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Image Based Plant Leaf Disease Recognition and Estimation System

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***Abstract*—** Agriculture is the back-bone of country's economy, where farmer's source of income widely depends upon farming. During the cultivation of crops, it is required to properly monitor and due to change in atmospheric condition or the loss of soil nutrition these crops get encountered with certain type of diseases. Health monitoring and disease detection on plants is very critical for sustainable agriculture. It is very difficult to monitor the plant diseases manually. It requires tremendous amount of work, expertise in the plant diseases, and also require the excessive processing time. Thus farmer cannot recognize easily because of which they incur loss in production and yield. So here we propose the system where we can detect the disease based on the leaf image and diagnose for proper medication based on the result.

***Keywords* :** *felzenszwalb, Quickshift, color based segmentation, ResNet, LeNet, Estimation.*

I. INTRODUCTION

India is a populated country and about 70% of the population depends on agriculture. Farmers have large range of diversity for selecting various suitable crops and finding the suitable pesticides for plant. Disease on plant leads to the significant reduction in both the quality and quantity of agricultural products. The studies of plant disease refer to the studies of visually observable patterns on the plants. Monitoring of health and disease on plant plays an important role in successful cultivation of crops in the farm. In early days, the monitoring and analysis of plant diseases were done manually by the expertise person in that field. This requires tremendous amount of work and also requires excessive processing time. The image processing techniques can be used in the plant disease detection.

The naked eye observation of experts was the main approach adopted in practice for detection and identification of plant leaves diseases in the olden days. However, this method requires continuously monitoring by experts which might be more expensive in large areas of farming. Further, in some developing countries, farmers may have to go long distances to contact experts for identification, this makes consulting experts too expensive and time consuming.

Automatic detection of plant diseases is a very important research topic as it may prove benefits in monitoring large fields of crops at early stage, and thus automatically detect the symptoms of diseases as they appear on the plant leaves. Therefore, an accurate and automatic less expensive and accurate method to detect plant diseases is of great realistic significance. Machine learning based on detection and recognition of plant diseases can provide clues to identify and treat the diseases in its early stages.

(Rest of the paper is organized as follows, Section I contains the introduction of plant leaf diseases and conventional methods used, Section II contain the related work of plant leaf diseases, Section III contains the methodology used for detecting diseases in the plants, Section IV design and implementation of plant leaf disease recognition and estimation system, section V tells the summary of the results obtained during the analysis. and Section VI concludes research work with future directions).

II. RELATED WORK

In this section, various methods of image processing for plant disease detection is discussed. Several papers have been published on automating the disease detection in plants. Major methods and classifiers used in these papers are summarized below along with their advantages and disadvantages.

Leaf Disease Detection and Grading using Computer Vision Technology &Fuzzy Logic[1]

- K-means clustering used to segment the defected area.
- GLCM is used for the extraction of Texture features.
- Disease grading using fuzzy logic.
- Artificial Neural Network.

• Severity of the disease is checked, Fast and highly efficient. Low-level segmentation.

Feature Extraction for Identification of Sugarcane Rust Disease[2]

• Texture, shape and colour features are extracted.
• Gray Level Co-occurrence Matrix (GLCM) used to extracts the second order statistical texture feature.
• Support vector machine Classifier (SVM).
• Combination of texture and colour feature extraction with results in 98.5 in 98.5%.
• Only efficient when considering narrow leaves

SVM based Multiple Classifier System for Recognition of Wheat Leaf Diseases[3]

• Colour features are represented in RGB to HIS.
• Gray Level Co-occurrence Matrix (GLCM) is used, seven
• Invariant moment s are taken as shape parameter.
• Support vector machine classifier (SVM).
• Off-line two stages SVM based MCS for the detection of
• wheat leaf diseases.
• Segmentation is difficult.

Advances in Image Processing For Detection Of Plant Diseases[4]

•K-means clustering used to segment the defected area, masking green pixels, SGDM matrix generation, Otsu's segmentation, Histogram matching.
• Neural Network.
• Otsu's segmentation is efficient, combination colour and texture feature provide efficient disease detection.
• Histogram is not accurate

III. METHODOLOGY

In order to overcome the limitations of existing solution methods, we have proposed a system which is more efficient and provide utmost assistance to farmers in detecting plant disease through the leaf image.

For farmers to achieve increased yield in plants it's not only enough to detect the plant disease, they should also be assisted with suitable way to cure it. Our proposed system takes this into consideration and suggests suitable pesticide for the detected plant disease based on the severity of the disease in affected plants.

