Android app for plant leaf disease detection

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***Abstract*—Plants play an important role in providing energy supply to mankind. Plant diseases can affect the leaf anytime between sowing and harvesting which leads to huge loss on the production of crop. Therefore, leaf disease detection plays an important role in agricultural field. On the contrary, manual interpretation requires huge amount of work, expertise in plant diseases, and also requires more processing time. Hence, machine learning can be applied to detect diseases in plant leaves as it analyzes the data from different aspects, and classifies it into one of the predefined set of classes. The images of the diseased plant leaves are taken as the input. The images that are considered as input consists of 13 different plant leaf images. Further, several types of diseases that can affect a plant leaf are considered as input. The morphological features and properties like color, dimensions and intensity of the plant leaves are taken into consideration for classification. The aim of this project is to integrate the classifier developed by using Machine Learning into an android application. Plant leaf disease detection is done by capturing the image using android application. This proposed system can help farmers detect the leaf diseases instantaneously so that they can take preventive measures at the earliest.**

Keywords- Machine learning, Classification, Android application.

I. Introduction

Android application for plant leaf disease detection is aimed at detecting 13 types of leaf diseases. This is a combination of Deep learning and Application development aiming at helping farmers to identify the type of leaf disease if any in an early stage which can further help farmers by making them cautious and use suitable pesticides to control the disease spread. Technology is taking over the world but agriculture is one such stream where practical application of Machine Learning and Artificial Intelligence still lacks. So, this is an attempt to help farmers to detect the leaf diseases accurately with the help of Deep Learning.

The general practice for detecting various leaf diseases is through manual work. The spots on the leaf when attacked the leaf and would use the pesticides accordingly. However, this manual practice may not work always and there are chances of being inaccurate thus leading to the loss of entire crop. For identifying the leaf disease experience and accuracy are considerably essential. Experience of a farmer can help to handle this situation to some extent, but the problem arises when the diseased leaf spots are visually sensitive. One can also consider taking the advice of an agricultural expert. But this solution turns out to be time consuming and costly too due to various personal reasons of farmers and experts. Now that all the manual solutions for detecting the leaf diseases have ruled out, a new innovative technique is required to address the problem. One such technique is using the algorithms of Artificial Intelligence (AI) or Machine Learning (ML).

Artificial Intelligence has numerous algorithms to solve various real world problems. The major input for any supervised Machine Learning or Deep Learning algorithms is input data. To proceed with the solution to identifying leaf diseases, we need the images of various plant leaves that consists of some kind of disease be it bacterial or fungal disease. Collection of proper data and data pre processing are the major tasks while working with Deep Learning algorithms. Since we are dealing with images, Deep learning algorithms would serve the purpose quickly and efficiently. Thus, the solution can be handled by the established technology called Deep Learning. The results obtained from the AI algorithm must be portrayed in a way which can be understood by all. To do so, the most common medium Android Application is chosen.

The symptoms of plant leaves affected by disease are detected manually based on prior experience which may not be accurate. Also there may be several leaf spots which are heard to be seen through naked eye which may lead to predicting other disease instead of the actual disease. If one type of disease is mistaken for another type and wrong pesticides are used, then entire crop may be damaged. There are no efficient software or hardware systems to detect the leaf diseases. The drawbacks of the existing system are as follows:

1. Time delay
2. Less accurate
3. Expensive

So, the main aim and focus is to develop a software system that performs leaf disease detection in a smart and efficient way. The main intention is to achieve better performance from the system and accuracy which are not in considerable amount in the existing systems.

There is no ideal system that can be developed. Every system has its own advantages and disadvantages. But using Machine Learning the accuracy of the model or the system is high as compared to the other systems. The ultimate target of any system is to raise the bar of standards of performance of the existing system or provide a unique and useful solution. The proposed system is developed in a manner that if any enhancements have to be made in future, the application is compatible with the changes. Several analytical discriminating

techniques are used to classify the images according to the problem present at the hand. The basic procedure includes image acquisition, image pre processing, image segmentation, feature extraction, statistical analysis and classification based neural networks. In the first step, the images are captured using digital camera that are to be classified. And the pre processing is done in the next step. Statistical analysis tasks are performed to choose the best features thus minimizing feature redundancy.

Plant disease detection can be done in various ways including an embedded system, an android application or cloud services [1]. The proposed system tries to overcome the existing faults by the use of machine learning. The idea is to build an ML model that detects plant leaf diseases using Convolution Neural Networks (CNNs) which is cost efficient and accurate. The final step is to deploy the ML model into an android application. The final proposal is to develop an application that can be installed into android which can detect the type of disease that attacked the leaves. This android application can be accessed by all the farmers from anywhere and the results displayed are accurate.

