MANGO SPECIES PREDICTION FROM LEAF USING CONVOLUTIONAL NEURAL NETWORK

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project/internship titled **"Mango Species Prediction From Leaf Using Convolutional Neural Network",** submitted by Md. Ariful Islam, ID No: 192-25-789 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 9th July 2020.

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Shah Md. Tanvir Siddiquee, Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this Thesis nor any part of this Thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Convolutional Neural Network (CNN) is a vast area of researches in Machine Learning. Various types of researches are using Artificial Intelligence (AI) in agricultural fields, medical sectors for detecting diseases. This research is going to recognize mango species from the image of mango leaves. The most recent age of convolutional neural systems (CNNs) has gained exceptional outcomes in the field of picture grouping. This examination is connected with another way to deal with the improvement of mango species identification model, in view of leaf picture arrangement, by utilizing Deep convolutional neural systems (DCNN). We use DCNN for classification of mango species and detect them. Here we use images of mango leaves as our dataset. We have five classes and about 600 images as dataset. After classifying we train and test our system using Convolutional Neural Network (CNN). The accuracy of our system to detect mango species is 75%. It should be improved in further research.

CHAPTRER 1

INTRODUCTION

1.1 Introduction

Mangifera indica, generally known as mango, is local to the Indian subcontinent where it is homespun. Several numbers of cultivated varieties have been introduced to other warm regions of the world. Various types of mangoes are available in our country such as Fazlee, Langra, Khirshapat, Himsagar, Gopalbhog, Mohanbhog, Mishribhog, Khisanbogh, Bombai, Amropali, Harivanga etc. All of us are not familiar of these varieties. But our people loves mango a lot. The taste of different species of mangoes differs from each other. Also the leaves of different mango species differ from each other. This research is to identify the species of mango from the image of the leaf. In this modern era, most of the people are used to modern technology. In this purpose the can use their smartphone to identify the species of mango. This research is based on Convolutional Neural Network (CNN), Image recognition methodology. Image recognition is a technique to identify any object from the image. CNN is used to train the whole system. Deep learning establishes an ongoing, modern procedure for image processing and data analysis, with exact outcomes and enormous potential. As Deep learning has been effectively applied in different areas, it has as of late entered likewise the space of agriculture. So we will apply deep learning to make an algorithm for mechanized identification and grouping of plant leaf by species. In present, Convolutional Neural Networks are considered as the main strategy for object detection. There are various methods for image identification, some of them are Image Processing techniques, Machine Learning, Support Vector Machine (SVM), Region Proposals (R-CNN, Fast R-CNN, Faster R-CNN), You Only Look Once (YOLO), Deep convolutional neural networks (CNN), Probabilistic Neural networks (PNN) etc. For our research Deep convolutional neural networks (CNN) is more applicable. We train the system using CNN and obtain training accuracy then test the system and obtain validation accuracy. This research is a classification of the mango species. The research will be very beneficial for people in real life application and also very helpful for the farmers who cultivate mangoes, who wants to learn about classification of mango species and who buy mango trees from the market. Also this system is very user friendly.

1.2 Motivation

Mango a fruit, broadly cultivated in the tropical and subtropical nations of the world. As indicated by FAO (Food and Agriculture Organization), in the course of the most recent 18 years the quick creation of mango has been the most noteworthy in Bangladesh. The creation has expanded by 16 percent for every year and the per head fulfillment multiplied in the course of the most recent 10 years.

Around 2.4 million tons of mangoes were cultivated in 2017-18 [1].

But most of the people do not know all the varieties of mango available in our country. Now-a-days technology is strong enough to identify the varieties of mango. This research will build a system so that anyone can identify the species of mango from its leaf. In many areas, specific types of mango cultivate widely. This research will help the people to choose the expected species of mango for their areas, gradually it will improve the cultivation of mangoes.

1.3 Rationale of the Study

Mango species detection using Deep Learning for how to detect mango species by capturing the picture of its leaf using a smartphone for recognizing several species of mangoes. Deep Learning is a propelled strategy for Machine Learning that utilizes Neural Networks. In this research Convolutional Neural Network (CNN) is used to train the system. There are several numbers of mango species are cultivated in this country. But people cannot distinguish between them from seeing the plants. This study will help us to detect the varieties of species by diagnosing the leaves of mango trees. Also recommend the areas that are best for the specific species of mango to cultivate.

1.4 Research Question

- Can technology build a system that identify the species of mango from its leaf?
- How useful it would be for the people if they can identify the varieties of mango using technology?

1.5 Expected Outcome

In this modern civilization, technology is developing rapidly. This research emphasis on species detection of mangoes from its leaf using Convolutional Neural Network (CNN). This research is about to leaf analysis of mango and develop a system to identify the species of the specific mango species. Also this system can be implemented in a mobile application so that anyone can use the system easily for recognition the varieties of mango species. When anyone wants to buy a mango tree from a seller, the seller cannot fraud to him as he can detect the species.

1.6 Report Layout

Chapter-2 Contains the Preliminaries, Related work for development of the current system, Comparative Analysis and Summary, Scope of the Problem and Challenges of this research. Chapter-3 Presents the Proposed Methodology for our system. It includes s Research Subject and Instruments, Data Collection Procedure, Statistical Analysis, training and testing with various figures and diagrams that were used for designing and developing of this system. Chapter-4 contains Experimental Setup, Analysis the results of the research and a short discussion on it. Chapter-5 Contains impact on society, environment and ethical aspects of this research. Chapter-6 Contains future work that we want to develop and conclusion.

CHAPTER 2
BACKGROUND

2.1 Preliminaries

This research is based on image processing. At present various researches are available on this methodology. Now the technology has been improved extensively. Today Convolutional Neural Network (CNN) has become familiar to the researchers. Many research has been done using CNN. Object Detection, Face Detection, Disease Detection of plant from leaf/stem/root, Medical research, Flower Detection and various researches used CNN as a basic. Other technologies are also available for image recognition/ detection such as Support Vector Machine (SVM), Region Proposals (R-CNN, Fast R-CNN, Faster R-CNN), You Only Look Once (YOLO), Deep Convolutional neural networks (DCNN), Probabilistic Neural networks (PNN) etc.

2.2 Related Works

This research is about predict Mango species from leaves using Convolutional Neural Network. Different types of prediction research have been done in this field. There are some related researches given below

- Flower species recognition system using convolution neural networks and transfer learning [2].
- Automatic recognition of wild Flowers [3].
- Detecting Jute Plant Disease Using Image Processing and Machine Learning [4].
- Detection of potato diseases using image segmentation and multiclass support vector machine [5].
- Detection of Strawberry Flowers in Outdoor Field by Deep Neural Network [6].
- Flower classification via convolutional neural network [7].
- Prediction of Potato Disease from Leaves using Deep Convolution Neural Network towards a Digital Agricultural System [8].
- Multi-column deep neural networks for image classification [9].

- Recognition of Jute Diseases by Leaf Image Classification using Convolutional Neural Network [10].
- Image Recognition of Tea Leaf Diseases Based on Convolutional Neural Network [11].

These are some research paper related to our research. There the researchers use different types of methodologies and various algorithms to train their systems.

2.3 Comparative Analysis and Summary

In this below Table 2.3.1, a comparative analysis of some related researches is discussed. Also attached their accuracy of result in the research. Most of their validation accuracy were between 80% to 98%. After observing each of those paper we can give a portrayal about the entirety of their work. For the most part it has been seen from the literature that image processing strategies has been applied for the prediction of plant/ leaf/ flower/ disease. Where the learning capacity of Neural Network (NN) likewise contributes for the identical reason. As it seen from the review authors have significantly focused on the prediction of plant/ leaf/ flower/ disease etc. In this table, showed the first author's name, methodology, application areas and accuracy.

TABLE 2.3.1: REVIEW OF SOME RESEARCH USING SOFT COMPUTING METHODS

Authors	Methodology	Application area	Accuracy(%)
Md. Zahid Hasan et al.	Convolutional Neural Network (CNN)	Recognition of Jute Diseases by Leaf Image	96%
Kestrilia R. Prilianti et al.	Convolutional Neural Network (CNN)	Photosynthetic Pigments Prediction	82%
Ping Lin et al.	Region-based Convolutional Neural Network (R-CNN)	Detection of Strawberry Flowers in Outdoor Field	86%
Yuanyuan Liu et al.	DCNN and R-CNN	Flower classification	84.02%
Faiza Nuzhat Joyee et al.	Image processing technique	Jute stem disease detection	80%
Md.Al-Amin et al.	Deep Convolution Neural Network (DCCN)	Prediction of Potato Disease from Leaves	98.33%
Santanu Phadikar et al.	Genetic algorithm and rough theory	Identification of rice leaf disease	78%

2.4 Scope of the Problem

This research is going to classify the mango trees form their leaves using Convolutional Neural Network (CNN). Different types of mangoes are available in our country. Most of them are Fazlee, Langra, Khirshapat, Himsagar, Gopalbhog, Mohanbhog, Mishribhog, Khisanbogh, Bombai, Amropali, Harivanga etc. The leaves of these mango tress are in different shape and size. Suppose the leaves of Fazlee mango tree will not match to any leaves of other types of mango trees. This research will analyse this differences between the leaves and train our system to detect the distinguish between different categories of mango tress.

2.5 Challenges

The first challenge of this research is to collect the proper or accurate data set. Because most of the leaves of the mango trees of different varieties are look alike. Then train the data set with a proper system like CNN with the right platform. Identifying the correct species of mango tree depends on the valid data. Capturing of the image of leaves should be perfect, classify the leaves to the proper data set. Make the system more user friendly.

CHAPTER 3

PROPOSED METHODOLOGY

3.1 Research Subject and Instruments

This research is based on Deep Convolutional Neural Network (DCNN) to identify the classification of mango tress from their leaves. Deep Convolutional Neural Network is an advanced method of machine learning. As CNN is a method to perform on a huge amount of data set to train and validation properly. The important part of this research is data set and train the data set. For this purpose we need to build a system using CNN than can identify the species of mangoes. To build the system of this research we used the code in Python 3, and import some Libraries like keras,Input, Conv2D, Dense, Flatten, MaxPool2D, sklearn.metrics, confusion_matrix, matplotlib.pyplot as plt, keras.preprocessing.image import ImageDataGenerator, utils import plot_model, keras.layers import Activation, Add, BatchNormalization, Dropout, IPython.display import SVG etc.

Convolutional Neural Network (ConvNets/CNN) are a kind of Neural Networks that have tested very efficient in many areas such as image identification, classification, segmentation and also for other auto correlated data. The convolution is basically sliding a filter over the input. ConvNets have been effective in distinguishing faces, objects, diseases, and traffic signs separated from controlling vision in robots and automated systems. It is a directed procedure for image grouping/object identification. CNN scans for structures in an image. We need not offer features to keep an eye out to structures in CNN; CNN makes sense of how to isolate features without any other individual as it jumps deep.

In computer vision problems like picture classification, perhaps the greatest test is that the size of the information can be huge. Assume the above picture is of size 32*32*3 (width, height and depth) at that point the input dimension will be 3072.

