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Mobile APP for Banana Leaf Spot Disease Detection and Classification using Convolution Neural Network Model

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***Abstract*—Agriculture is the backbone of our economy in India. Crop disease affected in leaves and stems are not identified and cured leads to the reduction in the crop production. If the diseases are identified at the earlier stage, we can safeguard the crops from major crop damage which in turn yields better crop production. Right in global economy, not only farmers do agriculture, many youngsters from corporate companies and many entrepreneurs enter into agriculture. Major problem faced by youngsters and entrepreneurs are identification of crop disease. But the youngsters did not have a well knowledge about the plants, crops or even the plant disease. Each and every time getting the input from the farmers or domain experts involves time, effort and money. The most common fruit liked by all categories of people is banana which is grown all over India. The banana leaves are affected by both bacterial and fungal disease which affects the growth of the plants. Farmers are able to find the remedial measures based on the experience but youngsters and entrepreneurs are unable to predict the disease. So to help the layman we are developing a mobile app which can detect the agriculturalist, banana leaf spot disease are identified in an early stage and recommend the remedies to cure the disease through voice assistance. The supervised machine learning algorithm - convolution neural network is very successful in identifying the image and classification of leaf spot disease. So in our proposed system Convolution Neural Network are used to detect and classify disease based on banana leaf spot.**

Keywords— Banana leaf spot disease; Convolution Neural Network; Mobile Application

I. INTRODUCTION

Agriculture is the backbone of our economy and plays a vital role in living life. Crop harvesting helps the economy of a country and is also necessary for the survival of each and every human being. In the world economy, India is the second largest producer of various agriculture products and produces more than 280 million tons of crops. Agriculture forms more than 70% of India's export capacity. Agriculture not only supports food but also provides people with employment opportunities, resources and technology. Agriculture is a rich source of food, nourishment and medicine for everyone and everywhere in all walks of life for several thousand years.

Banana is economically important fruit crops occupies 20% of the total crop area of India. Banana cultivation and harvesting is an important source of income and employment for many Indian citizens. Bananas is a rich source of nutrition fruit and consumed by more than 400 million people and 13% of worldwide banana production is exported to other countries. The plant disease found on banana leaf is black sigatoka and pestalotiopsis which are caused by fungi species. The leaf spot disease grow inside banana organs and drains away the nutrients thereby reducing their ability to photosynthesis by affecting leaves.

Black Sigatoka is a banana leaf spot disease when infected leaves can die and reduces the yield. The leaf spot disease can be controlled by applying fungicides and removal of affected leaves. The banana plants should be maintained with an sufficient spacing and efficient drainage within the plantation to be maintained. The symptoms of Pestalotiopsispalmarum is a tiny yellow, brown or black discoloration of the leaves. The spots or discoloration are0.25 inches in size which grow much larger forming lesions. The spots will turn into grayish color with a black outline. The banana leaf with wilting and a drying appearance is also the symptom of Pestalotiopsis palm. The disease spread can be controlled by applying pesticides to the banana plants but infected leaves cannot be recovered will stay infected until the leaf dies. The most important fungal disease widely spread around the world are Sigatoka, pestalotiopsis and cordana. So we are detecting and providing remedies to this disease.

The banana leaf spot disease are identified by the farmers based on their domain knowledge but existing youngsters or entrepreneurs could not identify the disease. They depends on the expert to get the information and remedial measures. To help the novice users to handle the issue, we proposed a mobile app to detect the leaf disease and also inform the remedial measures through voice assistance. The proposed system predicts the banana leaf spot disease with improved accuracy and also provides remedies for the disease cure through voice assistance.

The main focus of the paper is to apply mobile captured banana leaf image on the trained convolution neural network model to detect banana leaf spot disease. Our proposed system detects banana leaf spot disease in different illumination, varying complex background, resolution, size, pose and orientation.

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The rest of the paper focuses on the related work of researchers to detect the banana leaf spot disease. Based on the summary of the issues identified in the state of art, a proposed system is designed and developed under the section materials and methods. The proposed system is trained and tested with real time multiple banana leaf images and the accuracy of the system is measured. Finally after the discussion of the results achieved the final work is concluded with future work.

II. Related Work

SahilGandhi[1] developed a project to support farmers for detection of banana leaf spot diseases using machine learning techniques. The project helped the farmers to detect diseases and carry out necessary precautionary measures to prevent further spread of diseases. K. Lakshmi Narayanan[2] proposed a hybrid convolution neural network (CNN) for banana leaf disease detection. The system guides the farmers to apply fertilizers for prevention of disease in the initial stages.