Merits:

1. High Accuracy
2. Affordable system
3. Time constraint satisfaction
4. Efficient software system.

II. LITERATURE SURVEY

Generally, the crop productivity depends on factors such as temperature, humidity, labor and electrical costs. However, crop disease is the crucial factor and causes around 20-30 percentage reduction in the productivity in case of its infection. Thus, the disease of the crop is an important factor affecting the productivity of the crops. Therefore, farmers mostly concentrate on the cause of the disease in the crops during its growth, but it is not so easy to identify on the spot. They relied on their own experiences for identifying the disease which leads to the decrease in the productivity during times. In order to overcome this, we need a mechanism which analyses the images of the diseases and the feedback is collected from the farmer. In this mechanism, prediction of the disease with data set of images is performed using deep learning. Thus, it improves the productivity through the fast recognition of disease and the consequent action. For sustainable agriculture, monitoring the health of the crops and detection of diseases are important factors [2].

There are two factors which can affect the plants;living and nonliving agents. Insects, bacteria, fungi and viruses comes under living agents whereas extremes of temperature, excess moisture, poor light,insufficient nutrients, poor soil pH and air pollutants are nonliving agents. So considering all these factors an identification system must be developed [3].Because leaves play an important role to distinguish the health condition of a plant, researchers have used them as a comparative tool to classify plants. Deep learning is a class of techniques in machine learning, consisting of multiple processing layers that allow representation learning of multiple level data abstraction. More studies use shape recognition, texture, venation techniques to model and represent the contour shape of the leaf.

The existence of an automated computed system for detecting leaf diseases would provide valuable assistance for those who were asked to perform such diagnoses through optical observation of leaves of infected plants. If we could develop a simple mobile application, it could serve as a valuable tool for farmers in parts of the world lacking infrastructure for the provision of agronomic problems throughout the cultivation field. With the development of computational systems in recent years, Machine Learning related Artificial Intelligence applications have achieved exponential growth, leading to the development of novel models.

The early detection of diseases is useful for an effective crop yield. Datasets with symptoms of diseases were taken for classification and feature extraction. Detecting and classifying diseases in a timely manner is of the great importance. Advancements in artificial intelligence now makes it possible to make automatic plant disease detection from raw images. CNN is a multi-layer feed-forward neural network and is the popular deep learning model. Deep learning is defined as a class of machine learning algorithms that has sequential layers. Each layer uses the output of the preceding layer as input. Representation learning algorithms makes optimizations to find easy way to represent the data. CNN, which can easily identify and classify objects with minimal pre-processing is successful in analyzing images and can separate the required features with its multi-layered structure. It consists of four main layers: convolutional layer, pooling layer, activation layer and fully connected layer.

In convolutional layer a series of mathematical operations are performed to extract features of the input image. The input image is reduced to a smaller size using filter. The pooling layer is usually applied after the convolution layer to reduce the size of the output matrix obtained from the convolution layer. In ANN, the activation function provides a relationship between input and output layers. Network performance will be affected by this layer. Non-linear learning of the network usually occurs through activation function. There are several activation functions like linear, sigmoid, hyperbolic tangent but the nonlinear ReLU activation function is usually used in CNN. Recognition and classification are performed in fully connected layer [4].

Image processing is one of the frameworks which can be used for detection and classification of plant leaf diseases. The steps involved are segmenting images using the K-Means technique and pass them through a pre trained neural network. Image processing techniques are applied to extract important useful features that will be helpful for further analysis of the images. Then, several analytical discriminating techniques are used to classify the images according to the problem present at the hand. The basic procedure includes image acquisition, image preprocessing, image segmentation, feature extraction, statistical analysis and classification based neural networks [5], [6] [7], [8]. In the first step, the images are

captured using digital camera that are to be classified. And the preprocessing is done in the next step [9].Various advancements have been made to monitor and identify crop diseases, including RGB imaging, X-ray, ultrasound, and multispectral and hyperspectral technologies and Machine learning [10]. Statistical analysis tasks are performed to choose the best features thus minimizing feature redundancy.

III. Modules of the System

1. User Module
2. Application Module
3. CNN Module
4. Integration Module

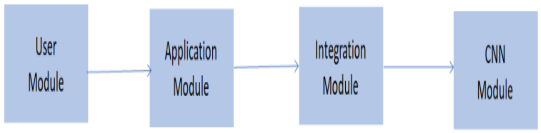

Fig. 1: Module Diagram

A. User Module

This module is completely user based. The android application responds to the user operations accordingly having 3 buttons which are:

1. Take a picture - Camera or Gallery 2. Detect 3. Clear The take a picture has 2 options. Choose from Gallery which means the picture of a leaf has already been clicked and stored in the gallery. Open camera option opens the phone camera and the user can click the picture of a leaf. The android application starts functioning accordingly only if the image of a leaf is given as input. The user captures the image of the leaf using the camera feature of our android application and finds the name of the disease.