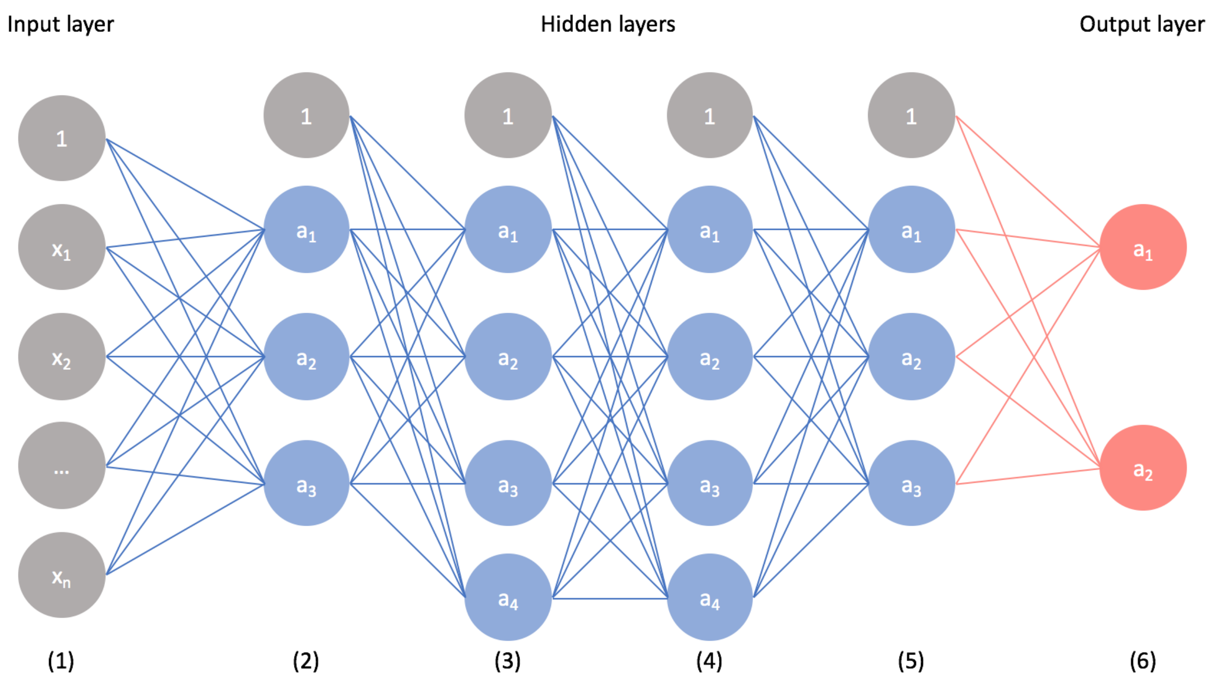

Figure 3.1.1 Convolutional Neural Network

3.2 Data Collection Procedure

For the research data collection is very important. Here we collect local data as image of mango leaves by capturing with camera. This pictures are collected from mango nursery.The data are in five classes and about 600. The five classes are Amropali, Fazlee, Khirshapat, Bombai and Harivanga as local name. The data set is divided into two categories,

- **Training data** are used to train the system.
- **Test data** are used to test the system for validation.

A brief information of selected classes: Amropali, Fazlee, Khirshapat, Bombai and Harivanga mango leaves is given below.

Khirshapat

Figure 3.2.1 shows the image of Khirshapat mango leaves.

Figure 3.2.1: Khirshapat mango leaves.

Harivanga

Figure 3.2.2 shows the image of Harivanga mango leaves.

Figure 3.2.2: Harivanga mango leaves.

Fazlee

Figure 3.2.3 shows the image of Fazlee mango leaves.

Figure 3.2.3: Fazlee mango leaves.

Bombai

Figure 3.2.4 shows the image of Bombai mango leaves.

Figure 3.2.4: Bombai mango leaves.

Amropali

Figure 3.2.5 shows the image of Amropali mango leaves.

Figure 3.2.5: Amropali mango leaves.

3.3 Statistical Analysis

Here we use image of mango leaves as our data set. In this research there are two categories of data as training data and test data each of having 5 classes: Amropali, Fazlee, Khirshapat, Bombai and Harivanga. The amount of training data is around 500 and the amount of the data is around 160. As the amount of overall data set is about 660.

3.4 Proposed Methodology

In this research we use Convolutional Neural Network (CNN) to build a system that can identify the classifications of mangoes from the leaves image. CNN has a great aspect in Machine Learning. The overall procedure is divided in some sub procedure. First of all, the important part of the procedure is to collect proper data set. Because the success of this research almost depends on the accurate data set. Below Figure 3.4.1 shows the overall procedure with a flowchart.

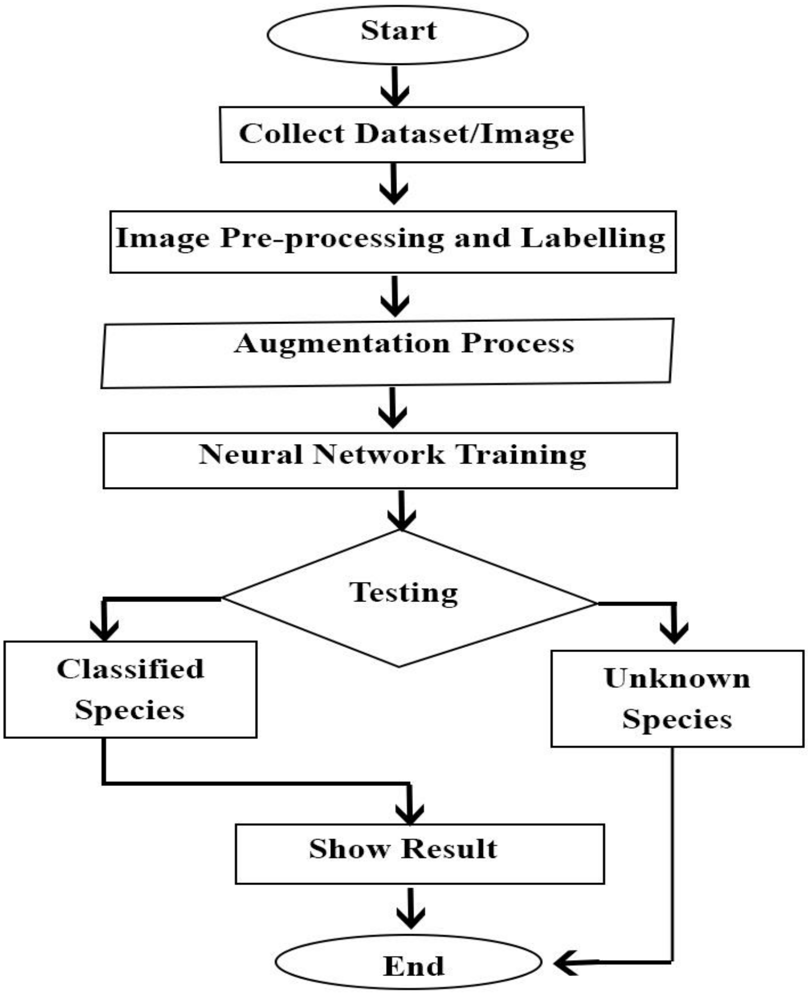

Figure 3.4.1: Flowchart of the Procedure

Image dataset Acquisition

Image dataset is physically take with a camera, improvement and divided pictures are applied, the pictures will at that point store in an organizer distinguishing the diverse class of mango species pictures and some obscure picture of leaves. The obtained picture dataset comprises of around 660 pictures of five distinct classes of mango species. Each picture is spared in the uncompressed JPG group utilizing RGB shading.

Image pre-processing and Labeling

In this research we used local data of images of mango leaves captured by camera. As the images are in different shapes, resolutions and sizes. To gain a good feature extraction, the ultimate images design to be usage as data for deep neural network classifier were pre-processed to touch constancy. We guaranteed that the pictures content all required information for feature learning. To obtain a better performance in classifying image by training in CNN we cropped and resized all the images into 256*256 (width*height) and same format. This will reduce the training time. Basically the training time is calculated in the Python script using Keras and TensorFlow framework.

For accurate dataset of images, we took the help of experienced people who work in a mango nursery and they were expert in mango species. Then we labeled all the images by appropriate species name of mango. Then removed the duplicated and unwanted images and also reduced noise of images from the dataset.

Augmentation

To increase dataset and neglect distortion we used augmentation which helps to reduce over fitting in the training procedure. In AI and insights over fitting happens when the measurable model describes arbitrary commotion or mistake instead of hidden relationship. Picture expansion comprises of some change procedures as relative change, point of view change and revolutions. Relative change used to communicate interpretation and turn. For this purpose, we rotate the image in several degrees.

Figure 3.4.2 shows the Augmentation process. Here we used Keras and Tensorflow library build in Python script. In Augmentation process various actions are performed such as rotation, height shift, width shift, rescale, shear, zoom, flip etc.

Figure 3.4.2: Augmentation Process

Neural Network Training

After the Augmentation transformation process is completed we have to train our Neural Network. To train the Neural Network there are several techniques/ Frameworks like Keras, TensorFlow, OpenCv, CaffeNet, cuDNN, Theano, Lua, Torch7 etc. These frameworks are very easy to install. Among them Keras and TensorFlow are very user-friendly to use them. To train Neural Network we have built a system using Keras and TensorFlow library in python script. The system is built in two platforms, at first in Google Colaboratory: here we have to upload our dataset in google drive and the mount google drive with google Colaboratory. Here we use CNN methodology, input_shape = (32,32,3), filters=32, kernel_size=(3, 3), padding="SAME", strides=(1, 1), filters=32, kernel_size=(3, 3), padding="SAME", strides=(1,1). So the above picture is of size 32*32*3 (width, height and depth) at that point the input dimension will be 3072. Then install Keras and TensorFlow in google Colaboratory and import the libraries that we need. We have run a python code in GUI interface connecting the dataset: training and test data, then run the system to train our Network. After that in the output there will be training result of the Network with training accuracy and training loss.

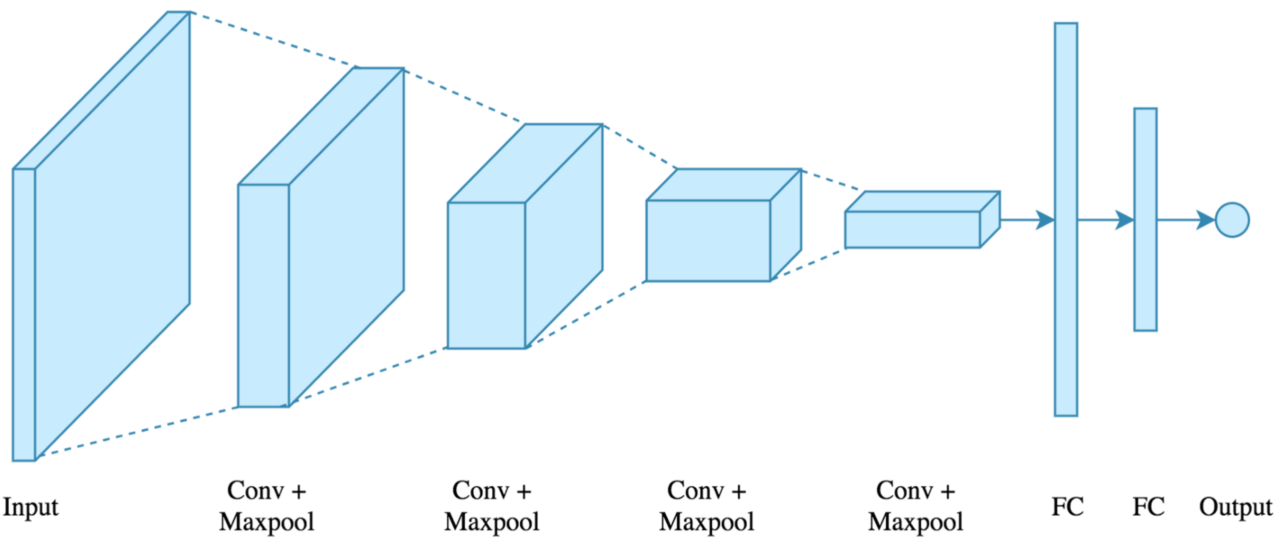

Figure 3.4.3: Convolutional Layers

Another platform is Anaconda 3. Here the procedure is same but it is in the local server of the computer. Jupiter notebook/Spider application is needed in this system to perform the training process.