PriyankaV[3] designed a convolutional neural network (CNN) model to train 50 epochs of batch size 64 to classify banana leaf diseases. The proposed model produced an accuracy of 90% for training and 89% on testing which can be further improved by tuning the hyper parameters of the model.

N V K Ramesh;Mohanpradeep Reddy B [4], proposed a system which can detect the disease in tomato plant leaf. The system uses the simple deep learning technique to identify the disease.The main aim of the system is to uses simple technique and limited resources to detect the disease. The proposed system give an accuracy of 94% on average.

Ravi Kishore Kodali [5], designed a system using CNN for classification and identification for tomato plant leaf disease. The accuracy of the system varies from 76% to 100% based on the class. The proposed system classified nine disease class and one healthy leaf class. R Swathika and S Srinidhi.[6] providesa architecture using convolution neural network layer. This paper introduces a new module for paddy disease classification.The dataset for the module are taken from public platform consists of 3500 images and give an accuracy of nearly 70%.

Wondatir, Dila[7] proposed a conventional neural network model to automatically classify banana leaf spot disease. The test image is segmented into infected area by applying K means clustering and texture features of gray level co- occurrence matrix (GLCM) are extracted from the infected leaf. The system is trained by using convolution neural network model which used 615 banana images collected from Arba Minch banana crop farms and other image repository. The classification accuracy based on CNN model is 91.41%. The accuracy based on texture feature for class healthy, yellow sigatoka, and panama are 82.3%, 70.7%, and 63.5%. SonerKiziloluk[8] used several deep learning models such as DarkNet, GoogleNet, Inception, Resnet and ShuffleNet to classify disease of potato, banana, cotton, and bean plants. The applied standard CNN models increased the accuracy from 7% to 25% with the transfer learning method of 5 epochs.

Sophia L. Sanga [9] proposed a methodology for early detection of banana diseases based on deep learning models. The deep learning architectures used to develop models for banana leaf spot disease identification are VGG16, Resnet18, Resnet50, Resnet152 and InceptionV3. The accuracies are 95.41% for InceptionV3 and 99.2% for Resnet152 with a confidence of 99% from the real environment. The proposed learning model helped the small scale farmers to detect banana leaf spot diseases at the early stage to enhance productivity.

Pruthvi P. Patel and Dineshkumar B. Vaghela [10] proposed system which detect both plant disease and pest identification. The proposed system uses deep learning technique to detect both crop disease and pest. V Suma and R AmogShetty [11], proposed a system which uses CNN and semi supervised technique to identify the crop diseases and detect the sickness of the plant. The proposed system will detect the sickness status of 4 distinct classes.

Prof.D.D.Pukale[12] proposed a system to identify, detect and rectify the banana leaf disease. The system also updates about the banana leaf disease to the farmer. An analysis report is produced which includes the symptoms and remedies of predicted disease and given to farmers for further actions. The system developed is an alert system which will notify the farmer through alert message about banana leaf spot disease.

Prof.N.A.Auti,ShraddhaKadam,[13], used deep learning approach to classify banana leaf using LeNetrchitectures. The proposed system efficiently classify banana leaf disease and give the remedial measures to prevent the leaf from further damage and destroy. Prof.D.D.Pukale[14] proposed a system to identify, detect and rectify the banana leaf disease. The system also updates about the banana leaf disease to the farmer. An analysis report is produced which includes the symptoms and remedies of predicted disease and given to farmers for further actions. The system developed is an alert system which will notify the farmer through alert message about banana leaf spot disease.

Jihen Amara[15] predicted two famous banana diseases banana sigatoka and banana speckle in real scene based on deep neural networks under varying challenging conditions. BassemBouaziz proposed an automatic LeNet deep neural network to classify banana leaves diseases.

From the above papers reviewed, we can conclude many researchers have done banana leaf spot disease detection and classification using Convolutional Neural Network (CNN) and its variant of deep neural network learning algorithms. The main issue of Convolution Neural Network fails to capture the pose, view and orientation of images. The CNN model requires large training data to build up the model and fails to learn the spatial relationship of the features. The future work is planned to target the automatic severity estimation to help the farmers to recover the plants from the disease.

III. Proposed system

In this system, first the image of the banana leaf is taken by the camera on the mobile phone. The captured image is pre-processed to resize to fixed size. The output of

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the pre- processing will be the input for the Convolution Neural Network (CNN) including two layers convolution and max- pooling. Through this CNN model, the features are extracted and the model is identified.