The next button that is displayed on the application interface is detect button. When the user clicks on detect button, the result must be displayed on the interface. The result consists of the name of the disease and confidence of the disease. The third and final button is clear. When user clicks on clear button the image will be cleared. These three buttons will be displayed once the user opens the android application.

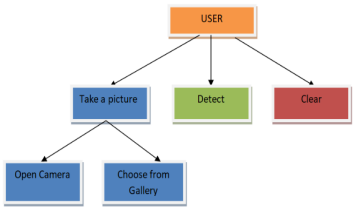

Fig. 2: User Module

B. Application Module

The application module uses Android Studio to make the user functionalities work in accordance with the requirements. For an android application, the look and feel of user interface is considered important. This module presents the user interface which helps them to capture leaf image and detect the disease using underlying Convolution Neural Network model. The user interface can be developed by using the components like text view, button and several kinds of layouts.

The user interface is provided to the user. This has three buttons to capture a image using camera or choosing an image from camera, clear and detect. Whenever users select leaf image it gets displayed in the image view. The user can also clear image using clear button. The user can find the particular leaf disease using detect button. The results are provided in the text view of the user interface.

C. Integration Module

Integration module is the important phase as it combines the application interface with the algorithm developed. In this module, the android studio is used as the medium to combine both the phases. The code is written in java and required function calls are made to perform the actions required. This integrates Application module with the CNN module. The CNN model that is developed in CNN module will be converted into a format that is compatible with android studio code. There are several formats into which a CNN model can be converted into and the preferred one is .tflite format.

This module acts as a bridge between application and CNN module. The prior module which is application module has its own significance and same is the case with later module CNN. Now connecting these both is utmost essential to make the most out of technology. The complex part of the entire project is integration module and it requires proper planning before developing. Plan is essential because the CNN module will take considerable time to become accurate and it should not be built repeatedly because it uses more amount of technical resources. So integration must be carefully performed.

D. CNN Module

CNN stands for Convolution Neural Network. It is part of deep learning termed as feature extractors [11]. The reason behind choosing CNN for developing the model is because of its accuracy and efficiency. CNN deals with the data which consists of images as input. CNN model is one of the most often used deep learning models used to identify the patterns on the images, classify the images, object detection and so on [12], [13].

This module builds a CNN model by learning the predefined dataset and predicts the disease for a new image. This module is entirely done in Google Colaboratory. 13 types of diseased leaf images are taken and each type in turn constitutes numerous images which are pre-processed initially and given as input to the CNN model for training. Data pre-processing is the standard step that is to be followed in all the Machine Learning algorithms.

IV. PROPOSED ARCHITECTURE

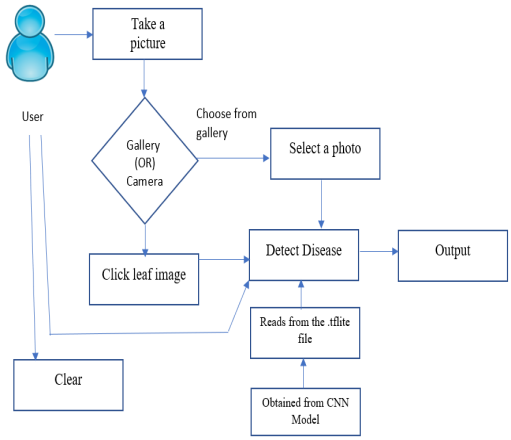

Fig. 3: Architecture of the system

There are 3 actors involved namely user, developer and application. The functionalities of the user are simple and do not require any knowledge on the technology that is used for application development. The user actions include opening the application, capturing the pictures using camera or selecting the required and relevant image from the gallery. The final action is to click on detect button to view the result. The ML developer performs all the major and result driven actions for the android application. Starting with the collection of dataset, pre-processing the data so that it is compatible with the CNN model that is to be built are the major tasks before developing the model. These steps require lot of attention to obtain accurate results ultimately. The next step involves building the CNN model which includes training and testing the model. The android developer now comes into the action to complete the remaining major portion. The actions include developing the user interface for the android application and integrating the CNN model into android studio so that the communication between CNN model and functions of android application happens properly. The final version is the android application. This is the sophisticated portion irrespective of the platforms used for developing the product. The essential actions are accessing the camera, gallery of the android phone to perform. The final action is to perform the functionality of detect button efficiently and accurately.

