USING DEEP CONVOLUTIONAL NEURALNETWORK FORPLANT LEAF DISEASEDETECTION

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Abstract

Agriculture plays an important role in economic growth of any country. The poor and inappropriate plant disease identification techniques might lead to heavy crop losses impacting national nutrition and health security. Most of the farmers from developing countries such as India, use laborious and time taking traditional methods for early disease identification. Use of machine learning techniques such as Convolutional Neural Network (CNN) are helpful in early-stage leaf disease detection and classifications. Such techniques can be easily used by Indian farmers to save their precious crop from harmful insect, pests and disease. Machine learning (ML), plays an important role in identification and cure of common and rare plant diseases. Use of machine learning techniques is helpful in early-stage leaf disease detection and classifications. ML based plant disease identification algorithms enable farmers to identify plant diseases on time and to provide proper cure against the diseases. India is among the largest producer of fresh mangoes. The mango called Alphonso is one of world's most popular fruit. This study investigates the role of ML and CNN in

identification of various Mango plant leaf diseases in India and discusses its benefits to the Indian farmers.

Keywords: Convolutional Neural Network, crop disease, Mango Disease Detection, Machine Learning
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1 . Introduction

Agriculture forms the backbone of India's economy and the human civilization. The continuous increasing world population of around 7.8 billion people requires 3.7 billion metric tons of food per year [13]. India being the second most populous country, the agricultural sector plays a crucial role in feeding its 1.27 billion people [14]. Plants are a major source of food for all of us [1]. Yield losses due to crop pests and diseases on food crops are large globally [15]. Leaf disease is a global threat to several agricultural crops and is one of the major underlying causes for the decrease in the number of quantity and quality of commercial fruit crops such as mango [1].Manual leaf disease monitoring is laborious and error-prone. The failure to diagnose disease in plant leaves leads to inappropriate pesticide/fungicide use. Excessive use of chemicals is dangerous for the crops as well as for humans [1, 2]. Traditionally, the naked eye examination is used to identify plant diseases. But traditional methods are prone to human error. The National Academy of Sciences (UA) had published an agricultural research agenda emphasizing the need for use of technology in the early and rapid detection and prevention of plantdiseases [16]. Examination of automatic leaf disease detection in agriculture could display advantages in the observation of vast fields and can help in early identificationof disease occurring on plant leaves [17].Thus, it is imperative that theplant leaf diseasedetectioninvolve the use advanced approaches such as the intelligent machine learning techniques [3].

India is among the largest exporters of fresh mangoes [18]. The variety of mango called Alphonso, which is also known as the king of mangoes is known for its taste, fragrance and color and isone of the world's most popular fruits [21]. This study investigates the use of automated techniques for leaf disease detection in Alphonso mango which can help farmers in identifying plant leaf diseases. A novel deep neural network classification model is proposed for the identification of leaf disease using plant image data. The results produced using this technique are more efficient (for production in both small and large fields), accurate and take relatively less time to detect diseases [4]. The next section in the study is the literature review which is followed by methodology, results, conclusion and discussion.

2. Literature review

Agriculture is the primary source of livelihood for around 58% of India's population [19].Agriculture, along with its allied sectors, is also the largest source of livelihoods in India [14]. Plant diseases result in significant losses in food crop production leading to reduction in yields, loss of species diversity, expensive control measures and impacts on human heath [15].

Every year agriculture industry suffers terrible loss of yield due to incorrect or late detection of plant diseases including disease of leaves, fruits and roots [5]. The traditional method of disease detection which basically includes observation through naked eyes requires more manual work, expenses and time. Such methods are inappropriate when the number of crops increase or the production is high. Often due to the lack of proper knowledge about plants leaf disease, and its control measures, the farmers fail to control the disease. The timely identification and early prevention of crop diseases are essential for improving crop yield and quality [5, 6].

Many farmers use pesticides to control disease carriers or pests without confirming the specific diseases. The excessive and wrong usage of pesticides can adversely affect the plant quality and eventually human health. Due to global warming and abrupt changes in climatic conditions, different types of leaf diseases such as bacterial, fungal and viral disease (7) are affecting the crops.