Client-Server architecture of the proposed system is a more advanced method for assisting farmers since it gives faster and more accurate results in low end devices with internet capability. The basic steps to develop our system are pre processing, segmentation and classification.

To develop an efficient modern system, various combination of segmentation and classification methods were considered, and the better combination is deployed in the final system.

Pre-processing

Before giving the raw image input to the model we have done pre-processing in two stages.

- We have converted each image of size 256x256 to 64x64 to reduce the memory and save time to train the model.
- After converting each image into 3D matrix. We have done min -max normalization. So that each pixel value will come within the range of 0-1 and hence our model will be more accurate.

Segmentation

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super-pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristics or computed property, such as colour, intensity, or texture.

Modern and efficient segmentation methods like felzenszwalb segmentation, Quickshift segmentation and colour based segmentation methods are considered. Segmented images from these methods are trained in combination with different classifiers and better combination is deployed in the final system.

Classification

After segmentation, image classification is done to assign input image to one label from various plant categories and then disease prediction is performed. We have considered ResNet and LeNet as classifiers for which segmented images are given as input.

The main objective of this paper includes:

- To build a system that automates the process of disease detection and its estimation in plants using plant leaf via image processing and machine learning.
- To choose appropriate dataset and relevant attributes.
- To choose and later use appropriate segmentation and machine learning algorithm that best fits the system.
- To Build a full-fledged system with user friendly android based mobile application and fine-tuned back end.

The outcome of this paper results in effective android application which is used to detect, estimate and get the suggestion of the pesticides from the plant leaves.

The applications of this paper:

- By Implementing the modern ways to detect plant diseases and estimating disease severity, farmers can detect the types of disease and prevent insects by harming the leaves using suitable pesticides so that they can increase their production and yield good quality of crops.
- It can be used by the scientists in the laboratory to study about various types of plant diseases.
- It provides a way to develop a backend software to detect plant disease using drones in farming industry.

IV. DESIGN AND IMPLEMENTATION

Fig.1 tells the detailed working of an android application. Before working out with android app, we will train the model in the server. The images of the dataset is taken from plant village collection. It consists of 18 classes with both diseased and healthy leaves of 9 species. Images are re-sized from 256x256 resolution to 64x64 and undergoes segmentation process. Each segmented image is converted to 64x64x3 matrix. Finally, a matrix of Ax64x64x3 is obtained, where A tells the number of images. This 4D Matrix is fed into the Deep Convolutional Neural Network which undergoes training process for prediction of plant leaf diseases.

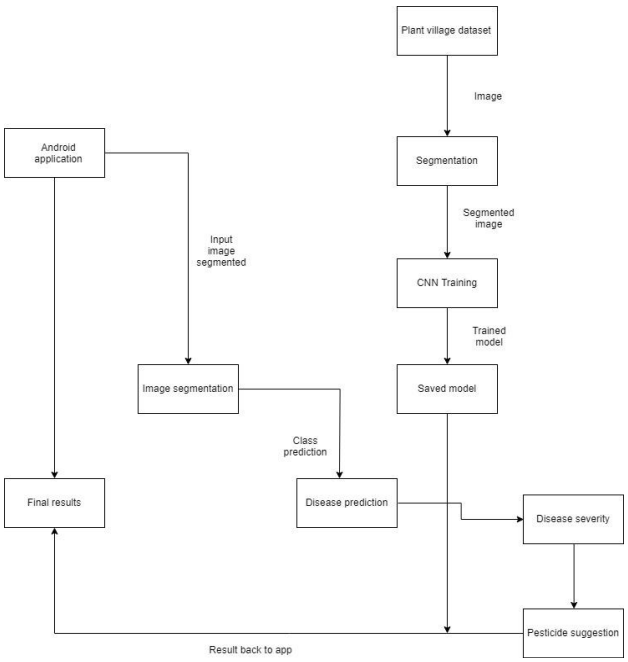

Fig. 1 : High Level Design of the model

After Training, The Model is saved for future prediction. We need to connect the android application to server before using it. Select/Click the image from the mobile device and send it for further processing. At the first step image undergoes segmentation process and gives to the trained model in the server.

The server predicts the class using the trained model, this results is analyzed in both the ways

- At the first if the image is diseased, it will display two results i.e Pesticide Suggestion and disease Estimation.
- If not diseased, the results are just displayed along with the confidence value of that predicted class.

All the results are sent from the server to mobile device through HTTP Client-Server Communication and display on the screen.