CaffeNet is a Deep CNN that contains various layers that a little bit at a time register highlights from the info picture. Exceptionally the framework contains eight learning layers, five are convolutional and three are totally connected. The last layer changed and the yield of the Softmax layer defined to the need of this examination [12]. In the Softmax layer, arrangement process is occurred. In this system Sofmax layer classify the varieties mangoes from analysis the leaves.

Figure 3.4.4 shows the convolutional process with diagram.

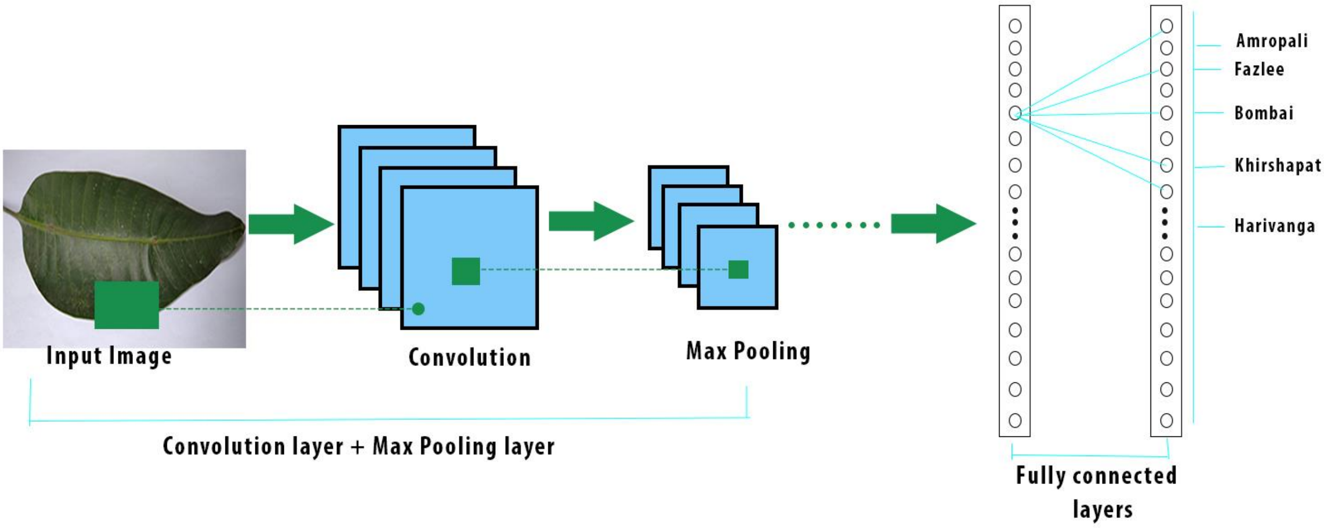

Figure 3.4.4: Convolutional Process

Rectified Liner Units (ReLU) is a combination and utilized as option for saturation nonlinearities. It upgrades the nonlinear properties of the decision capacity and Neural Network without influencing. Substantial field of the convolution layer. The actuation work in the long run learns the parameters of reconstruction and upgrade precision in extra-computational cost. The training is much impetuous using deep CNN with ReLU. This tactic is used for the output of every convolutional and fully connected layer.

The activation function is:

$$f(X_n)=\max(0, X_n)$$

Here, X_n stands for the input of the nonlinear activation function of on the nth channel.

In Convolutional Neural Network (CNN) Pooling is very important layer. It is a form of nonlinear down-inspecting. Max pooling is a nonlinear function that divides the input pictures into a set of non-overlapping rectangular and for all sub-region output is the highest. Pooling layer limits the overfitting. Unitedly ReLUs and dropout are more advantageous. Figure 3.4.4 shows the pooling process for 2*2 matrix.

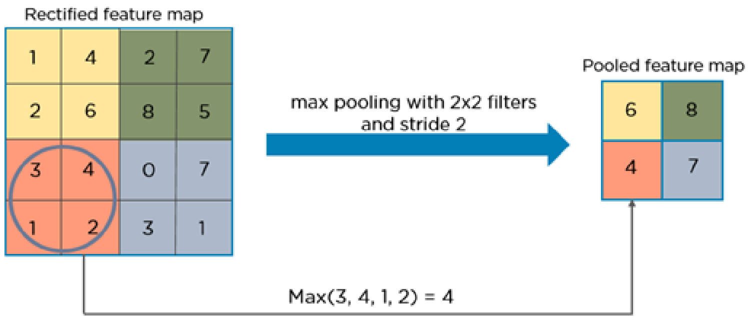

Figure 3.4.5: Pooling process

Testing

Testing is another vital part of this research. Test our system with texture feature extraction. The dataset was divided into two sub dataset, training dataset and test dataset. Among them around 75% were training data and around 25% were test data. We use Non-Maximum Suppression for Object Detection. NMS is a key post-handling step in various Computer vision applications. With respect to protest identification, it is utilized to change a delicate reaction map that triggers various estimated object window speculations in, ideally, a solitary bouncing box for each distinguished article. After training Neural Network, the training result is import to test operation. Finishing the test operation system gives output result with validation accuracy.

The output will be classified species of mangoes. Figure 3.4.6 shows the testing process of our model.

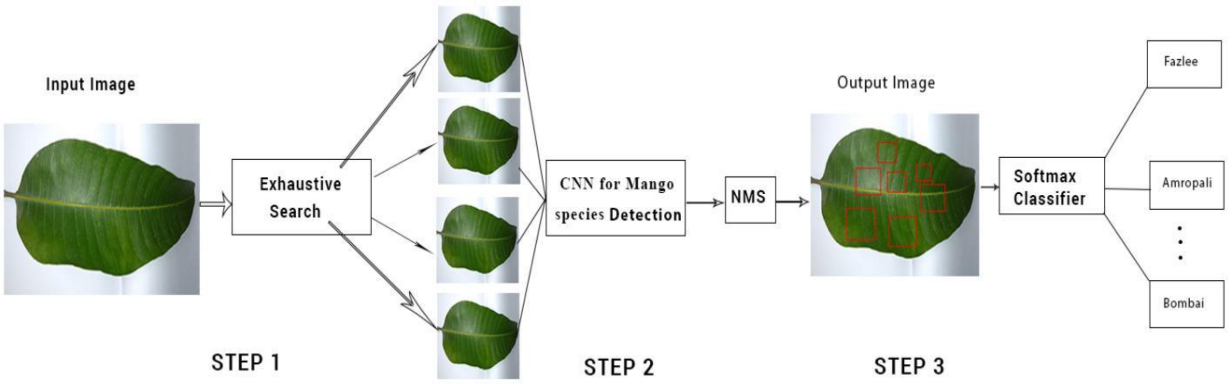

Figure 3.4.6: Testing process

CHAPTER 4

RESULT AND DISCUSSION

4.1 Experimental Setup

The dataset was around 660 pictures including 5 classifications of mango species leaves and among them 450 are ordered and 50 are in obscure class, the Neural Network Application Program Interface (API) was written in Python to be used for the CNN model application. All the pictures of dataset were utilized for preparing and testing process were taken from neighborhood pictures of mango leaves caught by camera. Information expansion procedures were performed into the application to improve the picture dataset by pivoting the pictures to 40 degrees, flipping, shearing and moving of pictures on a level plane and vertically. Adam enhancer is fused utilizing an absolute cross-entropy. Also minimized the learning rate to lr = 0.000001 using learning rate reduction tool. The model is trained for 40 epochs.

TABLE 4.1.1: IMAGES INTO DIFFERENT CLASSES

Classes	**Amount of Images**
Fazlee	130
Harivanga	110
Khirshapat	100
Amropali	60
Bombai	50
Unknown	50

4.2 Experimental Results & Analysis

We accomplished the assessment of this classification model by nine evaluation metrics. Samples of classified mango leaves and Unknown mango leaves are designated as the classified and the unknown class respectively.

- True Positive (TP): Accurately detected i.e. classified leaves are categorized as classified class.
- False Positive (FP): Inaccurately detected i.e. unknown leaves are categorized as classified class.
- True Negative (TN): Accurately rejected i.e. unknown leaves are categorized as unknown class.
- False Negative (FN): Inaccurately rejected i.e. classified leaves are categorized as unknown class.

Evaluation metrics are defined as follows:

- Accuracy = (TP + TN) / (TP + FN + FP+ TN)
- Sensitivity = TP / (TP + FN)
- Specificity = TN / (TN + FP)
- Precision = TP / (TP + FP)
- Negative Predictive Value = TN / (TN + FN)
- False Positive Rate = FP / (FP + TN)
- False Negative Rate = FN / (FN + TP)
- Error Rate = (FP + FN) / (TP + FN + FP+ TN)
- F1-Score = (2 * (Precision * Sensitivity)) / (Precision + Sensitivity)

We implement deep learning technique known as Deep Convolutional Neural Network (DCNN) for recognizing the species of mangoes from leaves. We have trained DCNN model for learning that it can identify the classified leaves with unknown leaves by implementation of the classification task. We have implemented python keras, TensorFlow libraries and executed to perform all the classification tasks.

Table 4.2.1 Confusion Matrix of Convolutional Neural Network

Deep Convolutional Neural Network (DCNN)			
Mango species		**Predicted Class**	
		Classified	**Unknown**
Actual Class	**Classified**	450 (True Positive)	50 (False Negative)
	Unknown	116 (False Positive)	50 (True Negative)

Accuracy = (TP+TN)/(TP+TN+FP+FN)

Accuracy rate of our System,

= (450+50)/666 = 0.75 * 100 = 75%

Error Rate = 100 – Accuracy

= 100 –75 = 25%

Accuracy is less than 60% that cannot be a proper solution to recognizing mango species. In our research, 75% training accuracy is acceptable scenario to observing this method.

Table 4.2.2 specifies the classification assessment of DCNN using evaluation metrics. DCNN has succeeded the accuracy 75% with the error rate of 25%. The sensitivity of 90% with the false negative rate of 10% and the specificity of 80% with the false positive rate of 30% have been achieved. The precision, negative predictive value and f1-score of CNN are 78%, 82% and 82% respectively. Figure. 4.2.3 plots the results of classification assessments.

TABLE 4.2.2 CLASSIFICATION PERFORMANCE ASSESSMENT OF DCNN

Evaluation Metrics	Convolutional Neural Network
Accuracy	0.75
Error Rate	0.25
Sensitivity	0.90
False Negative Rate	0.10
Specificity	0.80
False Positive Rate	0.30
Precision	0.78
Negative Predictive Value	0.82
F1-Score	0.82

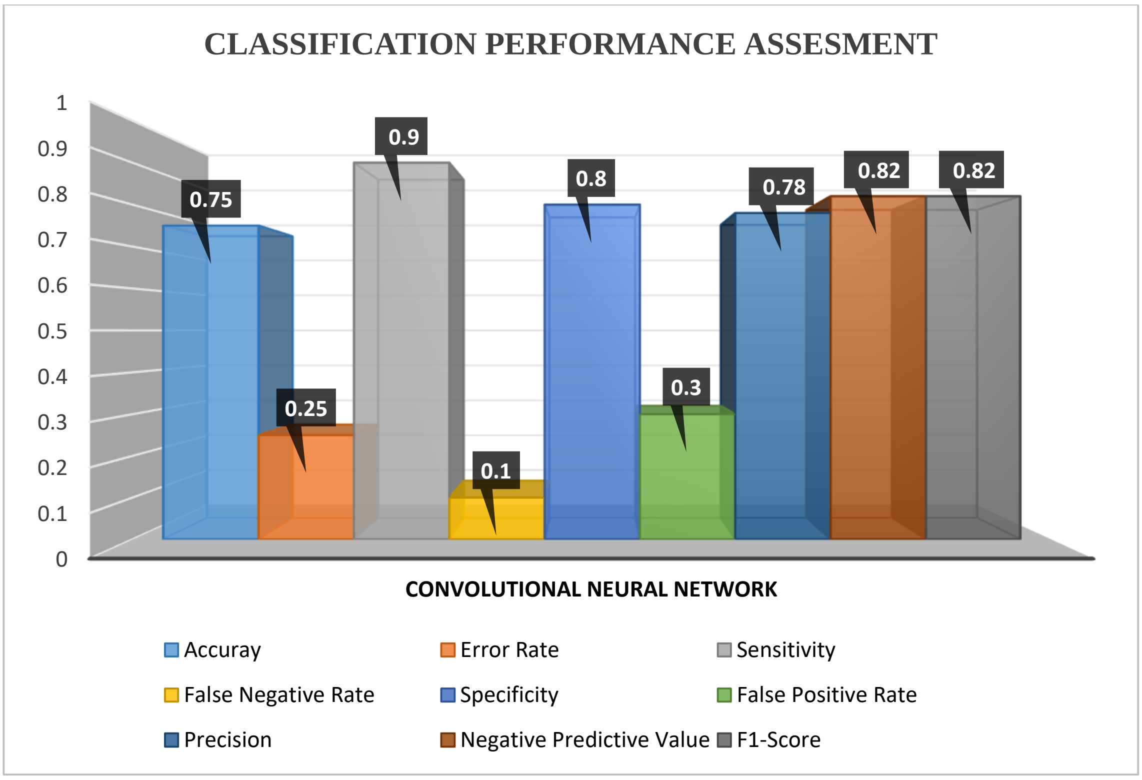

Figure 4.2.3: Output of Classification Performance Assessments Using CNN

We have performed 40 epochs to obtain training and validation accuracy. After 40 epochs we got training accuracy 75% and loss 25%.

