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Enhancing Areca nut Plant Wellness: Innovative Disease Detection using Deep Learning Algorithms

Namra Mahveen
Student, P.D.A. College of Engineering, Kalaburagi, India
khannamra07@gmail.com

Umaira Shahneen
Student, P.D.A. College of Engineering, Kalaburagi, India
umairashahneenkhan@gmail.com

S.M.Hasanuddin
Student, Methodist College of Engineering & Technology, Hyderabad
s.hasanuddin20@gmail.com

Ayesha Fatima
Student, Stanley College of Engineering & Technology for Women, Hyderabad
ayeshafatimaNMEIS@gmail.com

Saheba Aijaz
Student, Stanley College of Engineering & Technology for Women, Hyderabad
sahebaa05@gmail.com

Qutubuddin S.M.
Associate Professor
P.D.A. College of Engineering, Kalaburagi, India
syedqutub16@gmail.com

Abstract

Arecanut, commonly known as betel nut, is a tropical crop that holds significant importance in India, ranks second both in consumption and production globally. The plant is exposed to disease threats to its fruits, leaves and roots, in its entire lifecycle. Currently the disease detection is based on observation, requires farmers to carefully inspect each crop regularly for crop illness. The objective of the present study is to propose a Convolutional Neural Networks (CNN) based advanced system to detect arecanut crop disease in leaves, trunk and fruit. A Convolutional Neural Networks (CNN) is a powerful deep learning algorithm which is specifically designed for image analysis. It operates by processing input images, assigning learnable weights and biases to different elements within the images, andthen learning from these patterns to differentiate healthy plants from diseased arecanut plants. To develop and evaluate the CNN model, it is intended to use datasets from published literature, which contains a diverse range of images depicting both healthy and diseased arecanut plant samples. The main objective of the system is to identify and detect diseases of plant more accurately but also to provide practical remedies and guidance to farmers, helping them to maintain healthy crops and increase productivity.

Keywords
Areca nut, Disease, Dataset, Convolutional Neural Network

1. Introduction

Agriculture is considered as the backbone of India. So, Indian economy is highly dependent on the agricultural productivity. Therefore, the agricultural field must be maintained well where detection of disease in plants plays an important role. The plant diseases have to be detected in very initial stage so as to protect the crops as well as from destroying other crops, Dhanuja KC 2020. Therefore the use of automatic disease detection technique will be very much beneficial. For example, a disease by name Little Leaf Disease is found on pine trees in United States which is very hazardous. The affected tree has a stunted appearance and has a short life of about 6 years. This disease is also found in far off places like Georgia, Alabama and southern US, Manpreet et.al.2020. Hence an early plant disease detection system will be very fruitful to the people. Presently the disease identification and detection is mostly carried out by observations by naked eye by the experts or the farmers themselves.

For doing so, a large team of experts as well as continuous monitoring of plant is required, which costs very high when we do with large farms. At the same time, in some low economy countries, the farmers totally depend on qualified experts, Anandkrishnan et.al.2017. Because of this scenario, the consultants demand high fees and take much time. Therefore to overcome this the present project is proposed on early detection of plant diseases. Automatic detection of the diseases by just recognising through the naked eye visuals and the symptoms on the plant leaves makes it cheaper but may be too late.

Visually identifying the plant disease by naked eye is not much accurate and can be done in limited cases and is more tiresome. At the same time any kind of automation in plant disease detection leads to less time, effort and is more precisely done. Several diseases can be seen in plants like yellow and brown spots on leave, viral, fungal and bacterial diseases etc. Using the image processing technique the affected area can be measured and the color difference in affected area can be determined. The image segmentation technique is used in image processing to separate or group an image into different parts, Manisha et.al.. Many different methods are available of performing image segmentation, from simple thresholding method to the advanced color image segmentation technique. Computers lack certain intelligence in recognising the human language or signs, hence, the segmentation process are used, based on various features found in the image which might be colour information, boundaries or segment of an image.