System Implementation

The proposed system consists of different modules which cannot be implemented as a whole because they are structured under different languages and different architectures. Hence, the LeNet and ResNet trained modules of the system is implemented on TensorFlow and Keras using python and the disease detection module of the system is implemented as an android application using Java on Android with the help of XAMPP Software. The Dataset is trained using the LeNet and ResNet modules in the system with the help of tensor flow and Keras using python programming language.

The mobile device needs to be connected to the internet or localhost for the server where training and testing for the images through the trained model will take place. XAMPP is a software which provides server as a localhost to send and receive files. We have used Android Volley library which helps us to send and receive the http request in the form of the files and texts. With the help of this we can send the images to the server the server will test using the trained model and send the results back to the mobile device. With the help of this technology, there won't be any complexity or work load in computation in the mobile device. This implies any basic android device can use this application and hence all the set of users are benefited from this app.

Dataset

The dataset we use in this project is collected from crowdAI's challenge as a part of Plant disease detection research, hosted on www.crowdai.org. It is also named as Plant Village Dataset. The data records contain 19,039 images. The images span 09 crop species: Apple, Cherry, Corn, Grape, Peach, Bell Pepper, Potato, Strawberry and Tomato with both diseases and healthy leaves. Therefore this is a multi class problem and there are totally 18 classes in the dataset used.

Estimation of the percentage of disease affected area in plant leaves

The algorithms take image as input, which will then be converted to the Gray Scale image. Further this image is converted to binary image using some fixed threshold. Now we will calculate the density of the black pixels and white pixels. The ratio of the black with total pixels gives the percentage of the disease affected in the plant leaf. Input image should have an almost plain/white background along with no shadow present while taking the image, Only then this method will provide good results.

Below shown images depict the process while estimating the disease in the plant leaf.

Fig. 2: Original Image

Fig. 3: Image after undergoing Binarization

V. RESULT

We tested for both the Deep Neural Networks mentioned with all 3 different segmentation methods. which can be summarized in the below table.

Table 1: Summary of the training results obtained

Model	Segmentation method	Accuracy
LeNet	Quickshift	0.94
LeNet	Felzenszwalb	0.87
LeNet	Color based	0.51
ResNet	Quickshift	0.847
ResNet	Felzenszwalb	0.084
ResNet	Color based	0.242

The android app for detecting the disease present in the plant leaf is developed using LeNet Model which uses Quickshift Algorithm. Also, if the result predicted is diseased, the app suggests the pesticide which will cure the disease of the plant. Adding to that, it will tell you the amount of percentage of the part in the leaf that is affected by the disease.

Before using the app, we need to make sure that the Mobile device is connected to server/localhost. We have used XAMPP software for providing the server to mobile device. The testing images should be loaded into the mobile before the recognition of the images is done. We have selected 7 number of leaves from each class and tested for all of them.

The tracing of the detecting disease in plant leaf is shown below through various steps:-

a. When the application opens click on the 'choose image' button which shows the list of test sample to be tested using app.

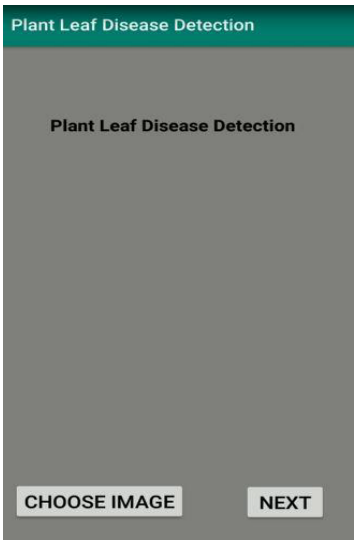

Fig. 4: Screenshot of the android app

b. Select any image from the gallery.

Fig. 5: Screenshot of the android app

c. After the image is chosen, it will be displayed on the screen. Further click on the 'next' button at right bottom of the app.

Fig. 6: Screenshot of the android app

d. Click on the 'segment button', the android app sends the selected image to the server which runs certain python programs which is used for segmentation and gives the result back to the android app using PHP Scripts.

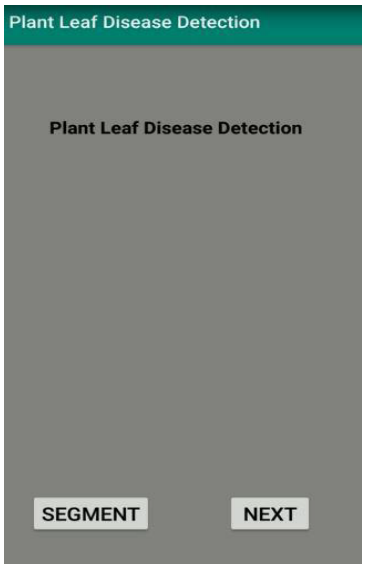

Fig. 7: Screenshot of the android app

e. The segmented imaged obtained from the server is displayed on the screen. Now again click on the 'next' button which is used for predicting the presence of the disease in the leaf and also type of plant leaf.