V. APPROACH AND IMPLEMENTATION

Android application's work starts with installation of the application. Once the installation is done, the user interface of the application will be opened. And the android application starts functioning according to the user actions. The backend actions to display the results will not be intervened with the user actions but are performed simultaneously. The CNN model which is converted into the model file called ".tflite" file is essential for the detection of leaf disease for the image that is displayed in the image view. The functioning of detect button is completely dependent on the .tflite file and "labels" text file which contains the labels of all the 13 types of leaf disease names.

The CNN model has to be developed using Tensorflow or Keras library. Keras in turn uses TensorFlow as back end. Once the trained model is ready with considerable accuracy, the immediate step to be performed is to convert the model into Tensorflow lite model file which is called .tflite file in short. All this conversion part is to be done in Jupyter notebook or Google Colaboratory.

Now the converted model file and another text file which contains the names of all the diseases is put in the assets folder in android studio. With the help of these 2 files the entire background running happens and the result will be displayed on the application screen. The quite ssential part is to integrate the ML model into android studio so the android application uses .tflite model as back end to perform predictions and identifications of leaf diseases. Integration is performed by using android neural networks API and the interpreter. Steps to be followed: 1. Write the Classifier.java file which takes image as the input. The image which is either clicked using camera or chosen from gallery is in the form of bitmap.

2. This bitmapped image is given as the input to the .tflite model file.

3. The result is predicted according to the image using the .tflite model. The result contains the classification of the diseased leaf along with confidence.

4. In short the disease name and the confidence is displayed in the respective result.

VI. EXPERIMENTAL RESULTS

To verify the performance of the proposed method, we have conducted a set of experiments on healthy and diseased leaf images of corn, grape, potato, tomato and have performed classification. The challenging aspect in disease detection and classification is that the leaves with different diseases are similar to each other which may lead to wrong prediction of the diseases. There were only few images which have been incorrectly classified into wrong classes. The classification results were shown for 13 different types of diseases leading to an accuracy of 87 percentage.