India is the highest producer of arecanut with a production of around 3.3-4.0Lakh tones and a total acreage under cultivation of 2.64lakh hectares, Areca nut, also called as Beetle nut is widely consumed in the southern Asian countries like: India, Bangladesh,Nepal, Pakistan etc, in India, with Karnataka and Kerala account for more than 70 percent of the total productions of the country. Commonly found diseases in areca tree are Mahali Disease (Koleroga), Bud Rot Disease, Stem Bleeding, Yellow Leaf spot, Yellow Disease which occurs due to continuous rainfall and various climatic changes, the spreading of these diseases must be controlled in the primary stage of the infection otherwise it will be difficult to control in the final stage which may lead to loss to the crops. To avoid such issues, through our project, we have used Machine Learning to detect disease and suggest some appropriate remedies to it. Arecanut disease detection can be done by examining the spot on the affected nut, leaves, and trunk. In the present work, the Machine learning technique specifically, the Convolution Neural Networks (CNN) method is used to detect plant diseases. The work involves around identification of Mahali disease (Kole Roga), yellow leaf spot disease and stem bleeding (Figure 1) and to recommend suitable solutions for the diseases detected.

Mahali Disease: This disease is widespread in occurrence in most of the areca nut growing grooves. Mahali Disease (heavy devastation) or Koleroga (rotting disease) causes the rotting of arecanut fruits and is the most dreaded disease, which occurs in regions getting heavy rainfall. It is difficult to estimate the exact losses due to this disease but some estimates of crop loss to the extent of 10 to 75 percent is recorded in different states. The development of disease may be due to low temperature, alternate sunshine, high humidity and heavy rain. The disease's first visual appearance is like water soaked lesions on the surface of the fruit near the calyx.
The infected nuts are unsuitable for chewing due to quality deterioration.

Stem Bleeding: grooves in the age group of 9-15 years are more prone to this disease. Symptoms appear on the basal (lower) portion of the stem as small discolored depressions. Later, the spots coalesce and develop cracks on the stem which leads to disintegration of the fibrous tissues inside the stem. The Symptoms of stem bleeding are observed on stems that changes color to dark red, and the stem tissue secretes a dark brown fluid, yellowish spots are observed on leaf blades, the roots are seen as yellowish brown and rot is not uncommon. The fruit changes its color to dark green. This disease is mostly caused by the fungus *Thielaviopsis paradoxa*.

Fig. 1. Healthy and Diseased Images of Areca Nut, Tree And Leaf

Yellow Leaf spot: The disease is more common during south west monsoon and infections are limited to about 5-6 leaves. The main symptom of the disease is yellowing of leaves. The yellowing starts from the tips of the leaflets of the outer leaves gradually extending along the margin to the middle of the lamina. The affected leaves often develop necrosis from their tips. In advanced stages, the leaves become smaller, stiff and pointed. In severe cases the infection causes quick drying and shedding of leaves. The problem of efficient plant disease protection is closely related to the problems of sustainable agriculture and climate change in India, as the farmers have got vast diversity of crops to grow. Different types of diseases are observed on the plants and crops. The main identification of the diseases plant or crop can be done through leaves. The multiple-coloured spots and patterns on the leaf help in detecting the disease. The method of identifying the disease with naked eye is mostly inaccurate and time consuming. In order to detect diseases requires different laboratory tests, well equipped laboratories and skilled people. These facilities are not available in remote areas. There are different techniques to detect plant pathologies. Some diseases do not show any visible symptom, or sometimes the effect becomes unnoticeable. In such situations it is necessary to have a sophisticated system of analysis.

1.1 Objectives

- To collect datasets containing images of arecanut (both diseased and healthy)
- To design and develop an algorithm for early detection of disease in arecanut.
- Develop an algorithm to recommend solution for diseases detected.