Fig 8: Screenshot of the android app

f. Click on the 'predict' button which gives the results of the predicted class along with the probability.

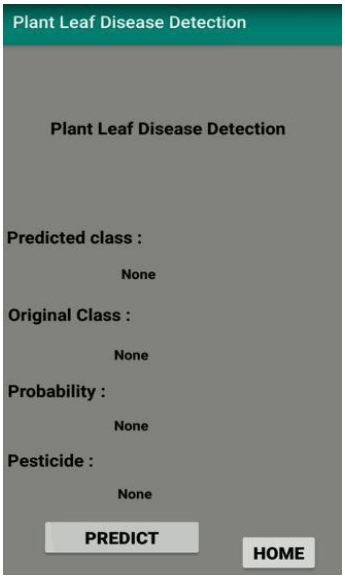

Fig.9: Screenshot of the android app

g. After few seconds the server sends the response to the app, which gives the predicted class, original class, probability and also suggests pesticide for the diseased leaf only. Click on the 'estimate' button for knowing the percentage of disease affected in the plant leaf.

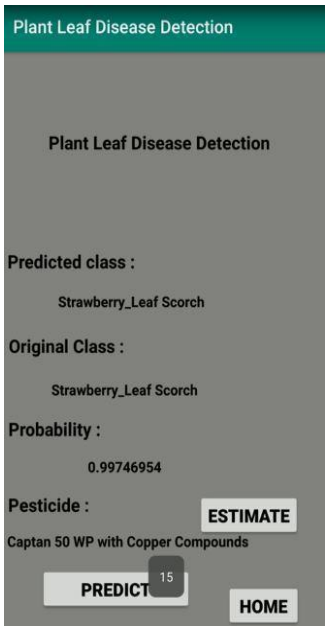

Fig. 10: Screenshot of the android app

h. Image will undergo binarization and gives us the percentage of the disease affected in the plant leaf.

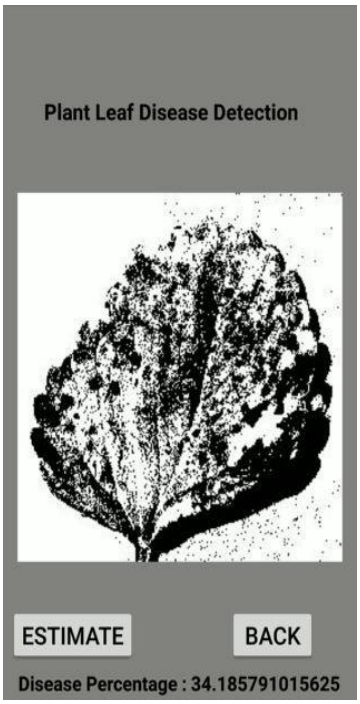

Fig.11: Screenshot of the android app

VI. CONCLUSION AND FUTURE WORK

This project helped us gain knowledge on machine learning algorithms. It helped us to understand the working of chosen machine learning algorithms. Many farmers have been affected by pesticide inhalation, showing symptoms such as respiratory problems, blurred vision, and nausea. We have lost many farmers due to these serious issues. It is possible to reduce the number of farmers losing their lives. Hopefully, our efforts of plant disease detection and suggestions will reduce such instances in the future and pave the way to a safer and more profitable form of agriculture in India.

Using the deep convolutional neural network architecture and with the help of Deep convolution neural networks technique, we trained a model on images of plant leaves with the goal of classifying both diseased and non-diseased of the 9 species within the Plant Village dataset which consist of 19,039 images. The images span 09 crop species: Apple, Cherry, Corn, Grape, Peach, Bell Pepper, Potato, Strawberry and Tomato with both diseases and healthy leaves. Our trained model is cable of detecting the diseases in their early stage. The goal has been achieved as demonstrated by the top accuracy of 94%. Importantly, while the training of the model takes a lot of time (Minimum 1 day on a high-performance GPU cluster computer), the classification itself is very fast (less than few second on a CPU), and thus we have implemented Android app for the above.

The future versions of this application can have capabilities of remote alerts such as experts coming straight away to the farming land with the help of GPS and include analysis of data carried by the farmers. Therefore our overall aim is to decentralize artificial intelligence and make use of it for global good plant disease detection.

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