Figure 4.2.4 is a snapshot of the output of the trained system.

```
                    validation_data=validation_generator,
                    validation_steps=20,
                    verbose=1,
                    callbacks=[learning_rate_reduction])

Epoch 1/40 21/20 [==============================] - 7s 342ms/step - loss: 0.4679 - acc: 0.6542- val_loss: 0.3679 - val_acc: 0.6842
Epoch 2/40 21/20 [==============================] - 7s 329ms/step - loss: 0.4665 - acc: 0.6542- val_loss: 0.3679 - val_acc: 0.6542
Epoch 3/40 21/20 [==============================] - 7s 325ms/step - loss: 0.4517 - acc: 0.6842- val_loss: 0.3679 - val_acc: 0.6857
Epoch 4/40 21/20 [==============================] - 7s 325ms/step - loss: 0.4332 - acc: 0.7157- val_loss: 0.3679 - val_acc: 0.6157
Epoch 00004: ReduceLROnPlateau reducing learning rate to 0.0004000000237487257.
Epoch 5/40 21/20 [==============================] - 7s 338ms/step - loss: 0.4379 - acc: 0.7557- val_loss: 0.3679 - val_acc: 0.6157
Epoch 6/40 21/20 [==============================] - 7s 326ms/step - loss: 0.4276 - acc: 0.7457- val_loss: 0.3579 - val_acc: 0.6557
Epoch 7/40 21/20 [==============================] - 7s 335ms/step - loss: 0.4376 - acc: 0.7157- val_loss: 0.3376 - val_acc: 0.6857
Epoch 00007: ReduceLROnPlateau reducing learning rate to 0.0002400000118743628.
Epoch 8/40 21/20 [==============================] - 7s 329ms/step - loss: 0.4409 - acc: 0.7057- val_loss: 0.3176 - val_acc: 0.7157
Epoch 9/40 21/20 [==============================] - 7s 330ms/step - loss: 0.4196 - acc: 0.6857- val_loss: 0.3196 - val_acc: 0.7257
Epoch 10/40 21/20 [==============================] - 7s 339ms/step - loss: 0.4303 - acc: 0.6557- val_loss: 0.2896 - val_acc: 0.7257
Epoch 00010: ReduceLROnPlateau reducing learning rate to 0.0001240000059371814.
Epoch 11/40 21/20 [==============================] - 7s 315ms/step - loss: 0.4272 - acc: 0.6557- val_loss: 0.2596 - val_acc: 0.7157
Epoch 12/40 21/20 [==============================] - 7s 320ms/step - loss: 0.4163 - acc: 0.6557- val_loss: 0.2196 - val_acc: 0.7057
Epoch 13/40 21/20 [==============================] - 7s 334ms/step - loss: 0.4061 - acc: 0.6557- val_loss: 0.2061 - val_acc: 0.6857
Epoch 00013: ReduceLROnPlateau reducing learning rate to 6.24000029685907e-05.
Epoch 14/40 21/20 [==============================] - 7s 330ms/step - loss: 0.4010 - acc: 0.6557- val_loss: 0.2010 - val_acc: 0.6657
Epoch 15/40 21/20 [==============================] - 7s 340ms/step - loss: 0.3288 - acc: 0.6557- val_loss: 0.1888 - val_acc: 0.6657
Epoch 16/40 21/20 [==============================] - 7s 316ms/step - loss: 0.3102 - acc: 0.6557- val_loss: 0.1588 - val_acc: 0.6857
Epoch 00016: ReduceLROnPlateau reducing learning rate to 3.124000148429535e-05.
Epoch 17/40 21/20 [==============================] - 7s 324ms/step - loss: 0.3100 - acc: 0.6557- val_loss: 0.1500 - val_acc: 0.6857
Epoch 18/40 21/20 [==============================] - 7s 325ms/step - loss: 0.2258 - acc: 0.6557- val_loss: 0.1458 - val_acc: 0.7157
Epoch 19/40 21/20 [==============================] - 7s 334ms/step - loss: 0.2200 - acc: 0.6557- val_loss: 0.1400 - val_acc: 0.7257
Epoch 00019: ReduceLROnPlateau reducing learning rate to 1.5624000742147677e-05.
Epoch 20/40 21/20 [==============================] - 7s 330ms/step - loss: 0.1440 - acc: 0.6557- val_loss: 0.1340 - val_acc: 0.7257
Epoch 21/40 21/20 [==============================] - 7s 317ms/step - loss: 0.1336 - acc: 0.6857- val_loss: 0.1336 - val_acc: 0.7357
Epoch 22/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1300 - acc: 0.6857- val_loss: 0.1300 - val_acc: 0.7257
Epoch 00022: ReduceLROnPlateau reducing learning rate to 7.812400371073838e-06.
Epoch 23/40 21/20 [==============================] - 7s 324ms/step - loss: 0.1231 - acc: 0.6857- val_loss: 0.1231 - val_acc: 0.7157
Epoch 24/40 21/20 [==============================] - 7s 326ms/step - loss: 0.1170 - acc: 0.6857- val_loss: 0.1170 - val_acc: 0.7157
Epoch 25/40 21/20 [==============================] - 7s 329ms/step - loss: 0.1105 - acc: 0.7257- val_loss: 0.1105 - val_acc: 0.7157
Epoch 00025: ReduceLROnPlateau reducing learning rate to 3.906240185536919e-06.
Epoch 26/40 21/20 [==============================] - 7s 321ms/step - loss: 0.1167 - acc: 0.6857- val_loss: 0.1167 - val_acc: 0.6857
Epoch 27/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1023 - acc: 0.6557- val_loss: 0.1023 - val_acc: 0.6857
Epoch 28/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1021 - acc: 0.6057- val_loss: 0.1021 - val_acc: 0.6757
Epoch 00028: ReduceLROnPlateau reducing learning rate to 1.9531240927684596e-06.
Epoch 29/40 21/20 [==============================] - 7s 330ms/step - loss: 0.1011 - acc: 0.5857- val_loss: 0.1011 - val_acc: 0.6557
Epoch 30/40 21/20 [==============================] - 7s 344ms/step - loss: 0.1057 - acc: 0.5557- val_loss: 0.1011 - val_acc: 0.6557
Epoch 31/40 21/20 [==============================] - 7s 311ms/step - loss: 0.1007 - acc: 0.5957- val_loss: 0.1007 - val_acc: 0.6657
Epoch 00031: ReduceLROnPlateau reducing learning rate to 1e-06.
Epoch 32/40 21/20 [==============================] - 7s 326ms/step - loss: 0.1007 - acc: 0.6257- val_loss: 0.1007 - val_acc: 0.6857
Epoch 33/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1007 - acc: 0.6857- val_loss: 0.1007 - val_acc: 0.6857
Epoch 34/40 21/20 [==============================] - 7s 330ms/step - loss: 0.1007 - acc: 0.7557- val_loss: 0.1007 - val_acc: 0.7457
Epoch 35/40 21/20 [==============================] - 7s 354ms/step - loss: 0.1007 - acc: 0.7557- val_loss: 0.1007 - val_acc: 0.7557
Epoch 36/40 21/20 [==============================] - 7s 319ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7557
Epoch 37/40 21/20 [==============================] - 7s 321ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7557
Epoch 38/40 21/20 [==============================] - 7s 334ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7557
Epoch 39/40 21/20 [==============================] - 7s 326ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7657
Epoch 40/40 21/20 [==============================] - 7s 334ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7657
```

Figure 4.2.4: Snapshot of output of the System

Figure 4.2.5 shows the graphical representation of training loss vs validation loss and training accuracy vs validation accuracy of our researched model. Here we can see the result of 40 epochs.

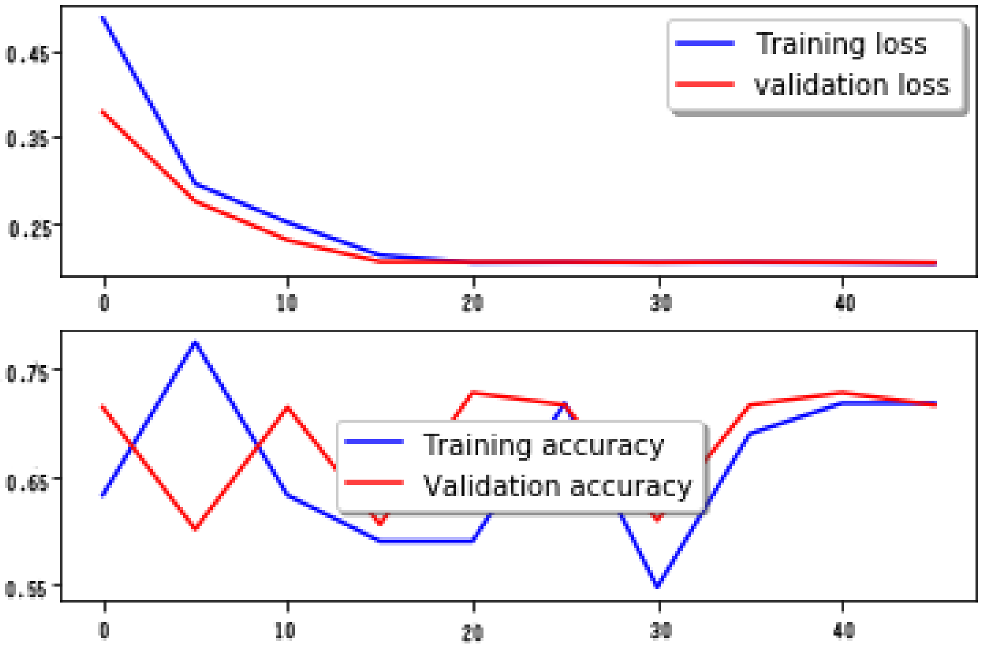

Figure 4.2.5: Graph of accuracy and loss

4.3 Discussion

We made a system with Google Colaboratory to train the Neural Network with our dataset. Different libraries are used here to run the system. Images were pre-processed and augmented to enrich our dataset in a view to get a perfect model. After training and testing performed we get training accuracy 75%. It is a good accuracy to perform the system after 40 epochs, any system is not perfect below 60% accuracy.