2.0 Literature survey

In the literature, several papers are found which covers the area of disease detection in plants and few are on arecanut. Dhanuja K C (2020) in his work proposed a system to detect arecanut diseases by image processing and following texture-based grading. The author has used about 144 samples for training and testing, which include 49 good, 49 negative and 46 poor samples. The K-nearest neighbour (KNN) algorithm used for detecting the diseases. Manpreet Sandhu et.al.2020 developed a system for disease detecting by using leaves image classification. The system automatically detects the spots or rotten spaces in the leaf by Machine Learning Algorithm. The authors used drone camera to capture the images of the leaf. Another study by Ashish Nage et.al. (2019) followed a image processing approach to detect plant diseases. They developed an android application to help farmer in identify plant disease. The image of leaves is uploaded to the system which then identifies the leaf disease using convolution neural network (CNN).

Similar studies are carried out by Swathy Ann Sam et.al. 2020 in which different algorithms like CNN, KNN, SVM and Decision Trees are used to detect plant disease. The system works on uploading a image of sample leaf

and the algorithm will detect the presence of any disease, and if it has any disease the system will print the detected disease. The authors used a CNN giving an accuracy of about 86 percent.

From the literature survey, it is observed that authors worked specifically on other general plant leaves for detecting the disease using image processing technology and various machine learning algorithms such as Support Vector Machine (SVM), Convolutional Neural Network (CNN), K-Nearest Neighbour (KNN) and Decision Tree by either creating their own datasets or considering the pictures taken by camera. The present work focuses on identifying the disease based on leaves as well as trunk and its fruit by mainly using Convolutional Neural Network and considering open source dataset.

3.0 Methodology

The authors have used the dataset of healthy and disease leaf to detect different diseases of leaves. The images were taken from using a digital camera at a distance of half-meter from the plant. The diseased and healthy arecanut images are taken from the arecanut plantations in Shimoga District, Karnataka, India. Inputs from researchers in the area of arecanut and farmers were taken into consideration while taking the photographs. The images taken consist of both healthy and diseased leaf, trunk, and nuts.

3.1 Dataset Collection

As discussed about the diseases of arecanut, the dataset contains images of healthy and diseased arecanut like Mahali, stem bleeding and yellow spot, Figure 2. Before training the model, these images undergo various stages like reshaping and resizing to get the images according to the requirements. The collected images are considered as the basic dataset to give the exact detection and also help in displaying the efficiency of the project.

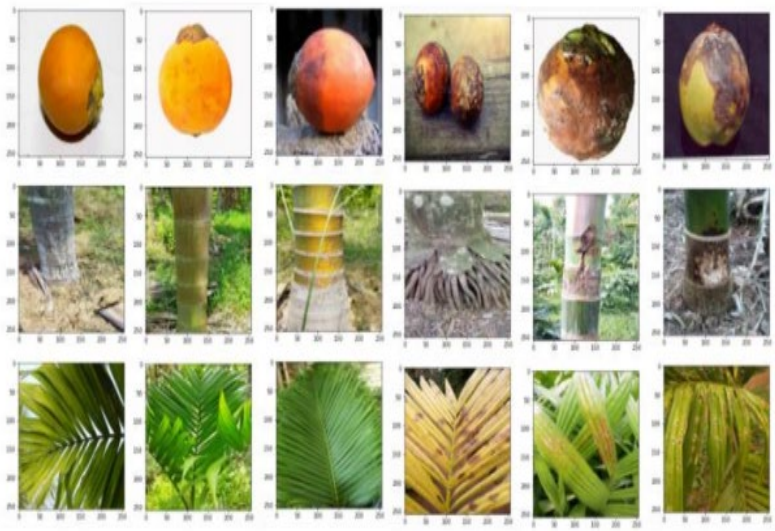

Fig.2. Image Database

The Deep Learning Algorithm CNN takes an image as input, and then assigns its significance (biases and learnable weights) to different aspects in the image, learn from the image and distinguish from one another. The amount of pre-processing required by a ConvNet is much less as compared to other methods of classification. ConvNets learn from the filters or characteristics with enough preparation when well trained. The working design model is shown in Figure 3.