The data sets chosen for the proposed model includes balanced 937 leaf images with high resolution of banana plants, both infected and healthy leaves. The source data-set originated from GIS & Remote Sensing Lab, Agricultural University, Bangladesh. The input images are for three common leaf spot diseases - cordana, sigatoka and Pestaliopsis with high resolution are taken for study. The data sets descriptions under study for each class are shown in table 1. The total images taken for training, test and validation are depicted in table 1.

TABLE 1: BENCHMARK DATASETS DESCRIPTION

Image Category	*Total Images*	*Train Images*	*Test Images*	*Validation Images*
Healthy	129	89	20	20
Cordana	162	122	20	20
Pestaliopsis	173	133	20	20
Sigatoka	473	433	20	20
Total Images	**937**	**777**	**80**	**80**

The sample images used for study to classify banana leaf images as healthy, cordona, sigakota and pestaliopsis are shown below in figure 1.

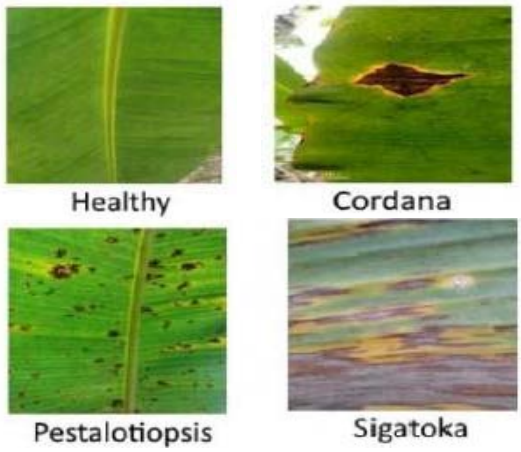

Fig.1. Banana Leaf Images

The hardware requirements may serve as the basis for a contract for the implementation. The hardware requirement for development are High Style Laptop with Intel Processor Core i3-4030U @ 1.90GHz with 8 GB RAM. The proposed system GUI is developed on Android Mobile Phone with high resolution camera facility to capture banana leaf image. The architecture of the proposed system is shown in figure 2.

A. Image Preprocessing

Image pre-processing is the initial stage for the classification of banana leaf spot disease. Image Preprocessing is applied to resize the image into standard size for efficient processing which in turn improve the image quality.

B. CNN Model Building

Convolution Neural Networks has three layers which are Convolutional layer, Pooling layer and Fully-connected (FC) layer. When the image data progresses through the CNN layers the objects shape and size are identified and forwarded to further layers till identifies the intended object. Convolution is the process in which the feature detector moves across theimage based on filter size. The filter size of 3*3 matrix is applied to the image area. A dot product is calculated between the input pixels and the filter and the resultant value is fed as an output array. The process is repeated until the kernel has swept across the entire image. The final output from the input image and from the filter is known as a feature map or activation map. CNN applies a Rectified Linear Unit (ReLU) transformation to the feature map.

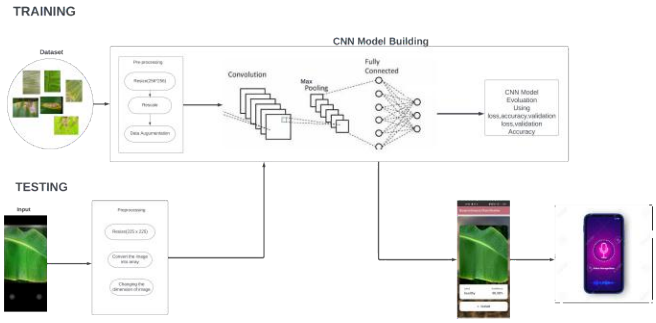

Fig. 2. Banana Leaf Spot Detection and Classification using Convolution Neural Network

The pooling layers sweeps a filter across the entire image used to reduce the number of parameters in the input. The image filter also termed as kernel applies an aggregation function either max pooling or average pooling and generates the output array. The filter moves across the input and selects the maximum pixel value which is shown in Figure 3. The filter moves across the input, and calculates the average value and sends to the output array. Pooling layer is used to drops lot of unwanted information, reduce complexity, improve efficiency, and limit risk of over fitting.