At last, contrasting our outcomes and different strategies for object location from leaf pictures, it very well may be said that our technique gives great outcomes and exactness.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT AND ETHICAL ASPECTS

5.1 Impact on Society

This research will impact a lot on the society. This research identifies the species of mangoes. It will be very easy to recognize the type of mango tree while buying it from the market or nursery. Then we can choose the desired mango tree and maintain the recommended environment for the tree. Following these we can cultivate more mangoes than before. After fulfill the demand of our country we can export mangoes to abroad and earn foreign currency. It may reduce unemployment problem of our country and enrich our economy.

5.2 Impact on Environment

Our research has no detrimental impact on the environment. Our system is very eco-friendly. There is no harmful technique used in this system. We only take the picture of the mango tree and detect the species of the tree. Also recommend the desired environment for the specific mango species so that the farmer can cultivate more mangoes.

5.3 Ethical Aspects

Using this system, a buyer can identify the species of mango tree before buying the mango tree. As a result, any seller cannot cheat the buyers. We have maintained honesty, integrity, objectivity and legality in our research. The dataset was prepared carefully. So that that the ethical aspects will be improved of our research.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 Future Work

Object Detection is a very interesting topic in Machine Learning. This research is about to classify mango species using Convolutional Neural Network (CNN) from the mango leaves. We have used five categories of mango species for our research. But in our country several numbers of mango species are cultivated. In future, those types of mango species can be including in this research. Also there should be a mobile application implemented that can make it easier to use the system for our people. For making this research more user friendly, the application should be in both English and Bangla language. It will be free to use for our people. So that we can cultivate specific mangoes in recommended weather and the production of mangoes increase to fulfill the country's need and can be exported to countries and earn foreign currency. Again we have to enrich out dataset with a view to obtain a better result with training and validation accuracy.

6.2 Conclusion

We have used five categories of mango species for our research. But in our country several numbers of mango species are cultivated. In future, those types of mango species can be including in this research. Also there should be a mobile application implemented that can make it easier to use the system for our people. For making this research more user friendly, the application should be in both English and Bangla language. It will be free to use for our people. So that we can cultivate specific mangoes in recommended weather and the production of mangoes increase to fulfill the country's need and can be exported to countries and earn foreign currency. Again we have to enrich out dataset with a view to obtain a better result with training and validation accuracy.

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MANGO SPECIES PREDICTION FROM LEAF USING CONVOLUTIONAL NEURAL NETWORK

BY

MD. ARIFUL ISLAM

ID: 192-25-789

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

Supervised By

SHAH MD. TANVIR SIDDIQUEE

Assistant Professor

Department of CSE

Daffodil International University

DAFFODIL INTERNATIONAL UNIVERSITY

DHAKA, BANGLADESH

09 JULY 2020

APPROVAL

This thesis titled **"Mango Species Prediction From Leaf Using Convolutional Neural Network"**, submitted by Md. Ariful Islam, ID No: 192-25-789 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of M.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 20/06/2020.

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ABSTRACT

Convolutional Neural Network (CNN) is a vast area of researches in Machine Learning. Various types of researches are using Artificial Intelligence (AI) in agricultural fields, medical sectors for detecting diseases. This research is going to recognize mango species from the image of mango leaves. The most recent age of convolutional neural systems (CNNs) has gained exceptional outcomes in the field of picture grouping. This examination is connected with another way to deal with the improvement of mango species identification model, in view of leaf picture arrangement, by utilizing Deep convolutional neural systems (DCNN). We use DCNN for classification of mango species and detect them. Here we use images of mango leaves as our dataset. We have five classes and about 600 images as dataset. After classifying we train and test our system using Convolutional Neural Network (CNN). The accuracy of our system to detect mango species is 75%. It should be improved in further research.

CHAPTRER 1

INTRODUCTION

1.1 Introduction

Mangifera indica, generally known as mango, is local to the Indian subcontinent where it is homespun. Several numbers of cultivated varieties have been introduced to other warm regions of the world. Various types of mangoes are available in our country such as Fazlee, Langra, Khirshapat, Himsagar, Gopalbhog, Mohanbhog, Mishribhog, Khisanbogh, Bombai, Amropali, Harivanga etc. All of us are not familiar of these varieties. But our people loves mango a lot. The taste of different species of mangoes differs from each other. Also the leaves of different mango species differ from each other. This research is to identify the species of mango from the image of the leaf. In this modern era, most of the people are used to modern technology. In this purpose the can use their smartphone to identify the species of mango. This research is based on Convolutional Neural Network (CNN), Image recognition methodology. Image recognition is a technique to identify any object from the image. CNN is used to train the whole system. Deep learning establishes an ongoing, modern procedure for image processing and data analysis, with exact outcomes and enormous potential. As Deep learning has been effectively applied in different areas, it has as of late entered likewise the space of agriculture. So we will apply deep learning to make an algorithm for mechanized identification and grouping of plant leaf by species. In present, Convolutional Neural Networks are considered as the main strategy for object detection. There are various methods for image identification, some of them are Image Processing techniques, Machine Learning, Support Vector Machine (SVM), Region Proposals (R-CNN, Fast R-CNN, Faster R-CNN), You Only Look Once (YOLO), Deep convolutional neural networks (CNN), Probabilistic Neural networks (PNN) etc. For our research Deep convolutional neural networks (CNN) is more applicable. We train the system using CNN and obtain training accuracy then test the system and obtain validation accuracy. This research is a classification of the mango species. The research will be very beneficial for people in real life application and also very helpful for the farmers who cultivate mangoes, who wants to learn about classification of mango species and who buy mango trees from the market. Also this system is very user friendly.

1.2 Motivation

Mango a fruit, broadly cultivated in the tropical and subtropical nations of the world. As indicated by FAO (Food and Agriculture Organization), in the course of the most recent 18 years the quick creation of mango has been the most noteworthy in Bangladesh. The creation has expanded by 16 percent for every year and the per head fulfillment multiplied in the course of the most recent 10 years.

Around 2.4 million tonnes of mangoes were cultivated in 2017-18 [1]..

But most of the people do not know all the varieties of mango available in our country. Now-a-days technology is strong enough to identify the varieties of mango. This research will build a system so that anyone can identify the species of mango from its leaf. In many areas, specific types of mango cultivate widely. This research will help the people to choose the expected species of mango for their areas, gradually it will improve the cultivation of mangoes.

1.3 Rationale of the Study

Mango species detection using Deep Learning for how to detect mango species by capturing the picture of its leaf using a smartphone for recognizing several species of mangoes. Deep Learning is a propelled strategy for Machine Learning that utilizes Neural Networks. In this research Convolutional Neural Network (CNN) is used to train the system. There are several numbers of mango species are cultivated in this country. But people cannot distinguish between them from seeing the plants. This study will help us to detect the varieties of species by diagnosing the leaves of mango trees. Also recommend the areas that are best for the specific species of mango to cultivate.

1.4 Research Question

- Can technology build a system that identify the species of mango from its leaf?
- How useful it would be for the people if they can identify the varieties of mango using technology?

1.5 Expected Outcome

In this modern civilization, technology is developing rapidly. This research emphasis on species detection of mangoes from its leaf using Convolutional Neural Network (CNN). This research is about to leaf analysis of mango and develop a system to identify the species of the specific mango species. Also this system can be implemented in a mobile application so that anyone can use the system easily for recognition the varieties of mango species. When anyone wants to buy a mango tree from a seller, the seller cannot fraud to him as he can detect the species.

1.6 Report Layout

Chapter-2 Contains the Preliminaries, Related work for development of the current system, Comparative Analysis and Summary, Scope of the Problem and Challenges of this research. Chapter-3 Presents the Proposed Methodology for our system. It includes s Research Subject and Instruments, Data Collection Procedure, Statistical Analysis, training and testing with various figures and diagrams that were used for designing and developing of this system. Chapter-4 contains Experimental Setup, Analysis the results of the research and a short discussion on it. Chapter-5 Contains impact on society, environment and ethical aspects of this research. Chapter-6 Contains future work that we want to develop and conclusion.

CHAPTER 2
BACKGROUND

2.1 Preliminaries

This research is based on image processing. At present various researches are available on this methodology. Now the technology has been improved extensively. Today Convolutional Neural Network (CNN) has become familiar to the researchers. Many research has been done using CNN. Object Detection, Face Detection, Disease Detection of plant from leaf/stem/root, Medical research, Flower Detection and various researches used CNN as a basic. Other technologies are also available for image recognition/ detection such as Support Vector Machine (SVM), Region Proposals (R-CNN, Fast R-CNN, Faster R-CNN), You Only Look Once (YOLO), Deep Convolutional neural networks (DCNN), Probabilistic Neural networks (PNN) etc.

2.2 Related Works

This research is about predict Mango species from leaves using Convolutional Neural Network. Different types of prediction research have been done in this field. There are some related researches given below

- Flower species recognition system using convolution neural networks and transfer learning [2].
- Automatic recognition of wild Flowers [3].
- Detecting Jute Plant Disease Using Image Processing and Machine Learning [4].
- Detection of potato diseases using image segmentation and multiclass support vector machine [5].
- Detection of Strawberry Flowers in Outdoor Field by Deep Neural Network [6].
- Flower classification via convolutional neural network [7].
- Prediction of Potato Disease from Leaves using Deep Convolution Neural Network towards a Digital Agricultural System [8].

- Multi-column deep neural networks for image classification [9].

These are some research paper related to our research. There the researchers use different types of methodologies and various algorithms to train their systems.

2.3 Comparative Analysis and Summary

In this below Table 2.3.1, a comparative analysis of some related researches is discussed. Also attached their accuracy of result in the research. Most of their validation accuracy were between 80% to 98%. After observing each of those paper we can give a portrayal about the entirety of their work. For the most part it has been seen from the literature that image processing strategies has been applied for the prediction of plant/ leaf/ flower/ disease. Where the learning capacity of Neural Network (NN) likewise contributes for the identical reason. As it seen from the review authors have significantly focused on the prediction of plant/ leaf/ flower/ disease etc. In this table, showed the first author's name, methodology, application areas and accuracy.

TABLE 2.3.1: REVIEW OF SOME RESEARCH USING SOFT COMPUTING METHODS

Authors	Methodology	Application area	Accuracy(%)
Md. Zahid Hasan et al.	Convolutional Neural Network (CNN)	Recognition of Jute Diseases by Leaf Image	96%
Kestrilia R. Prilianti et al.	Convolutional Neural Network (CNN)	Photosynthetic Pigments Prediction	82%
Ping Lin et al.	Region-based Convolutional Neural Network (R-CNN)	Detection of Strawberry Flowers in Outdoor Field	86%
Yuanyuan Liu et al.	DCNN and R-CNN	Flower classification	84.02%
Faiza Nuzhat Joyee et al.	Image processing technique	Jute stem disease detection	80%
Md.Al-Amin et al.	Deep Convolution Neural Network (DCCN)	Prediction of Potato Disease from Leaves	98.33%
Santanu Phadikar et al.	Genetic algorithm and rough theory	Identification of rice leaf disease	78%

2.4 Scope of the Problem

This research is going to classify the mango trees form their leaves using Convolutional Neural Network (CNN). Different types of mangoes are available in our country. Most of them are Fazlee, Langra, Khirshapat, Himsagar, Gopalbhog, Mohanbhog, Mishribhog, Khisanbogh, Bombai, Amropali, Harivanga etc. The leaves of these mango tress are in different shape and size. Suppose the leaves of Fazlee mango tree will not match to any leaves of other types of mango trees. This research will analyse this differences between the leaves and train our system to detect the distinguish between different categories of mango tress.

2.5 Challenges

The first challenge of this research is to collect the proper or accurate data set. Because most of the leaves of the mango trees of different varieties are look alike. Then train the data set with a proper system like CNN with the right platform. Identifying the correct species of mango tree depends on the valid data. Capturing of the image of leaves should be perfect, classify the leaves to the proper data set. Make the system more user friendly.

