Plant Disease Detection using ML and UAV

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Abstract - *Agriculture serves as the primary source of food in India, and it predominantly affects the economy of India. To increase the productivity of cultivated plants, early detection of diseases is very important so that all other crops remain uninfected. The manual detection of disease realistically is an extremely challenging task. We can apply machine learning algorithms to develop a system that correctly identifies diseases in leaves. This will typically assist farmers to minimize crop failure and accurately identify the infections in plants more precisely and effortlessly. This paper is concerned with the development of an automated system that can automatically detect disease using leaf image classification. We can utilize ML to automatically find the changes in color or the existence of spots or rotten areas in the plant leaf. Furthermore, in this system, we also automate the process of capturing images of the leaves using an unmanned aerial vehicle(UAV) with a camera that automatically captures the images.*

***Key Words*: plant disease detection, Neural network, Drone, AutoML, UAV, Automatic image capturing**

1. INTRODUCTION

In developing countries like India, the economy mainly depends on agriculture. In India, agriculture is the principal source of food as well as the primary source of income for farmers. Hence, a loss of cultivated crops due to a disease would indeed imply a significant loss of income for the farmers and if this happens on a massive scale, then it will lead to the scarcity of food. Agriculture also serves as a solution to many environmental problems and provides habitats, preserves the ecosystem and as well plays a role in the water cycle.

Plant diseases drastically reduce the quality and quantity of crops which destroys the potential benefits of agriculture. Reducing yield loss to diseases will typically allow farmers to produce food more efficiently, benefiting the agricultural industry and the environment. Plant diseases are extremely important to be detected and properly cured at an initial stage else, the uncured disease might affect the entire farm and ruin it.

Currently, farmers have to carefully analyze each and every crop periodically to detect diseases, which is an extremely challenging and time-consuming task (notably when the number of crops is enormous).

If we can automate the process, then this will yield massive benefits for the farmer. Hence, our main objective is to reduce the human effort and increase the accuracy to detect the disease and eliminate the traditional method of visiting the farm for identifying diseases by developing an automated system for the same.

2. Literature Survey

This section describes the various methods used by others to detect plant diseases

Vijai Singh, A.K. Mishra... [1] Here, we see the application of image processing and Genetic algorithm for the detection of plant diseases. Image processing is used for pre-processing of the image which includes removing distortion from the image, clipping the image, image smoothing. Then green pixels are masked. After this, image segmentation is done using clustering and Genetic algorithms. Then, the minimum distance criterion and SVM is used to do the classification.

Anandhakrishnan MG Joel Hanson, Annette Joy, Jerin Francis... [2] In this, a dataset is created for training a neural network for image classification. The images for the dataset were downloaded from the internet. To get better feature extraction, image preprocessing was done which included noise removal, intensity normalization, removing reflections, and masking portions of the image. Then using these processed images, a deep convolutional neural network model was trained to classify the images. Tensor Flow software library was used for numerical computations.

Saradhambal.G, Dhivya.R, Latha.S, R.Rajesh... [3] In this system, they included a voice navigation system so a person with less expertise will also be able to use the software. In this system, images of various diseases are acquired from the public repository. After the acquisition of the image, the noise in the image is eliminated, so that the quality of the image is enhanced. After this, image segmentation and clustering are performed using the Otsu classifier and k-means clustering algorithm. The last step is feature extraction. Here, the shape oriented features like Area, Color axis length, eccentricity, solidity, and perimeter and texture oriented feature extraction like contrast, correlation, energy, homogeneity and mean are found.

S. Batmavady, S. Samundeeswari... [4] Input to this system is cotton leaf images that are acquired from the village plant dataset which is available on the internet. The first step includes conversion of the images to grayscale which is then used for noise removal. Then enhancement of the image is done using histogram enhancement and then using morphological process. After this, segmentation is performed to segment the infected part using Fuzzy C-Means algorithm. Feature extraction is performed on the segmented image, and then these features are input to the SVM classifier and proposed RBF neural network classifier.

3. Proposed System

The project is divided into two parts:

a) Building a UAV (unmanned aerial vehicle or drone).
b) Training a neural network model for the prediction of plant diseases.

3.1 Building a UAV

The first part involves building a UAV and attaching a camera to it so that it can be used to get images of plants in real-time. The UAV should be capable of flying missions by giving the appropriate commands and GPSco-ordinates, it can automatically survey the whole farm. The drone will be used to capture images of the specified area.

A Quadcopter or Hexacopter will be suitable for such missions. Below is the explanation of components of the quadcopter drone.

The setup

The quadcopter itself has two main components:

a) flight components (stuff required to fly) and
b) radio gear (network components).

The ground station is also divided into two main parts:

a) radio gear and
b) monitoring (for mission planning and monitoring) equipment.