India's Alphonso mango besides beingamong the world's most popular fruits is exported to countries such as Japan, Korea, US and Australia [20]. Good Alphonso crop yield contributes to farmers income and growth. However, this delicate fruit plant is affected by different diseases and it is very difficult to detect disease in naked eye [20].

Convolutional neural networks enable a scalable approach to image classification and object recognition tasks, to identify patterns within an image [21]. This study presents a Convolutional Neural Network for mango leaf disease recognition that help to identify diseases more easily and accurately as compared to the traditional system. This study intends to detect the diseases of mango leaf with machine learning monitoring where different symptoms of diseased leaves are taken into consideration. The proposed system of leaf disease detectioncould successfully detect and classify the examined disease with accuracy of 82.85%, depending upon the quality of images captured. The system is efficient, effective and can be used easily without the presence of any agriculture or horticulture specialist. It would also help farmers in improving the overall yield of Alphonso fruits by timely identification and elimination of the disease[8].

3. Methodology

3.1 Objectives

The main objectives of this study are:

- To develop a system that has a capability to detect and classify the diseases in Alphonso mango plants from their leaves.
- To improve the crop production by early detection of leaf diseases of Alphonso mango tree.

3.2 Working of trained model

An automated technique for leaf disease detection makes the farmer's life easier. In this study, deep convolutional neural network models are implemented through extensive research work, to identify and classify diseases in Alphonso mango the plants from the images of their leaves. Deep Convolutional Neural Network is used to classify the diseased and healthy leaves and to detect the disease in the affected leaves. This technique is efficient for both small and large Alphanso mango orchards. The disease

identification is highly accurate in this proposed model and it takes very less time to detect the diseases [8].

3.3Trainingprocedure

First of all, an image of Alphonso mango leaf is captured (see figure 1) from the field with digital camera or smart phone or drone [9].

Bacterial Disease

Algae Disease

Fungal Disease

Figure.1: Alphonso Plant Leaf Diseases

Following categories of diseases were captured:

A) **Bacterial Disease:** Bacteria are single-celled microscopic organisms which spread from one plant to another by means of wind, rain water splash and insects. The bacterial disease in plants occur mainly on leaves, but some may also occur on stems and/or fruit. Example is Bacterial Canker.

B] **Viral Disease:** Viruses are obligate parasites which feed on living host for their survival and multiplication. Virus infection in leaves mainly spread through infected seeds, grafting, wind, splashing and pollination.

C] **Fungal Disease:** Fungi are the most common parasites in fruit plants like mango. Fungus diseases are common during wet and humid weather. Few examples of fungal diseases are Powdery

Mildew, Anthracnose, Alternaria leaf spot etc.

3.4Image acquisition and CNN model buildingprocedure

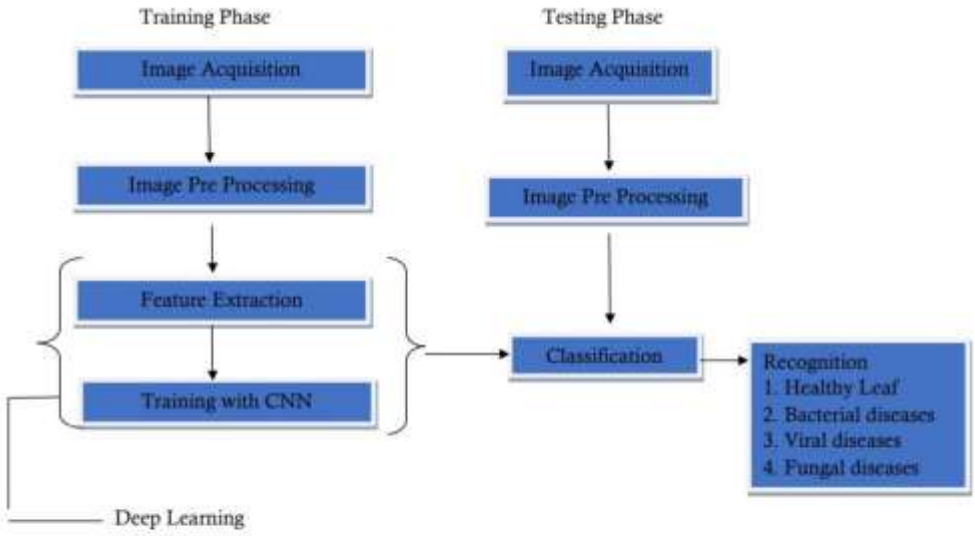

Figure.2: Model Circuit Diagram for Mango Leaf Disease Detection

Model of CNN was built as per the steps mentioned below:

A] **Image Acquisition**: First the image of Alphonso mango leaves will be captured from the digital camera or drone. The captured image will be in either RGB or grey scale image.