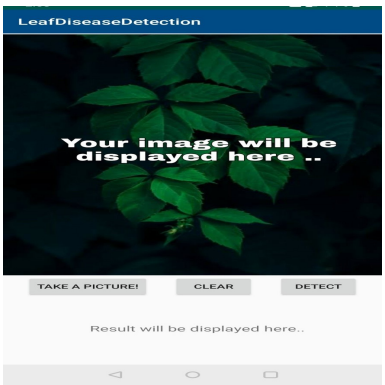

Fig. 4: User Interface

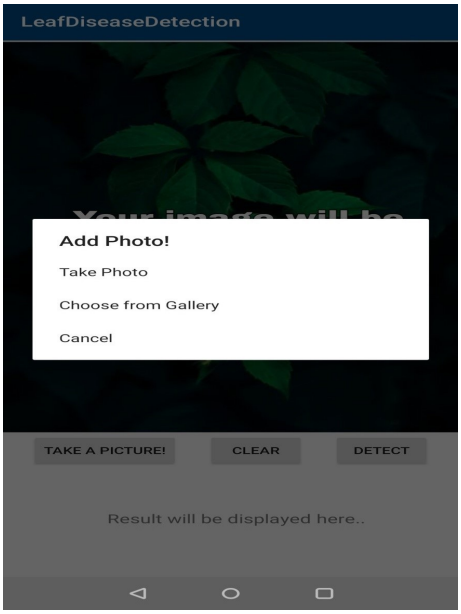

Fig. 5: Take a Picture

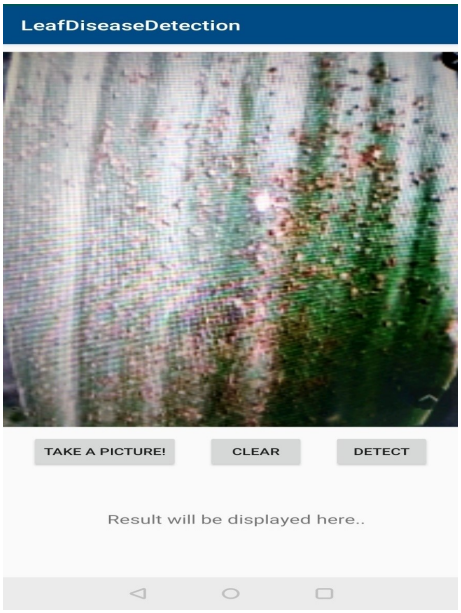

Fig. 7: Display of image captured using camera

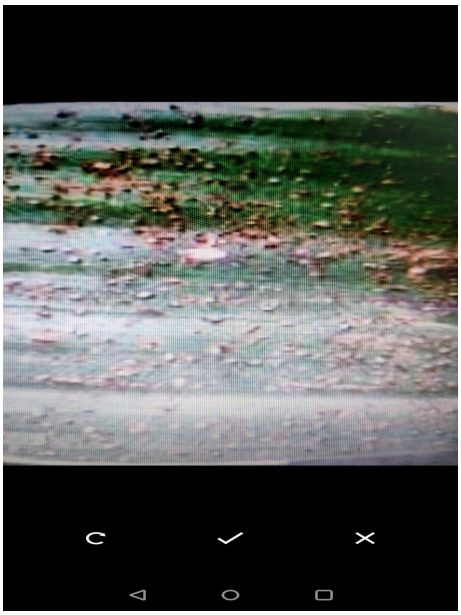

Fig. 6: Capture using Camera

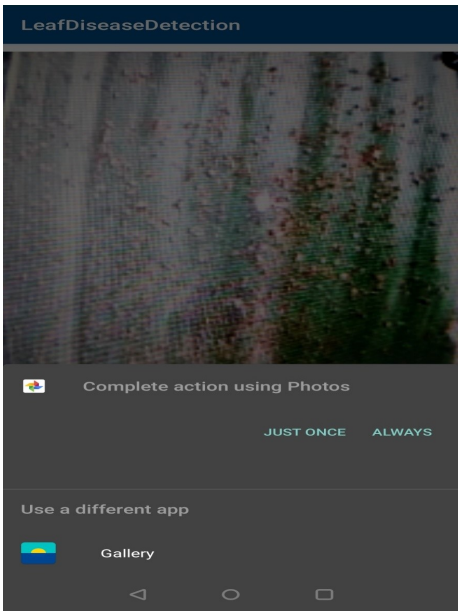

Fig. 8: Choose from Gallery

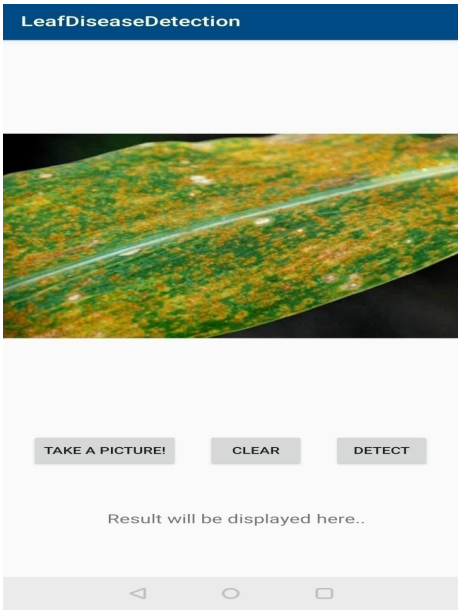

Fig. 9: Image from gallery is displayed

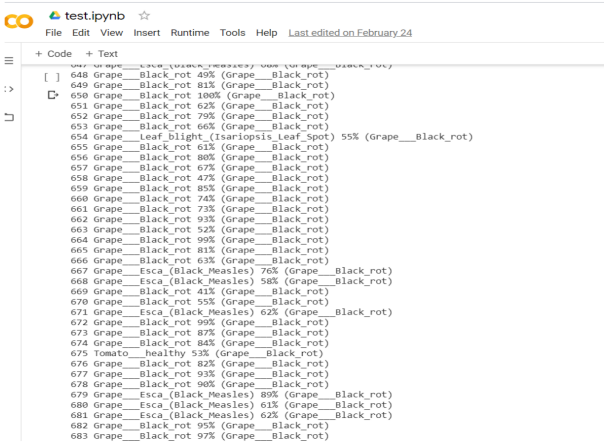

Fig. 10: CNN model test output

VII. CONCLUSION AND FUTURE SCOPE

When the symptoms of leaf diseases are ignored, the crop yield reduces which leads to a great loss for farmers. If the disease is detected early then suitable Pesticides can be suggested. Our proposed system will turn out be an efficient solution. As the project involves several modules, each module can be further enhanced so that the android application will turn out to be a useful software system for farmers in identifying leaf diseases, In the CNN module, we can increase the operations of convolution layers by including few more layers so that the accuracy of the ML model increases and efficiency of the android application will be improved. The user interface of the android application can be framed even more better so that the look and feel of the application can be easily be understood by everyone irrespective of their background knowledge. Further, we can enhance this project by identifying the nutrient deficiency in the leaves and suggest appropriate fertilizers.

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