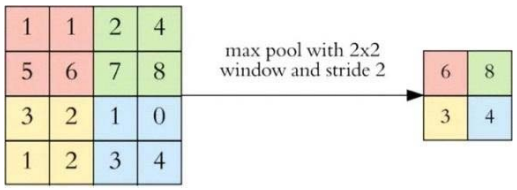

Fig 3. Max Pooling Operations

The proposed model is developed with convolutional and pooling layers with ReLu activation functions. Fully Connected layers use softmax activation function to classify inputs into its corresponding class labels. The proposed system takes the input image of the fixed size 256*256. The first layer is the preprocessing layer which includes resize and rescale. The input image is first resized to 256*256 and the image is rescaled to pixel size of 0 to 1. After the first layer the size of the image is (32, 256, 256, 3). The second layer is the data augmentation where the image is randomly flipped in both horizontal and vertical directly. The image is

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randomly rotated to 0.2 degree for better performance. After completing data augmentation process, the size of the image is (32, 256, 256, 3). There are totally 6 convolution layers with kernel size3*3and the activation function used is Reluand the batch size is (32,64). There are 6 max pooling layers with 2*2 kernel size and a softmaxlayer. After each layer the size of the image is reduced. In the flatten layer the images are converted to a single array of size 256. In dense layer, the final image is reduced to the output of 4 classes such as healthy, cordanasigatoka and pestalotiopsis.

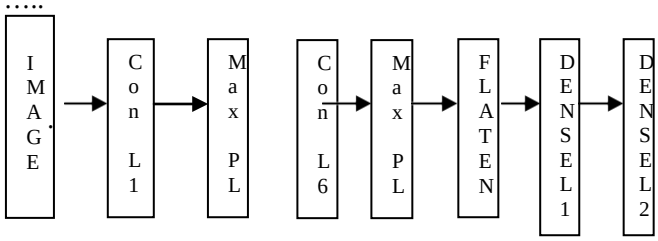
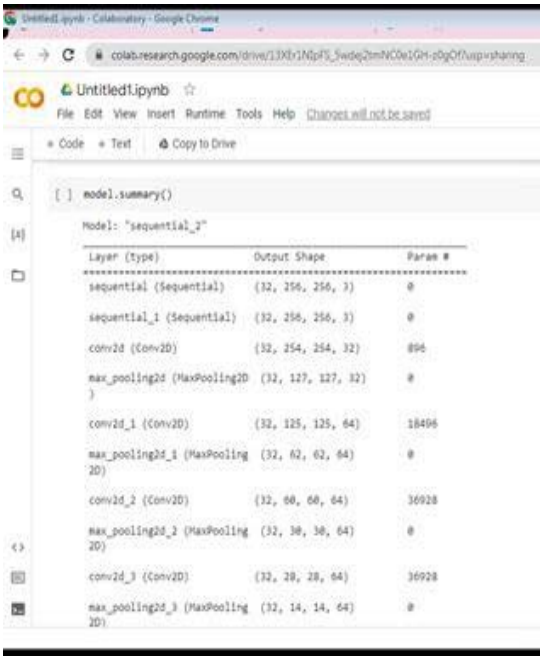


Fig. 4. Proposed Convolution Neural Network Layers

The proposed system takes input of resized image of 256*256*3 into convolution layer. After passing through multiple convolutions flatten and two dense layers, the final output are achieved of image size of 32 with 4 classes. The model is trained for 50 epochs, the training loss and validation loss is decreased. The model produced improved classifier and validation accuracy and finally the trained model is saved.

IV. Results and Discussion

The proposed system captures the image through smart phones and extracts the features from the image using Convolutional Neural Network (CNN). Then with the extracted features, the image is classified into healthy leaf or infected leaf. If the image is an infected leaf then it is classified as either one of the three classes such as cordana, sigatoka, pestalotiopsis.



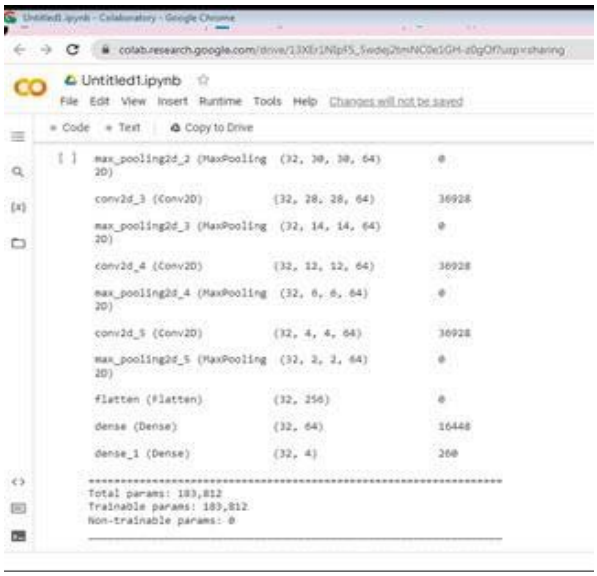


Fig. 5. Proposed Convolution Neural Network Model

The sample test images taken for the study for different banana leaf spot detection and classification are shown in figure 6 – figure 8.