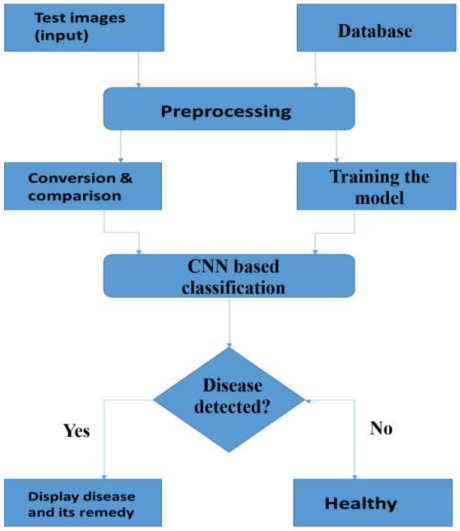

Fig. 3. Working Model Design

3.2 Model Structure

The Figure 4 shows a simple CNN model structure. As shown the CNN has several layers which includes Dropout, Dense Layer, Activation, Convolution 2D, MaxPooling 2D and Flatten for training model. By using the CNN 1000 to 1500 neurons can be used in first layer, 500 to 800 neurons in second layer, 250 to 300 neurons in third layer and 5 neurons in the last dense layer. The activation function used in the first 3 layers in RELU, and for the last layer SOFTMAX is used. The total parameters calculated are about 248,655,647 including the biases and weights. The last activation function SOFTMAX, indicates the probability of the detected disease.

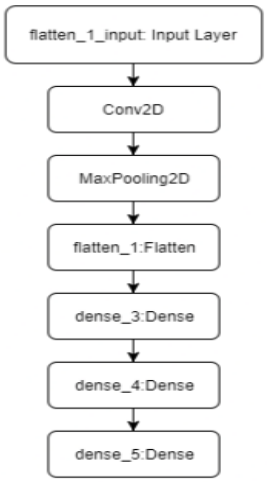

Fig.4. Simple CNN Model Structure

3.3 Training the model

To train and test the models, various images of both healthy and diseased are considered here. The dataset which we used here is limited so we are using Augmentation technique which performs rotation, zooming, shifting and flipping the image to create new data for the training model. The trained and tested data is divided into 80:20 ratio. The total number of 50 Epochs is used to train the model, which can achieve high validation and test accuracy with a minimum loss.

3.4 Feature Extraction

The previous step (training the model) provides the gray scale images. The images are converted into its reduced variables. Basically, each pixel of the image is taken and gets converted into matrix for performing convolutions. The same process is carried out across all the pixels where the convolution matrix is simply multiplied with each pixel matrix. The numbers of strides, already mentioned, are used for shifting pixel matrix.
Once all the values are obtained by multiplication, then pooling on the matrix is performed. The MaxPooling system is used for better extraction and accuracy. An Epoch is formed with both the processes i.e. Convolution and Pooling. To further improve the system and obtain accuracy in results, the number of Epochs is performed. Hence by following the steps discussed the unique features from the image are obtained.

3.5 Detection of Disease and Classification

The disease in plant is detected in two stages; first detecting the type of crop and then detecting the disease type, with the help of CNN. The Transfer Learning technique is used for model building. In this technique the current models are created using the pertained models. This is done by flattening the image which converts the pooled image to single dimension vector. It is easy to classify the images once it gets converted into vectors. If the leaf is healthy and shows no signs of any disease, there is no classification and the result is shown as healthy, Figure 5. But if any symptoms of disease is indicated when gray scaled, black spots are shown and it is classified as diseased leaf. Furthermore, it can be distinguished as the type or kind of disease and its possible remedies. The classification takes place between two numerical arrows.