CHAPTER 3

PROPOSED METHODOLOGY

3.1 Research Subject and Instruments

This research is based on Deep Convolutional Neural Network (DCNN) to identify the classification of mango tress from their leaves. Deep Convolutional Neural Network is an advanced method of machine learning. As CNN is a method to perform on a huge amount of data set to train and validation properly. The important part of this research is data set and train the data set. For this purpose we need to build a system using CNN than can identify the species of mangoes. To build the system of this research we used the code in Python 3, and import some Libraries like keras,Input, Conv2D, Dense, Flatten, MaxPool2D, sklearn.metrics, confusion_matrix, matplotlib.pyplot as plt, keras.preprocessing.image import ImageDataGenerator, utils import plot_model, keras.layers import Activation, Add, BatchNormalization, Dropout, IPython.display import SVG etc.

Convolutional Neural Network (ConvNets/CNN) are a kind of Neural Networks that have tested very efficient in many areas such as image identification, classification, segmentation and also for other auto correlated data. The convolution is basically sliding a filter over the input. ConvNets have been effective in distinguishing faces, objects, diseases, and traffic signs separated from controlling vision in robots and automated systems. It is a directed procedure for image grouping/object identification. CNN scans for structures in an image. We need not offer features to keep an eye out to structures in CNN; CNN makes sense of how to isolate features without any other individual as it jumps deep.

In computer vision problems like picture classification, perhaps the greatest test is that the size of the information can be huge. Assume the above picture is of size 32*32*3 (width, height and depth) at that point the input dimension will be 3072.

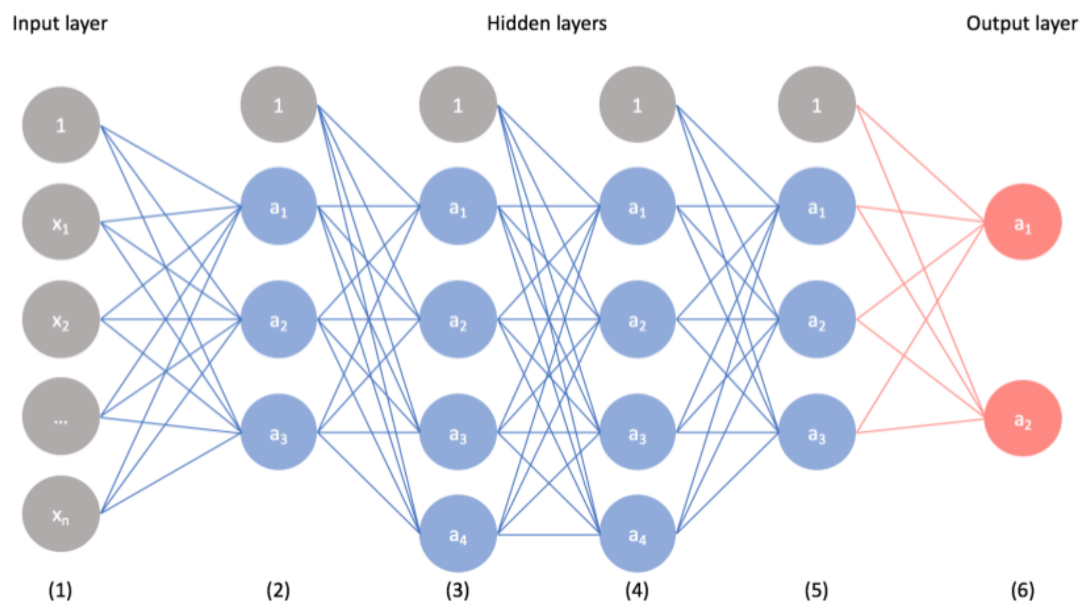

Figure 3.1.1 Convolutional Neural Network

3.2 Data Collection Procedure

For the research data collection is very important. Here we collect local data as image of mango leaves by capturing with camera. This pictures are collected from mango nursery.The data are in five classes and about 600. The five classes are Amropali, Fazlee, Khirshapat, Bombai and Harivanga as local name. The data set is divided into two categories,

- **Training data** are used to train the system.
- **Test data** are used to test the system for validation.

A brief information of selected classes: Amropali, Fazlee, Khirshapat, Bombai and Harivanga mango leaves is given below.

Khirshapat

Figure 3.2.1 shows the image of Khirshapat mango leaves.

Figure 3.2.1: Khirshapat mango leaves.

Harivanga

Figure 3.2.2 shows the image of Harivanga mango leaves.

Figure 3.2.2: Harivanga mango leaves.

Fazlee

Figure 3.2.3 shows the image of Fazlee mango leaves.

Figure 3.2.3: Fazlee mango leaves.

Bombai

Figure 3.2.4 shows the image of Bombai mango leaves.

Figure 3.2.4: Bombai mango leaves.

Amropali

Figure 3.2.5 shows the image of Amropali mango leaves.

Figure 3.2.5: Amropali mango leaves.

3.3 Statistical Analysis

Here we use image of mango leaves as our data set. In this research there are two categories of data as training data and test data each of having 5 classes: Amropali, Fazlee, Khirshapat, Bombai and Harivanga. The amount of training data is around 500 and the amount of the data is around 160. As the amount of overall data set is about 660.

3.4 Proposed Methodology

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In this research we use Convolutional Neural Network (CNN) to build a system that can identify the classifications of mangoes from the leaves image. CNN has a great aspect in Machine Learning. The overall procedure is divided in some sub procedure. First of all, the important part of the procedure is to collect proper data set. Because the success of this research almost depends on the accurate data set. Below Figure 3.4.1 shows the overall procedure with a flowchart.

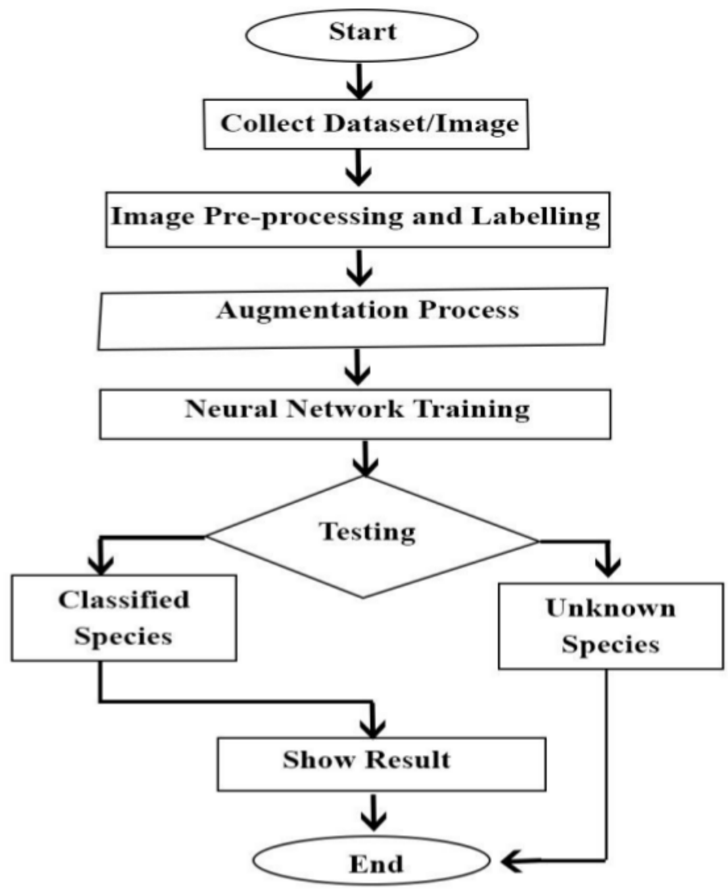

Figure 3.4.1: Flowchart of the Procedure

Image dataset Acquisition

Image dataset is physically take with a camera, improvement and divided pictures are applied, the pictures will at that point store in an organizer distinguishing the diverse class of mango species pictures and some obscure picture of leaves. The obtained picture dataset comprises of around 660 pictures of five distinct classes of mango species. Each picture is spared in the uncompressed JPG group utilizing RGB shading.

Image pre-processing and Labeling

In this research we used local data of images of mango leaves captured by camera. As the images are in different shapes, resolutions and sizes. To gain a good feature extraction, the ultimate images design to be usage as data for deep neural network classifier were pre-processed to touch constancy. We guaranteed that the pictures content all required information for feature learning. To obtain a better performance in classifying image by training in CNN we cropped and resized all the images into 256*256 (width*height) and same format. This will reduce the training time. Basically the training time is calculated in the Python script using Keras and TensorFlow framework.

For accurate dataset of images, we took the help of experienced people who work in a mango nursery and they were expert in mango species. Then we labeled all the images by appropriate species name of mango. Then removed the duplicated and unwanted images and also reduced noise of images from the dataset.

Augmentation

To increase dataset and neglect distortion we used augmentation which helps to reduce over fitting in the training procedure. In AI and insights over fitting happens when the measurable model describes arbitrary commotion or mistake instead of hidden relationship. Picture expansion comprises of some change procedures as relative change, point of view change and revolutions. Relative change used to communicate interpretation and turn. For this purpose, we rotate the image in several degrees.

Figure 3.4.2 shows the Augmentation process. Here we used Keras and Tensorflow library build in Python script. In Augmentation process various actions are performed such as rotation, height shift, width shift, rescale, shear, zoom, flip etc.

Figure 3.4.2: Augmentation Process

Neural Network Training

After the Augmentation transformation process is completed we have to train our Neural Network. To train the Neural Network there are several techniques/ Frameworks like Keras, TensorFlow, OpenCv, CaffeNet, cuDNN, Theano, Lua, Torch7 etc. These frameworks are very easy to install. Among them Keras and TensorFlow are very user-friendly to use them. To train Neural Network we have built a system using Keras and TensorFlow library in python script. The system is built in two platforms, at first in Google Colaboratory: here we have to upload our dataset in google drive and the mount google drive with google Colaboratory. Here we use CNN methodology, input_shape = (32,32,3), filters=32, kernel_size=(3, 3), padding="SAME", strides=(1, 1), filters=32, kernel_size=(3, 3), padding="SAME", strides=(1,1). So the above picture is of size 32*32*3 (width, height and depth) at that point the input dimension will be 3072. Then install Keras and TensorFlow in google Colaboratory and import the libraries that we need. We have run a python code in GUI interface connecting the dataset: training and test data, then run the system to train our Network. After that in the output there will be training result of the Network with training accuracy and training loss.

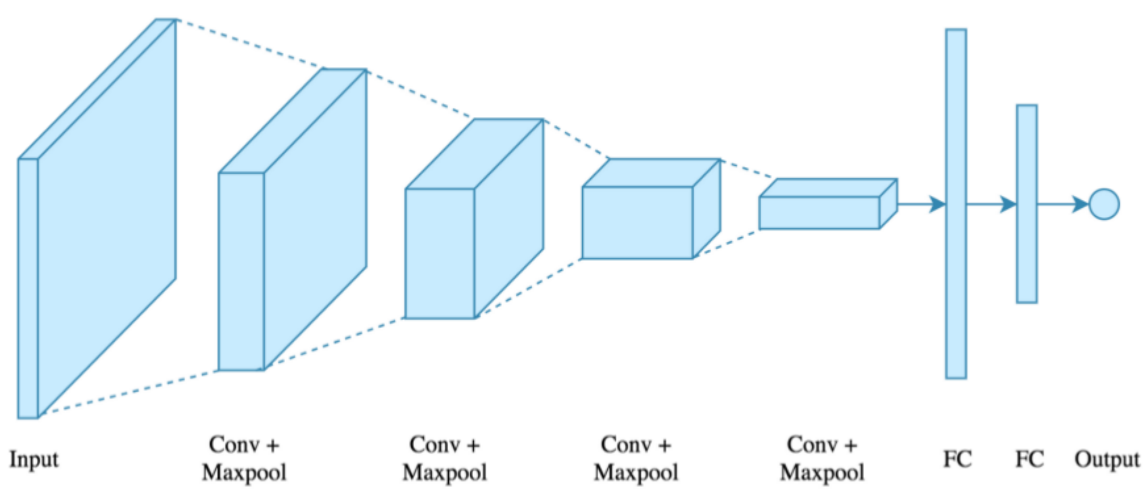

Figure 3.4.3: Convolutional Layers

Another platform is Anaconda 3. Here the procedure is same but it is in the local server of the computer. Jupiter notebook/Spider application is needed in this system to perform the training process.

