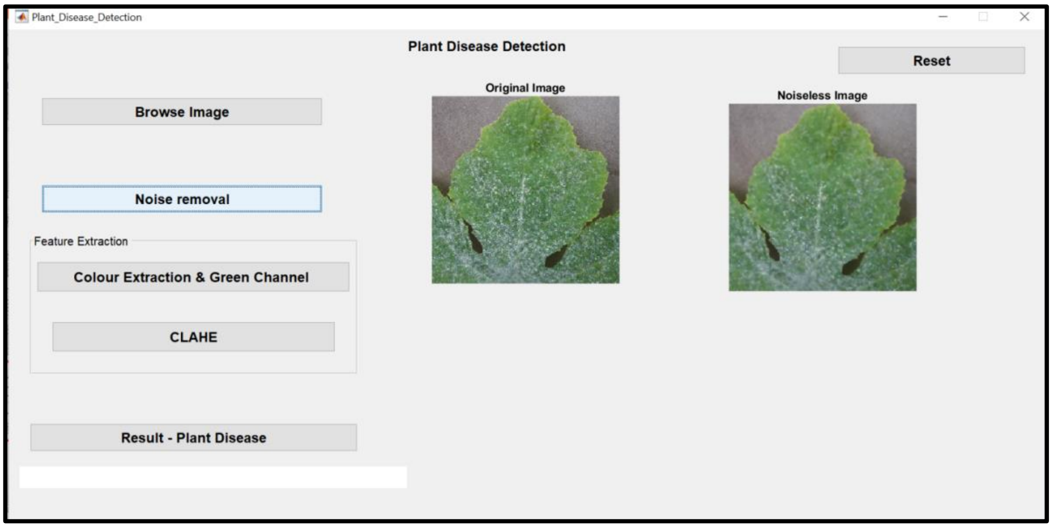

Fig. 4 GUI for Noisy Image for Plant Disease detection using CNN

4..1.3 :Colour extraction & green channel

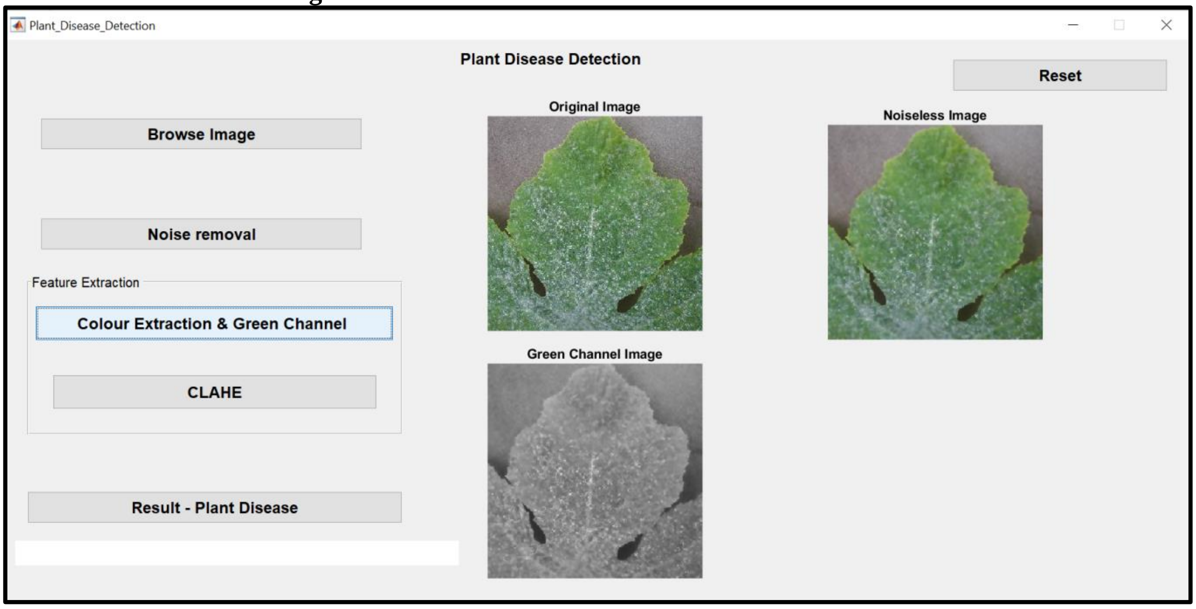

Fig. 5 GUI for Green Channel Extraction for Plant Disease detection using CNN

4.1.4 CLAHE :

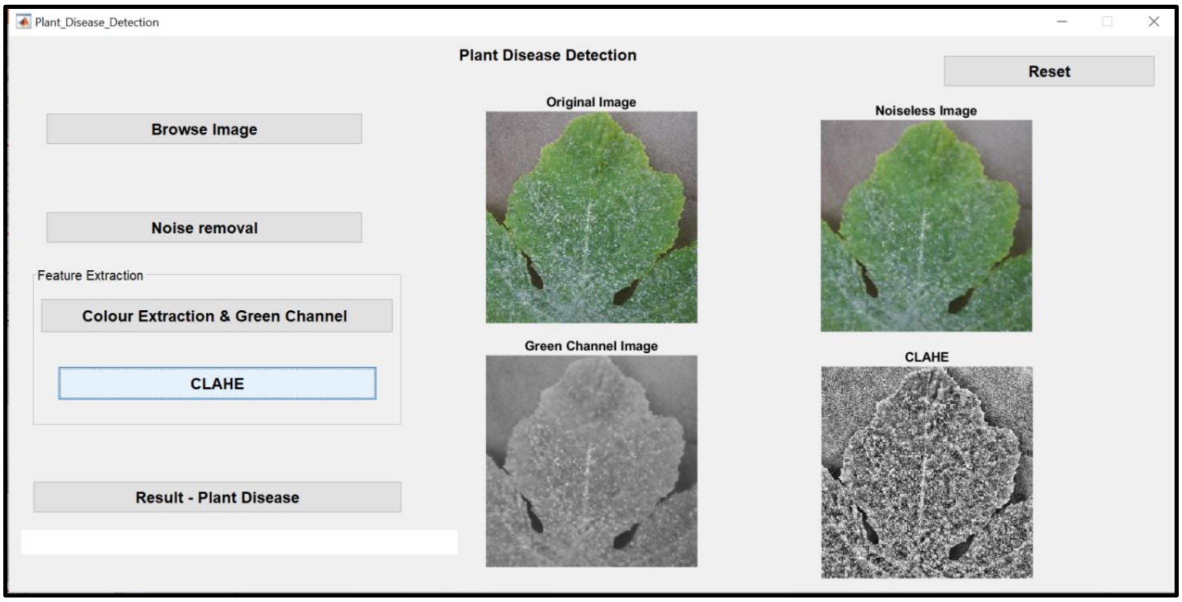

Fig. 6 GUI for CLAHE for Plant Disease detection using CNN

4.2 Convolutional Neural Network Code :

The convolutional neural network (CNN) is a class of deep learning neural networks and works by extracting features from the images. The role of CNN is to reduce the images into a form that is easier to process, without losing features critical towards a good prediction

CNN consists of the following:

Hidden layers consist of convolution layers, ReLU (rectified linear unit) layers, the pooling layers, and a fully connected Neural Network.

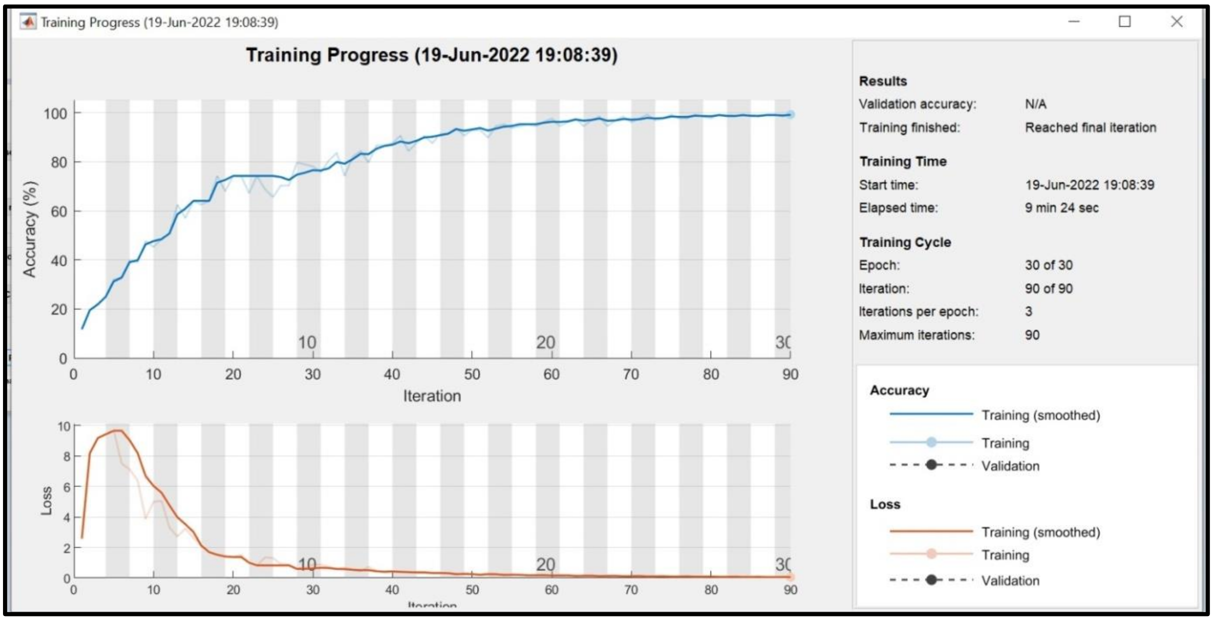

Fig. 7 Training Accuracy And Validation Accuracy Graph.

In most of the researches, the PlantVillage dataset was used to evaluate th performance of the DL models. Although this dataset has a lot of images of several plant species with their diseases, it was taken in the lab. Therefore, it is expected to establish a large dataset of plant diseases in real conditions.

V. CONCLUSION