B] **Image Pre-processing**: The captured image of healthy and diseased plant leaves cannot be used without pre-processing stage, since there will be a lot of disturbances and noises in the captured images from the field. In pre-processing the noises from the image are required to be removed to obtain an accurate result.

C] **Feature extraction**: It helps to remove the redundant data from the original data set. It is useful when we have a large data set and need to reduce the number of resources without losing any important or relevant information.

D] **Training CNN:** Training a neural network consists of two phases. In forward phase, the input is passed completely through the network. In backward phase, gradients are back propagated and weights are updated.

E] **Convolutional Neural Network:** A convolutional neural network is a feed-forward neural network that is generally used to analyze visual images by processing data with grid-like topology. A convolutional neural network is used to detect and classify objects in an image.

F] In this study, the CNN model is built to identify both healthy and diseased leaves (see figure 2). The images are trained and the output will be produced according to the input leaf. Finally, the decision will be taken whether the given input leaf is healthy or affected by plant diseases.

4. Results

This section of the paper deals with the Python commands used and results obtained from CNN model for Alphonso Leaf Disease Detection. The accuracy of model was about 82.85%.

4.1 IMPORT LIBRARIES

Below mentioned Python libraries were added to enhance image processing capabilities to Python interpreter.

COMMANDS:

- import PIL
- import PIL.Image
- import tensorflow as tf
- import IPython.display as display
- from tensorflow.keras.callbacks import ReduceLROnPlateau, EarlyStopping, ModelCheckpoint
- import pathlib
- from tensorflow.keras.models import Sequential
- import numpy as np
- import matplotlib.pyplot as plt
- from tensorflow.keras.models import load_model
- import os
- from tensorflow.keras.layers import Dense, Conv2D, Flatten, Dropout, MaxPooling2D
- import matplotlib.pyplot as plt

4.2 LOAD IMAGE DATA&NUMBER OF IMAGES

Total of 2000 imago leaf images were considered into the study (for example, figure 3 shows the test image of healthy mango leaf), out of which 1500 images were used in data training and 500 images were used in data testing. After pooling the images of mango leaf into the system, the data was further converted into “healthy mango leaf” and “diseased mango leaf” dataframe.

Figure.3:Healthy Alphonso Mango Leaf

4.3IMAGE GENERATOR&CLASS LABELS

The photo array of classified mango leaf is given in figure 4. The array is produced as a result of ML algorithm used in the study. Algorithm classifies all the captured images of mango leaf as healthy or unhealthy plants, along with the overall percentage of "healthy" and "diseased" classification. Further adding to the accuracy, the unhealthy plants would be further classified into "Bacterial", "Viral" or "Fungal" diseases. Classification also showed that in training model the accuracy was 87.3% but in testing model it came down to about 82.85%.