CaffeNet is a Deep CNN that contains various layers that a little bit at a time register highlights from the info picture. Exceptionally the framework contains eight learning layers, five are convolutional and three are totally connected. The last layer changed and the yield of the Softmax layer defined to the need of this examination. In the Softmax layer, arrangement process is occurred. In this system Sofmax layer classify the varieties mangoes from analysis the leaves.

Figure 3.4.4 shows the convolutional process with diagram.

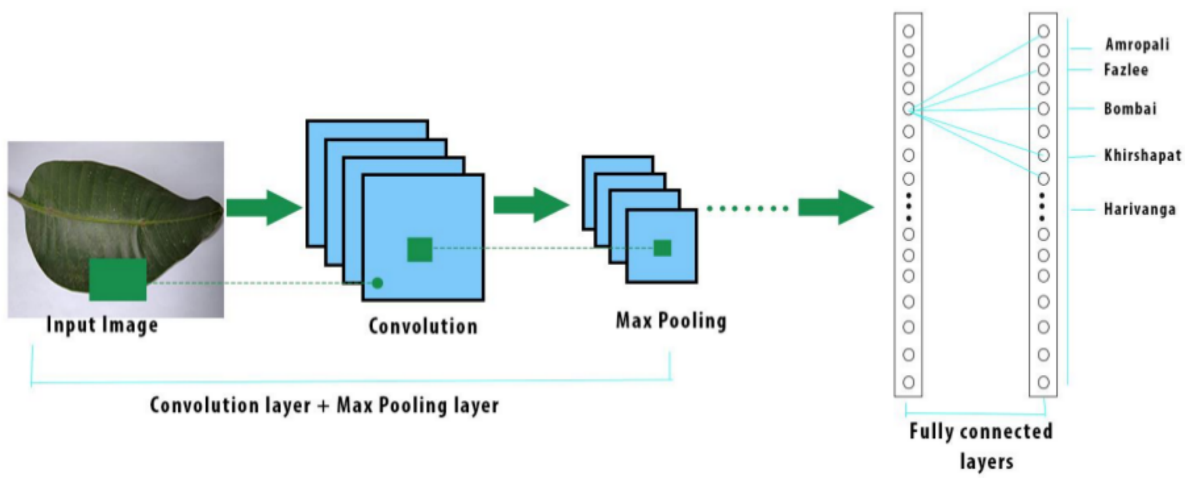

Figure 3.4.4: Convolutional Process

Rectified Liner Units (ReLU) is a combination and utilized as option for saturation nonlinearities. It upgrades the nonlinear properties of the decision capacity and Neural Network without influencing. Substantial field of the convolution layer. The actuation work in the long run learns the parameters of reconstruction and upgrade precision in extra-computational cost. The training is much impetuous using deep CNN with ReLU. This tactic is used for the output of every convolutional and fully connected layer.

The activation function is:

$$f(X_n)=\max(0, X_n)$$

Here, X_n stands for the input of the nonlinear activation function of on the nth channel.

In Convolutional Neural Network (CNN) Pooling is very important layer. It is a form of nonlinear down-inspecting. Max pooling is a nonlinear function that divides the input pictures into a set of non-overlapping rectangular and for all sub-region output is the highest. Pooling layer limits the overfitting. Unitedly ReLUs and dropout are more advantageous. Figure 3.4.4 shows the pooling process for 2*2 matrix.

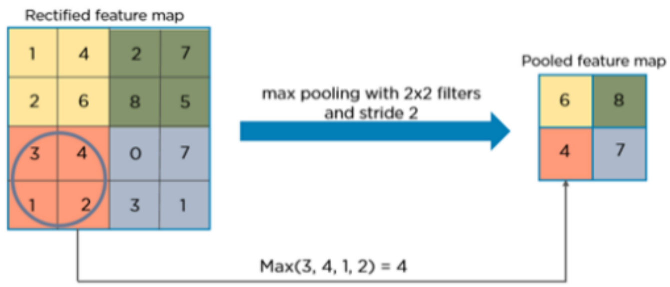

Figure 3.4.5: Pooling process

Testing

Testing is another vital part of this research. Test our system with texture feature extraction. The dataset was divided into two sub dataset, training dataset and test dataset. Among them around 75% were training data and around 25% were test data. We use Non-Maximum Suppression for Object Detection. NMS is a key post-handling step in various Computer vision applications. With respect to protest identification, it is utilized to change a delicate reaction map that triggers various estimated object window speculations in, ideally, a solitary bouncing box for each distinguished article. After training Neural Network, the training result is import to test operation. Finishing the test operation system gives output result with validation accuracy.

The output will be classified species of mangoes. Figure 3.4.6 shows the testing process of our model.

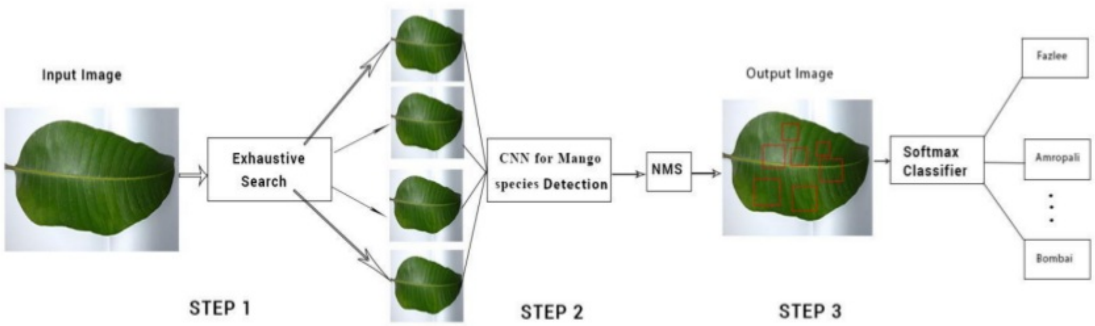

Figure 3.4.6: Testing process

CHAPTER 4

RESULT AND DISCUSSION

4.1 Experimental Setup

The dataset was around 660 pictures including 5 classifications of mango species leaves and among them 450 are ordered and 50 are in obscure class, the Neural Network Application Program Interface (API) was written in Python to be used for the CNN model application. All the pictures of dataset were utilized for preparing and testing process were taken from neighborhood pictures of mango leaves caught by camera. Information expansion procedures were performed into the application to improve the picture dataset by pivoting the pictures to 40 degrees, flipping, shearing and moving of pictures on a level plane and vertically. Adam enhancer is fused utilizing an absolute cross-entropy. Also minimized the learning rate to lr = 0.000001 using learning rate reduction tool. The model is trained for 40 epochs.

TABLE 4.1.1: IMAGES INTO DIFFERENT CLASSES

Classes	Amount of Images
Fazlee	130
Harivanga	110
Khirshapat	100
Amropali	60
Bombai	50
Unknown	50

4.2 Experimental Results & Analysis

We accomplished the assessment of this classification model by nine evaluation metrics. Samples of classified mango leaves and Unknown mango leaves are designated as the classified and the unknown class respectively.

We implement deep learning technique known as Deep Convolutional Neural Network (DCNN) for recognizing the species of mangoes from leaves. We have trained DCNN model for learning that it can identify the classified leaves with unknown leaves by implementation of the classification task. We have implemented python keras, TensorFlow libraries and executed to perform all the classification tasks.

TABLE 4.2.1 CONFUSION MATRIX OF CONVOLUTIONAL NEURAL NETWORK

Deep Convolutional Neural Network (DCNN)			
Mango species		**Predicted Class**	
		Classified	**Unknown**
Actual Class	**Classified**	450 (True Positive)	50 (False Negative)
	Unknown	116 (False Positive)	50 (True Negative)

Accuracy = (TP+TN)/(TP+TN+FP+FN)

Accuracy rate of our System,

= (450+50)/666 = 0.75 * 100 = 75%

Error Rate = 100 – Accuracy

= 100 –75 = 25%

Accuracy is less than 60% that cannot be a proper solution to recognizing mango species. In our research, 75% training accuracy is acceptable scenario to observing this method.

Table 4.2.2 specifies the classification assessment of DCNN using evaluation metrics. DCNN has succeeded the accuracy 75% with the error rate of 25%. The sensitivity of 90% with the false negative rate of 10% and the specificity of 80% with the false positive rate of 30% have been achieved. The precision, negative predictive value and f1-score of CNN are 78%, 82% and 82% respectively. Figure. 4.2.3 plots the results of classification assessments.

TABLE 4.2.2 CLASSIFICATION PERFORMANCE ASSESSMENT OF DCNN

Evaluation Metrics	**Convolutional Neural Network**
Accuracy	0.75
Error Rate	0.25
Sensitivity	0.90
False Negative Rate	0.10
Specificity	0.80
False Positive Rate	0.30
Precision	0.78
Negative Predictive Value	0.82
F1-Score	0.82

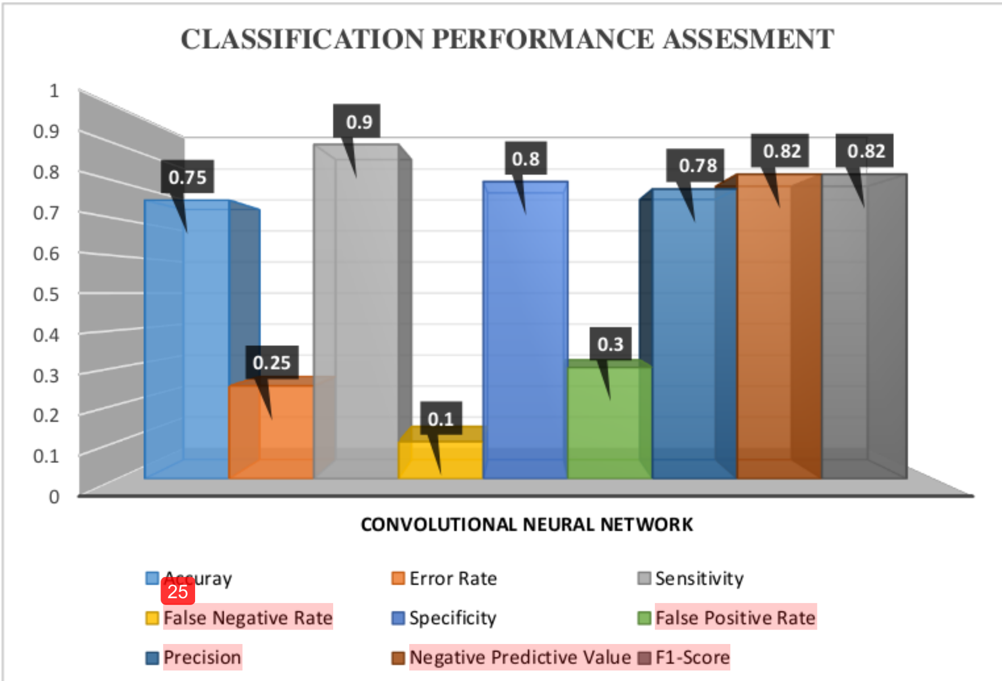

Figure 4.2.3: Output of Classification Performance Assessments Using CNN

We have performed 40 epochs to obtain training and validation accuracy. After 40 epochs we got training accuracy 75% and loss 25%.