Radio gear

It uses a network of Wi-Fi cards in “monitor mode” to obtain a bi-directional UDP style stream.
It is used for RC control, video downlink and telemetry downlink

Ground station

The ground station uses three Wi-Fi cards connected to a raspberry pi in a “diversity” configuration.

Here packets from the quadcopter are received by all the Wi-Fi-cards simultaneously, so if a bad packet is received it can be replaced by the packet from another Wi-Fi card.

Below are some of the images of the ground station:

Fig -1(a): Side view of the ground station

Fig -1(b): Top view of the ground station

Network components on the drone

On the quadcopter, we have a raspberry pi 3 a+ (a smaller version of the raspberry pi 3), an8mp Sony camera and a Wi-Fi card. The UART from the raspberry pi is connected to the flight controller to receive and transmit critical flight data.

The camera feed obtained from the camera is compressed and sent to the ground station.

Throughout the software, care is taken to reduce latency as much as possible. We were able to achieve a video latency of about 80-120 milliseconds in ideal conditions.

The software used for this purpose is OpenHd.

Quadcopter hardware

It uses 4 brushless motors along with a 30Amp (per channel) 4 in 1 Electronic speed controller to interface the brushless motors with a flight computer.

The flight computer (also known as a flight controller) has built-in sensors necessary for flight.

It has an onboard gyroscope and accelerometer (to tell its orientation in space) and a barometer detects its altitude. For autonomous navigation, external GPS and compass were added.

Quadcopter software

The flight controller on the quadcopter runs a software called Ardupilot. This is an open-source flight control software specially engineered for autonomous vehicles. It supports waypoint missions, remote mission planning, Blackbox logging, mission simulation among many other tasks.

Below are some images of the drone:

Fig -2(a): Top view of drone

Fig -2(b): Side view of drone

3.2 Training a neural network model for the prediction of plant diseases.

The second part involves the training of a neural network model. The images required for training the model are taken from the datasets that are easily available on the internet. The dataset available is preprocessed and then it is used to train the neural network.

There are two ways in which the dataset can be used for training. If the dataset is big enough then the model can be directly trained. Alternatively, if the number of images in a dataset is limited, then augmentation can be performed which includes rotating, shifting, zooming, flipping the image to create new data for training.

Many neural network architectures can be used to train a neural network. We have used two different models/architectures for prediction which are Google's AutoML and Inception_v3. Inception_v3 is a widely used model for image classification, and it has a fixed architecture. Instead of creating a very deep neural network, Inception_v3 uses a wider network with less depth. On the other hand, AutoML doesn't have a fixed architecture, and it uses a Neural Architecture Search (NAS). NAS is a technique used for automating the process of designing/searching the best neural network architecture that fits our data.

Below is a basic flowchart for training the model:

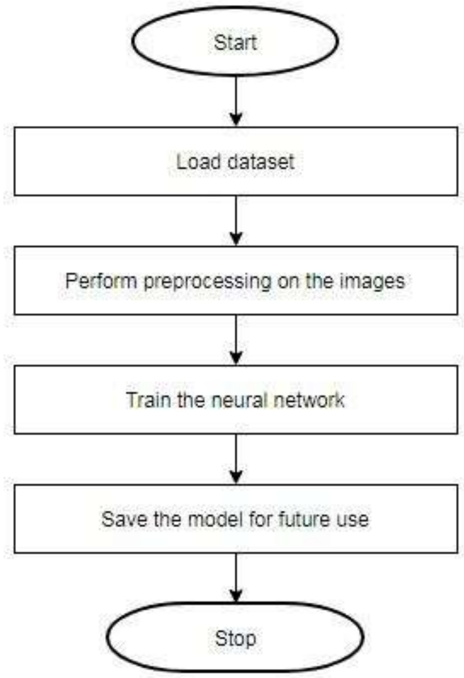

Fig -3: Flowchart for training the model

The images of plants taken by the UAV are appropriately cropped and the cropped images serve as an input to the neural network model which then predicts the disease if present in the plant.

Below is a flowchart of how the entire system works:

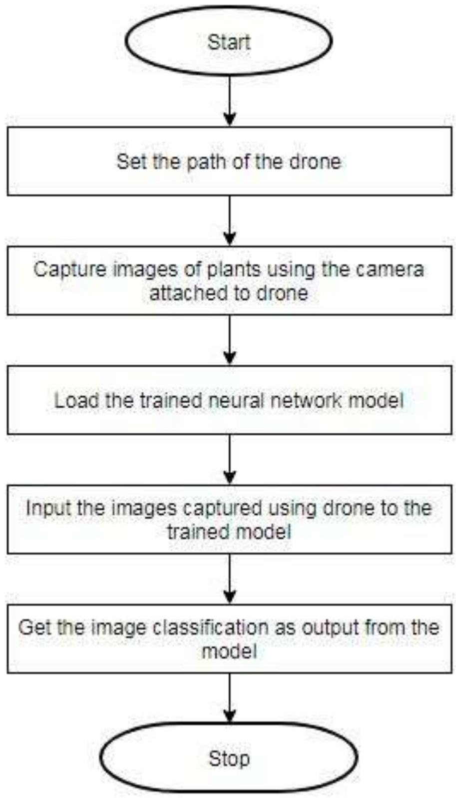

Fig -4: Flowchart of working of the entire system

Additionally, we require an external camera to be attached to the drone that can capture images of the crops. But there are some issues while capturing images which are:

- The drone flies at a certain height from the ground level. Therefore, we require a camera that can retain all the pixels of the leaf image properly after the image is captured from the specified height.
- The drone is in motion, so if we capture images, we might get blurred images.

To overcome the above challenges, we need an external camera with some properties or requirements as stated below:

- The camera should have high resolution and should be capable to provide optical zoom so that the image of the leaf is clear, and no information about the pixels of the image is lost.
- The shutter speed of the camera must be adjustable. This will help us to reduce motion blur.

We have taken a sample output of the implemented neural network. For this, we have taken images of leaves from the internet which serve as an input to the model. Below are some screenshots of the output.

Fig -5(a): Input to the model trained using InceptionV3

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tomato tomato yellow leaf curl virus (score=0.94319)
tomato late blight (score=0.01528)
tomato leaf mold (score=0.00864)
potato late blight (score=0.00842)
tomato bacterial spot (score=0.00815)
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Fig -5(b): Output given by model trained using InceptionV3

The image in Fig -5(a) is used as an input to model trained using inceptionV3 and Fig -5(b) represents its corresponding output. In the output, we get the name of the disease along with its probability which is indicated as a score in Fig -5(b).

The output model trained using AutoML was checked on two different sample inputs.

Fig -6(a): Input1 to model trained using AutoML

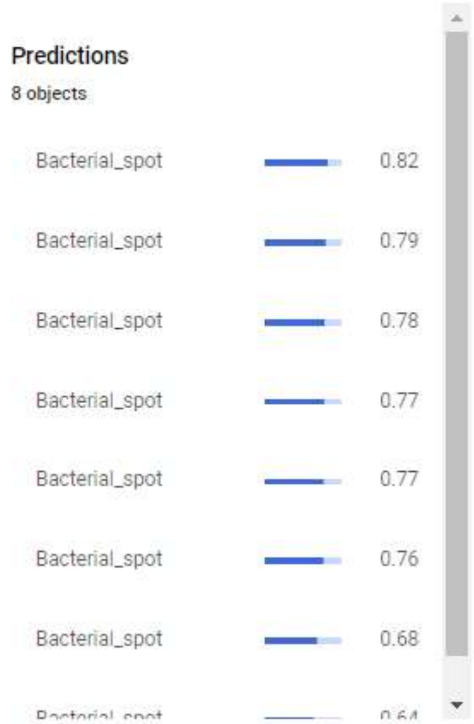

Fig -6(b): Output1 given by model trained using AutoML

Fig 7(a): Input2 to model trained using AutoML

Fig 7(b): Output2 given by model trained using AutoML

The images of leaf as shown in Fig -6(a) and Fig -7(a) were given as input to the model trained using AutoML. These images were given as input without the bounding boxes. The trained model detects diseases in leaves and draws a bounding box at the location of each disease in the leaf. Also, disease present in the corresponding bounding box is displayed as an output along with the probability of disease as shown in Fig -6(b) and Fig -7(b)

4. Observations

We split the dataset for train and test data. We trained both the models by keeping all the input parameters (images, number of images, species of plants) constant for both the models. After training was complete, we tested the models on the test data. The images for testing were directly taken from the internet. By testing model trained by inception_v3, we got an accuracy of 92% and by testing the model trained by Google's AutoML, we have achieved an accuracy of 94%. When we test the models using the images captured using the drone, the accuracy reduces drastically due to the quality of the image.

5. CONCLUSIONS

The proposed system allows the users to automate the entire process of plant disease detection thus reducing the difficulties that the farmers face while growing crops and saving their time. We have achieved good accuracy in the prediction of plant diseases. The model trained using AutoML delivers a better accuracy as compared to the model trained by using the Inception_v3 architecture.

Although this method can be pretty effective for disease detection in plants, but there is a very important challenge in designing this system, which is capturing the images using the camera and drone. The challenge is to get a high-resolution image of the plant leaf for which we need a camera with proper shutter speed, optical zoom, and a high resolution. We need to look at various parameters to make this system perfect.

6. Future Scope

- Before training the model, we can use some clustering algorithms to extract the infected part of the leaf and use these features to train the model.
- We can create and use a dataset of multi-spectral images to create the model, and then use multi-spectral cameras on drones for capturing images.

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