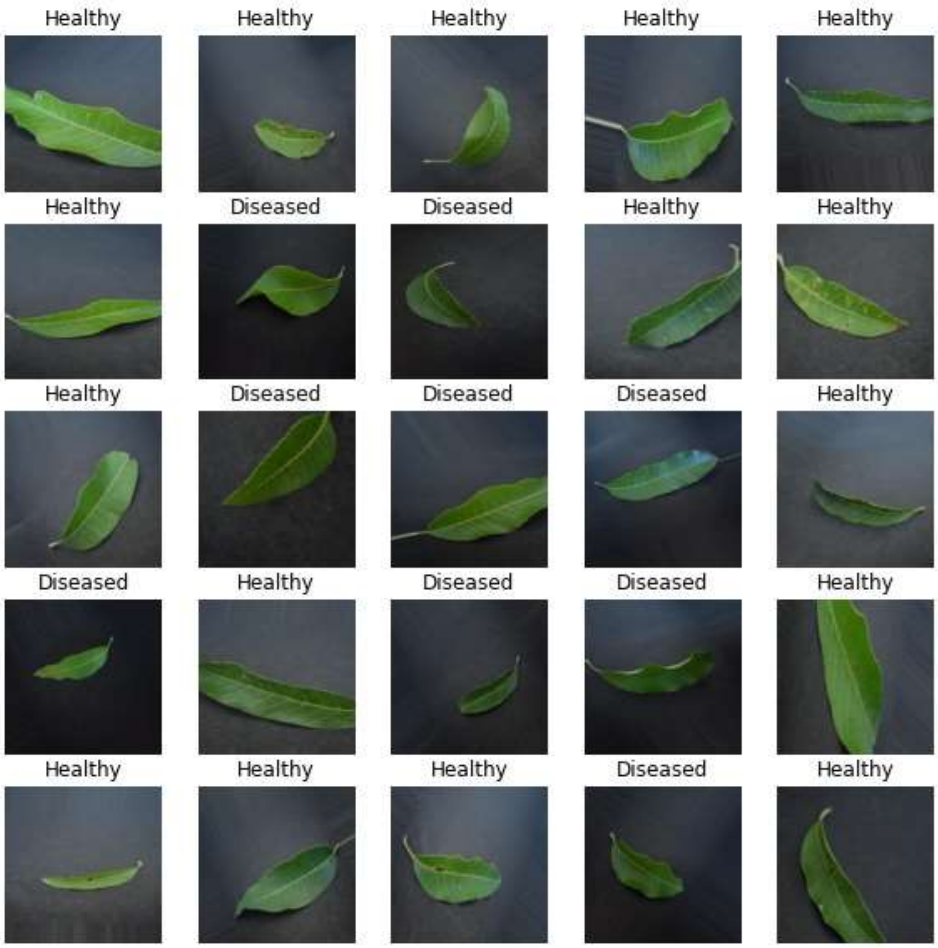

Figure.4: Grid of healthy and unhealthy Alphonso Mango Leaf

4.4 CONVOLUTION NETWORK COMMANDS&PLOT LOSS & ACCURACY

While running the CNN model, its was observed that at around 6 epochs the training and validation loss are decreasing resulting in increasing in accuracy. The accuracy at this is around 82%.

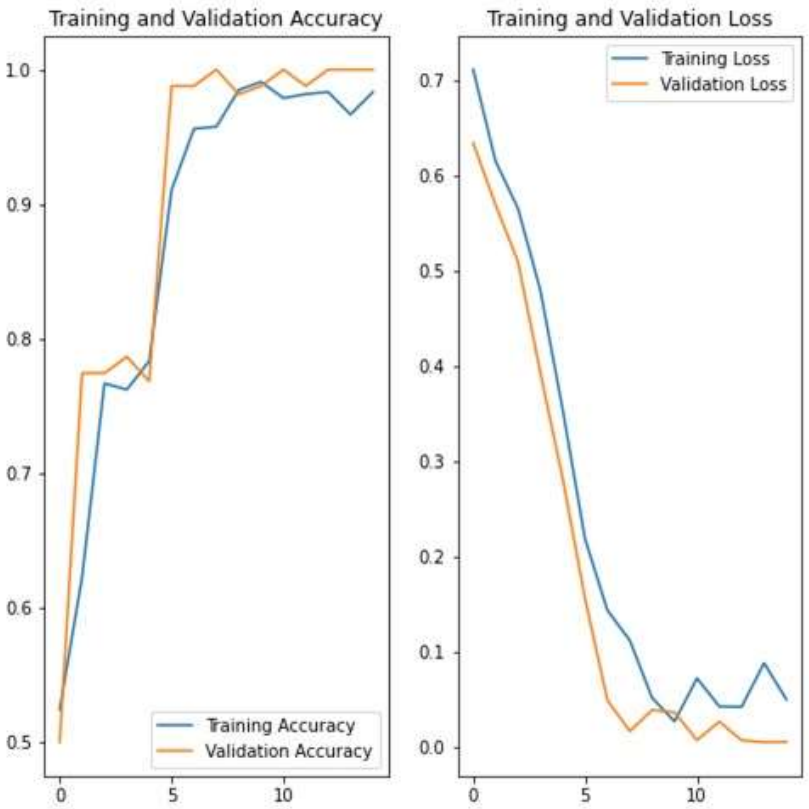

Figure.5: Training and Validation Accuracy and Loss

The readings of CNN model are given below for 500 testing data points under 2 classifications “healthy” and “diseased”.