Fig.6. Sigakota Leaf Spot Disease

Fig. 7. Cordana Leaf Spot Disease

Fig. 8. Healthy Banana Leaf

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The performance of the system is measured b y accuracy based on confusion matrix. A confusion matrix is a table of rows and columns and diagonal value denotes the correctly classified values for the test input samples.

The 4 elements used in the 2*2 confusion matrix are shown in Figure 9 as true positive (TP), true negative (TN), false positive (FP) and false negative (FN).

TP	FP
FN	TN

Fig. 9. Confusion Matrix

The proposed convolution neural network model confusion matrix for the test data sets is shown in figure 10.

```
Confusion Matrix
[[20 0 0 0]
 [ 0 18 2 0]
 [ 0 0 19 1]
 [ 0 0 0 20]]
```

Fig. 10. Confusion Matrix

The overall correct prediction of the proposed model is measures through accuracy. The recall measure is used to calculate the misclassification of negatives whereas precision is used to measure the misclassification as positives, F1 score is the harmonic mean of precision and recall. The classification accuracy report for the proposed Convolution Neural Network model is shown in figure 11.

Classification Report

```
precision recall f1-score support
cordana 0.19  0.19  0.19  122
healthy 0.11  0.10  0.11  89
pestalotiopsis
        0.14  0.15  0.15  133
sigatoka0.57  0.58  0.57  433
accuracy   0.39  777
macro avg0.25 0.25  0.25  777
weighted
avg  0.38  0.39  0.39  777
```

Fig. 11. Classification Performance Report

For a multi-class classification problem, precision is calculated as the sum of true positives across all classes and recall is calculated as the sum of false positives across allclasses. Both precision and recall numerator value is divided by the sum of true positives and false positives across all classes.

$$\text{Precision\_c} = \sum \text{TP\_c} / \sum (\text{TP\_c} + \text{FP\_c}) \quad (1)$$

$$\text{Recall\_c} = \sum \text{C FP\_c} / \sum (\text{TP\_c} + \text{FP\_c}) \quad (2)$$

F-Measure combines both precision and recall into a single measure and calculated using equation 3.

$$\text{F-Measure} = (2 * P * R) / (P + R) \quad (3)$$

Validation accuracy depicts how the model is able to classify the images with the validation dataset. Loss functions are the important aspects of neural networks which are responsible for fitting the model to the given training data. The accuracy graph for training and validation is shown in Figure 12. The validation loss is measured based on the performance of a deep learning model on the validation set.

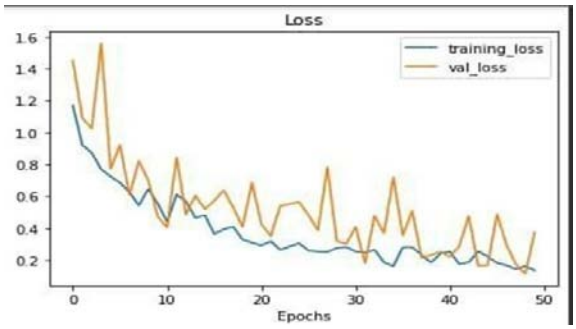

Fig. 12 . Accuracy Graph for training and validation

A loss function is used to compares the target and predicted output values. Loss function shows how well the neural network models fit the training data. Loss value should be minimized between the predicted and target outputs. The Loss graph for training and validation is shown in Figure 13.

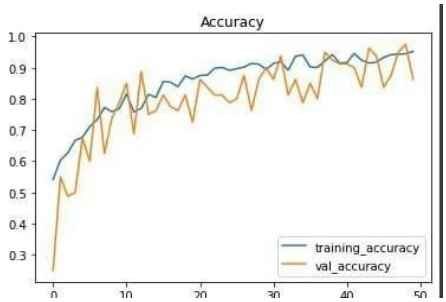

Fig. 13 . Loss Graph for training and validation

V. CONCLUSION

Farmers should monitor the banana plants to identify for leaf spot disease regularly. If the leaves are affected by fungal disease and not monitored by the farmers reduces the production and quality yield. Hence, the banana leaf spot diseases should be identified at the early stage. So, this paper presented a convolution neural networks model to identifyand classify banana leaf spot fungal diseases. The proposed system helped farmers or any agriculturalist as a decision support tool to identify the disease in the banana plant.

In our future work the model should be enhanced to identify more banana leaf spot diseases. To identify and learn the spatial relationship of the features in an object, a large training data sets are required. To overcome the shortcomings of Convolution Neural Network in learning spatial features, Capsule Neural Network can be trained to identify the spatial and orientation of the object. After detecting the disease we are providing remedies to the disease for the farmers in text format and voice format. The

voice assistance help the layman in agriculture to clearly understand about the banana leaf spot disease.

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