Fig.5. Detection of Disease

4.0 Results and Discussion

The plants exhibit different kinds of features and vary in shape, colour and type of diseases. It can make a million odd disease combinations which the model has to characterize and accept in the system. As the features are accepted into different categories the image is decoded to get the result in the form of layered output.
The layered output is different layers of the disease detection. These can be the gray scale images and the RGB of the images. These help to separate different coloured features of the leaf so that they can be categorized into multiple different categories. And, it also helps the user to recognise the location of the disease and the numerical value can easily make the white and black images into 0 and 1.

This is more beneficial to the farmers whose crops are suffering from diseased arecanut plants, as the disease is identified early and the possible loss can be reduced and help grow healthy crops. It also helps the arecanut industry, which manufactures various products with high demand. By early detection of the diseases, the industry can expect healthy arecanut crop, which can increase the quality and productivity of the finished product.

4.1 Numerical and Graphical Results

The test accuracy obtained after training the model is around 88 percent as shown in Figure 6. The images of the leaf shown in Figure 7 were given as an input to trained model using CNN. The model identifies the disease and prints the probability of the detected disease as shown in Figure 6. The system also suggests the remedy for the disease with the maximum probability, as shown in Figure 8.

```
print("[INFO] Calculating model accuracy")
scores = model.evaluate(x_test, y_test)
print(f"Test Accuracy: {scores[1]*100}")
```

```
[INFO] Calculating model accuracy
2/2 [==============================] - 0s 179ms/step - loss: 0.5850 - accuracy: 0.8846
Test Accuracy: 88.46153616905212
```

Fig. 6 Model Accuracy

Fig. 7 Input Images Given for Testing

```
result=model.predict(npp_image)
itemindex = np.where(result==np.max(result))
for i in range(len(result[0])):
    print(label_binarizer.classes_[i]+" "+str(round(result[0][i]*100,2))+ " %")
if itemindex[1][0]>2:
    print("\nRemedy for the "+ label_binarizer.classes_[itemindex[1][0]]+" :\n",Remedy[itemindex[1][0]])
```

```
Healthy_Leaf 1.18 %
Healthy_Nut 0.13 %
Healthy_Trunk 0.35 %
Mahali_Koleroga 0.23 %
Stem_bleeding 0.77 %
yellow_leaf spot_disease 97.35 %

Remedy for the yellow_leaf spot_disease :
 Disease can be controlled by spraying with one per cent Bordeaux mixture or Dithane M 45 @ 3 gram/Liter.
```

Fig. 8 Graphical Outcome

4.2. Proposed Improvements

The present system developed based on small sample of dataset, the model is trained for detecting only 25 type of plant diseases. It is planned to train the system with more datasets of different plants and the diseases so that the scope of the system is expanded to other plants as well. In future the dataset can be used to build better models and improved in terms of accuracy by implementing advanced algorithms developed in future. The present work is based solely on data set collection and image scaling and detection of diseases. The system being a part of the project work may show some errors or have accuracy issues. The sample of datasets if very large, the system may take more time to process.

CONCLUSION

The present paper mainly focuses on the early detection of arecanut plant diseases like its leaves, trunk and fruit using CNN- Convolutional Neural Networks. The system works in steps- firstly pre-processing, feature extraction, training the model and then classification. As demonstrated by the system, it is capable of detecting diseases like Yellow Leaf, Mahali and Stem Bleeding in arecanut Plant, and also suggests remedies. The system may exhibit varied levels of detection accuracy, which totally depends on the stage of the disease and quality of input image.

As shown in Figure 6, the model accuracy is about 88 percent. The system provides information on preventive measures and corrective action to be taken. The CNN used here to help detect diseases, and the model was built using Tensor Flow and Keras Framework, implemented on Android/Linux. This proposed system is a small step towards encouraging farmers to adapt and practice smart farming, thus getting better yields and higher productivity. This system can be improved or more developed in future by using a drone with camera facility and cover large area and also expanded to other crops and make a drastic change in the agricultural sector

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