The machine learning algorithm used in proposed work is SVM. SVM gave good result in whenthedetectioncategorieswereless.Asthenoofdiseasecategoriesincreaseditfailedtoachievetheaccuracy. Transfer learning is the current effective research for obtaining the better performanceof the models with a minimal and faster training phase. It proved very true with the proposedframework. The proposed framework able to attain better accuracy with all the three models suchasConvolutional Neural Networkbasedtransferlearningmodelabitmoreefficient when compared to the other models. The proposed framework efficient with the multi-class classification of various diseases along with healthy leaves that include crops of pepper,potato,and tomato.

LIMITATIONS:

1. Thethreemost crucialpointsintheselectionofanytransferdeep learning modelare:

- Theproposedframeworkisutilizedfortheclassificationofdiseasesacrossthevariousspecies ofcrops.
- Theproposedframeworkutilizedtheconceptofdeeplearning.
- Theproposedframeworkalsoadoptedatrendingresearchconceptoftransferlearningandable to achieveabetter efficient model.

Ifanyofthesethreeareneglected willresultinanegativetransferoroverfittingproblem.

2. Machinelearningmodelsarenotveryefficientinpredictingdiseasesfromleafimageswhenthe no of categories is increased.

FUTURESCOPE:

1. The disease detection system can be integrated in cloud system for efficient result processing.
2. Integration of automated disease detection system with sensos to measure soil p

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