Figure 4.2.4 is a snapshot of the output of the trained system.

```
                    validation_data=validation_generator,
                    validation_steps=20,
                    verbose=1,
                    callbacks=[learning_rate_reduction])
```

```
Epoch 1/40 21/20 [==============================] - 7s 342ms/step - loss: 0.4679 - acc: 0.6542- val_loss: 0.3679 - val_acc: 0.6842
Epoch 2/40 21/20 [==============================] - 7s 329ms/step - loss: 0.4665 - acc: 0.6542- val_loss: 0.3679 - val_acc: 0.6542
Epoch 3/40 21/20 [==============================] - 7s 325ms/step - loss: 0.4517 - acc: 0.6842- val_loss: 0.3679 - val_acc: 0.6857
Epoch 4/40 21/20 [==============================] - 7s 325ms/step - loss: 0.4332 - acc: 0.7157- val_loss: 0.3679 - val_acc: 0.6157
Epoch 00004: ReduceLROnPlateau reducing learning rate to 0.0004000000237487257.
Epoch 5/40 21/20 [==============================] - 7s 338ms/step - loss: 0.4379 - acc: 0.7557- val_loss: 0.3679 - val_acc: 0.6157
Epoch 6/40 21/20 [==============================] - 7s 326ms/step - loss: 0.4276 - acc: 0.7457- val_loss: 0.3579 - val_acc: 0.6557
Epoch 7/40 21/20 [==============================] - 7s 335ms/step - loss: 0.4376 - acc: 0.7157- val_loss: 0.3376 - val_acc: 0.6857
Epoch 00007: ReduceLROnPlateau reducing learning rate to 0.0002400000118743628.
Epoch 8/40 21/20 [==============================] - 7s 329ms/step - loss: 0.4409 - acc: 0.7057- val_loss: 0.3176 - val_acc: 0.7157
Epoch 9/40 21/20 [==============================] - 7s 330ms/step - loss: 0.4196 - acc: 0.6857- val_loss: 0.3196 - val_acc: 0.7257
Epoch 10/40 21/20 [==============================] - 7s 339ms/step - loss: 0.4303 - acc: 0.6557- val_loss: 0.2896 - val_acc: 0.7257
Epoch 00010: ReduceLROnPlateau reducing learning rate to 0.0001240000059371814.
Epoch 11/40 21/20 [==============================] - 7s 315ms/step - loss: 0.4272 - acc: 0.6557- val_loss: 0.2596 - val_acc: 0.7157
Epoch 12/40 21/20 [==============================] - 7s 320ms/step - loss: 0.4163 - acc: 0.6557- val_loss: 0.2196 - val_acc: 0.7057
Epoch 13/40 21/20 [==============================] - 7s 334ms/step - loss: 0.4061 - acc: 0.6557- val_loss: 0.2061 - val_acc: 0.6857
Epoch 00013: ReduceLROnPlateau reducing learning rate to 6.24000029685907e-05.
Epoch 14/40 21/20 [==============================] - 7s 330ms/step - loss: 0.4010 - acc: 0.6557- val_loss: 0.2010 - val_acc: 0.6657
Epoch 15/40 21/20 [==============================] - 7s 340ms/step - loss: 0.3288 - acc: 0.6557- val_loss: 0.1888 - val_acc: 0.6657
Epoch 16/40 21/20 [==============================] - 7s 316ms/step - loss: 0.3102 - acc: 0.6557- val_loss: 0.1588 - val_acc: 0.6857
Epoch 00016: ReduceLROnPlateau reducing learning rate to 3.124000148429535e-05.
Epoch 17/40 21/20 [==============================] - 7s 324ms/step - loss: 0.3100 - acc: 0.6557- val_loss: 0.1500 - val_acc: 0.6857
Epoch 18/40 21/20 [==============================] - 7s 325ms/step - loss: 0.2258 - acc: 0.6557- val_loss: 0.1458 - val_acc: 0.7157
Epoch 19/40 21/20 [==============================] - 7s 334ms/step - loss: 0.2200 - acc: 0.6557- val_loss: 0.1400 - val_acc: 0.7257
Epoch 00019: ReduceLROnPlateau reducing learning rate to 1.5624000742147677e-05.
Epoch 20/40 21/20 [==============================] - 7s 330ms/step - loss: 0.1440 - acc: 0.6557- val_loss: 0.1340 - val_acc: 0.7257
Epoch 21/40 21/20 [==============================] - 7s 317ms/step - loss: 0.1336 - acc: 0.6857- val_loss: 0.1336 - val_acc: 0.7357
Epoch 22/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1300 - acc: 0.6857- val_loss: 0.1300 - val_acc: 0.7257
Epoch 00022: ReduceLROnPlateau reducing learning rate to 7.812400371073838e-06.
Epoch 23/40 21/20 [==============================] - 7s 324ms/step - loss: 0.1231 - acc: 0.6857- val_loss: 0.1231 - val_acc: 0.7157
Epoch 24/40 21/20 [==============================] - 7s 326ms/step - loss: 0.1170 - acc: 0.6857- val_loss: 0.1170 - val_acc: 0.7157
Epoch 25/40 21/20 [==============================] - 7s 329ms/step - loss: 0.1105 - acc: 0.7257- val_loss: 0.1105 - val_acc: 0.7157
Epoch 00025: ReduceLROnPlateau reducing learning rate to 3.906240185536919e-06.
Epoch 26/40 21/20 [==============================] - 7s 321ms/step - loss: 0.1167 - acc: 0.6857- val_loss: 0.1167 - val_acc: 0.6857
Epoch 27/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1023 - acc: 0.6557- val_loss: 0.1023 - val_acc: 0.6857
Epoch 28/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1021 - acc: 0.6057- val_loss: 0.1021 - val_acc: 0.6757
Epoch 00028: ReduceLROnPlateau reducing learning rate to 1.9531240927684596e-06.
Epoch 29/40 21/20 [==============================] - 7s 330ms/step - loss: 0.1011 - acc: 0.5857- val_loss: 0.1011 - val_acc: 0.6557
Epoch 30/40 21/20 [==============================] - 7s 344ms/step - loss: 0.1057 - acc: 0.5557- val_loss: 0.1011 - val_acc: 0.6557
Epoch 31/40 21/20 [==============================] - 7s 311ms/step - loss: 0.1007 - acc: 0.5957- val_loss: 0.1007 - val_acc: 0.6657
Epoch 00031: ReduceLROnPlateau reducing learning rate to 1e-06.
Epoch 32/40 21/20 [==============================] - 7s 326ms/step - loss: 0.1007 - acc: 0.6257- val_loss: 0.1007 - val_acc: 0.6857
Epoch 33/40 21/20 [==============================] - 7s 325ms/step - loss: 0.1007 - acc: 0.6857- val_loss: 0.1007 - val_acc: 0.6857
Epoch 34/40 21/20 [==============================] - 7s 330ms/step - loss: 0.1007 - acc: 0.7557- val_loss: 0.1007 - val_acc: 0.7457
Epoch 35/40 21/20 [==============================] - 7s 354ms/step - loss: 0.1007 - acc: 0.7557- val_loss: 0.1007 - val_acc: 0.7557
Epoch 36/40 21/20 [==============================] - 7s 319ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7557
Epoch 37/40 21/20 [==============================] - 7s 321ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7557
Epoch 38/40 21/20 [==============================] - 7s 334ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7557
Epoch 39/40 21/20 [==============================] - 7s 326ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7657
Epoch 40/40 21/20 [==============================] - 7s 334ms/step - loss: 0.1007 - acc: 0.7457- val_loss: 0.1007 - val_acc: 0.7657
```

Figure 4.2.4: Snapshot of output of the System

Figure 4.2.5 shows the graphical representation of training loss vs validation loss and training accuracy vs validation accuracy of our researched model. Here we can see the result of 40 epochs.

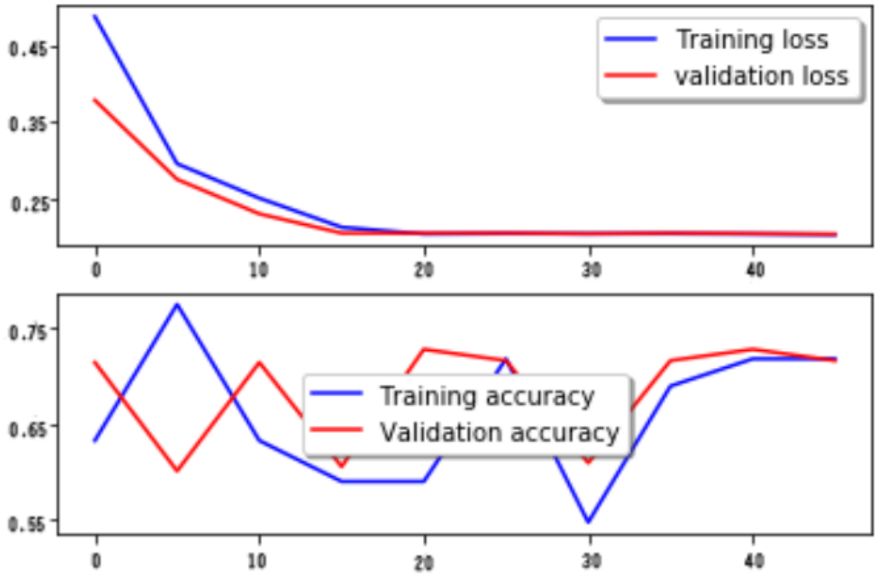

Figure 4.2.5: Graph of accuracy and loss

4.3 Discussion

We made a system with Google Colaboratory to train the Neural Network with our dataset. Different libraries are used here to run the system. Images were pre-processed and augmented to enrich our dataset in a view to get a perfect model. After training and testing performed we get training accuracy 75%. It is a good accuracy to perform the system after 40 epochs, any system is not perfect below 60% accuracy.

At last, contrasting our outcomes and different strategies for object location from leaf pictures, it very well may be said that our technique gives great outcomes and exactness.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT AND ETHICAL ASPECTS

5.1 Impact on Society

This research will impact a lot on the society. This research identifies the species of mangoes. It will be very easy to recognize the type of mango tree while buying it from the market or nursery. Then we can choose the desired mango tree and maintain the recommended environment for the tree. Following these we can cultivate more mangoes than before. After fulfill the demand of our country we can export mangoes to abroad and earn foreign currency. It may reduce unemployment problem of our country and enrich our economy.

5.2 Impact on Environment

Our research has no detrimental impact on the environment. Our system is very eco-friendly. There is no harmful technique used in this system. We only take the picture of the mango tree and detect the species of the tree. Also recommend the desired environment for the specific mango species so that the farmer can cultivate more mangoes.

5.3 Ethical Aspects

Using this system, a buyer can identify the species of mango tree before buying the mango tree. As a result, any seller cannot cheat the buyers. We have maintained honesty, integrity, objectivity and legality in our research. The dataset was prepared carefully. So that that the ethical aspects will be improved of our research.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 Future Work

Object Detection is a very interesting topic in Machine Learning. This research is about to classify mango species using Convolutional Neural Network (CNN) from the mango leaves. We have used five categories of mango species for our research. But in our country several numbers of mango species are cultivated. In future, those types of mango species can be including in this research. Also there should be a mobile application implemented that can make it easier to use the system for our people. For making this research more user friendly, the application should be in both English and Bangla language. It will be free to use for our people. So that we can cultivate specific mangoes in recommended weather and the production of mangoes increase to fulfill the country's need and can be exported to countries and earn foreign currency. Again we have to enrich out dataset with a view to obtain a better result with training and validation accuracy.

6.2 Conclusion

We have used five categories of mango species for our research. But in our country several numbers of mango species are cultivated. In future, those types of mango species can be including in this research. Also there should be a mobile application implemented that can make it easier to use the system for our people. For making this research more user friendly, the application should be in both English and Bangla language. It will be free to use for our people. So that we can cultivate specific mangoes in recommended weather and the production of mangoes increase to fulfill the country's need and can be exported to countries and earn foreign currency. Again we have to enrich out dataset with a view to obtain a better result with training and validation accuracy.

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