<tf.Tensor: shape=(500, 2), dtype=float32, numpy=
array([[9.9999964e-01, 3.3767157e-07],
[1.0000000e+00, 1.8451163e-09],
[9.9999964e-01, 4.1004253e-07],
[4.2477641e-05, 9.9995756e-01],
[9.9999559e-01, 4.3518880e-06],
[2.1168244e-05, 9.9997878e-01],
[1.0017561e-05, 9.9998999e-01],
[1.0000000e+00, 5.9889396e-09],
[5.7911064e-05, 9.9994206e-01],
[9.9996102e-01, 3.9005881e-05],
[1.5872525e-05, 9.9998415e-01],
[2.9797116e-05, 9.9997020e-01],

[1.0000000e+00, 4.3421938e-08],
[1.0000000e+00, 2.5546275e-11],
[3.0258516e-05, 9.9996972e-01],
[1.0000000e+00, 9.3171781e-10],
[1.0000000e+00, 8.8788887e-10],
[9.9990678e-01, 9.3166884e-05],
[3.8773680e-05, 9.9996126e-01],
[1.0000000e+00, 1.4735859e-08],
[9.9984884e-01, 1.5110012e-04],
[1.4621354e-05, 9.9998534e-01],
[1.0000000e+00, 9.9287412e-10]], dtype=float32)>

5. Discussion

Agriculture sector has the significant potential forexport in India. Owing to the wide range of agroclimatic conditions and low-costlabor, India has the advantage of expanding its exportbasket and exploiting the hitherto untapped potential indigenous Alphonso mango. Plant diseases could tremendously decrease the productivity and quality of product. Identification of plant leaf diseases by traditional methods such as observation through naked human eye can make the diagnosiserror prone. Image processing techniques can prove to be powerful technique to identify the diseased leaf by pre-processing and classifying leaf unhealthy regions. This studypresents an effective approach formango leaf unhealthy region detection and classification. The study uses CNN for diseases classification and segmentation. The experimental results exhibit the effectiveness of the proposed method in recognizing the healthy and unhealthy mango leaf [9].In this research, we detected early disease on Alphonso plant leaves with higher resolution images, by convolution neural network (CNN) approach. After a pre-processing step using a contrast enhancement method, all the disease infested mango leaves are segmented into healthy and unhealthy datasets. The CNN's results are better using a simpler network structure (assuring 80-95% accuracy). This shows that our approach can be implemented on low-end devices such as smartphones, which will be of great assistance to farmers on the field [11, 12].This proposed research studywill be helpful in automatic detection and analysis of disease based on particular disease symptoms.Early detection of diseases in agriculture is very tedious task. Microbes like fungi, bacteria, virus etc.,are the major causes of plant diseases [10]. The study achieved the data accuracy of 82 % which is highly encouraging for undertaking future research so as to make it more relevant for

commercial purposes. The developed grid considering the healthy and the unhealthy plants facilitates effective analysis and diagnosis of the diseases. The approach presented can effectively and efficiently aid in the mass surveillance of big orchards. This research also presents an opportunity to extend this study to other fruit orchards along with improving the data accuracy.

Conclusion(s)

The method and the data analysis employed in the study achieved a data accuracy of 82 % which is in the vicinity of the expected range of 85 to 90%. The data accuracy achieved further encourages future research which can be extended to other fruit orchards. The approach used in the study will be helpful inidentification and classifies bacterial, viral and fungal diseases in the plant leaves more effectively. It would help to reduce the use of pesticides by early detection of the diseases and in turn provides healthy crop. It willimprovethe crop production by early detection of the leaf diseases and willdecreases the labour requirement.

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Conflict of Interest

The authors declare no conflict of interest.

Notes/Thanks/Other declarations

This research is still at development stage and increased dataset for Alphonso mango could help in achieving higher accuracy of results

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