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***Abstract*— Every year many of farmers had to face a huge amount of loss due to the papaya disease. From the last several year's thousands of researchers pay attention to the papaya disease recognition system to reduce the losses of farmers. Farmers have no prior knowledge about the detection technique to mitigate the disease. They found the diseases when the papaya already affected and wasted. Due to the loss of cultivation, many of them are now frightening to take steps about planting papaya. On this matter, we have performed a research by the advancement of deep learning technology to detect and classify the papaya disease. We have used CNN model according to Keras API. This model reliable with fully connected where classification is completed and all the process is a deep learning based. It took the fixed size of image 200x200 RGB image as input.**

Keywords— Papaya Diseases, Deep Learning, Keras, Classification.

I. INTRODUCTION

Bangladesh's economy is a developing market economy having GDP 302.571 billion USD (https://data.worldbank.org/). The agriculture sector is the third-largest contributor to the GDP with sector wise 13.02% share (Gross Domestic Product (GDP) of Bangladesh 2019-20(p)) [1]. Here, the agriculture sector is playing an important role in socio-economic development like feeding, employment, & export earning etc. Most of the farmers here in Bangladesh do not follow the scientific methods while they are harvesting due to lack of proper training, advanced tools & technique, and literacy etc. They get hardly any assistance from the agricultural centers because of transportation fare & lack of communication etc. The farmers are using old agricultural tools and techniques [2]. If they get any proper training, advanced tools, and techniques, they will be able to produce more crops and use their resources efficiently. Among many agricultural products, we have chosen papaya, a widely harvested and leading fruit in Bangladesh [2]. Papaya disease turns farmers into loss of revenue because it can affect production significantly in both quality and quantity. This is a huge economic loss for the farmers as well as the nation. There is a report saying that it was an estimated 39.9% post-harvest losses of papaya fruits in Bangladesh (Hasan & M.K., 2010). Therefore, identification of disease and find out the time of disease attack can play a vital role in the successful cultivation of papaya fruit [24]. Images are the significant resource for data and information in agricultural science. In this paper, we have performed research for recognition of papaya disease following the Deep Learning-based approach. Our model is implemented by Convolution Neural Network (CNN) with Keras API which directly takes the papaya images and then fit the model for checking the accuracy and finally predict the disease affected and fresh papaya.

II. Related Work

Most of the cases researchers pay attention to detect fault of fruits disease. But the technique mainly divides into two parts. One is fault detection and another is fault classification. By classifying the fault, we can get the best way to prevent fruits disease. Based on this vision some of the researchers are performed image processing, mathematical expression to identify the disease. Tarek Habib [2], in their research work they have used K-means clustering for image segmentation and SVM to find the inspection results. Though they have achieved a good accuracy but they didn't performed the test for a large feature set where we can do it efficiently. Harsha. A [3], doing research about the corps with some AI based experiment with the objects pH and others. But they didn't summarize the process for image classification, recognition or detection. M.Malathi [4], they pay attention to detection and classification of plant leafs disease by K-nearest neighbor's algorithm. But they do not obtained the prediction result as convenient and not mentioned in their research. Veeraballi, R. K [5], they usually experiment with the curl leaf of papaya and identify the disease using CNN classification model. However they didn't deal with the fruits. Where they have gained an average of 85% accuracy for the leaf disease detection. Behera, S. K [6**]**, they did a research to check papaya maturity based on their layer using KNN and SVM classification algorithm. They were not aware about the disease and gained accuracy of average 90% only for the papaya maturity status using machine learning. Pothen [7], they did research leaf disease using image processing technique with HOG and SVM classification model. They used HOG to detect the separation layer based on their algorithm. Vijayakumar [8], the researcher detect mellowness of a fruits by using deep neural network and RESTNET152 to identify the fruits mellowness. Chen, Joy Iong Zong [9], they performed research for deformation of harvested crops using the texture failure option with machine el earning approach. Kelly [10], in this research they have determined the impact level of fruits on a body. They also worked on the temperature and other bio materials for their findings. Liang [11], they did research to create a multi-duct cleaning device for rice combine harvesters utilizing CFD and experiments. Chandy [12], here the researcher did research on RGBD analysis different stage pf mature or immature fruits. Manoharan [13], here the authors tries to do research about hermitical graph wavelets in feature detection. Later the research also leading to an accurate information for future research. I. Hamim [14], in their works they have performed a research to get survey of affected fruits disease and the type of disease based on the past several years records. Shiv [15], in their research they have discovered a great technique to detect the fault from a set of image data by processing them mathematical equation and graph visualization. But they do not perform any advancement on this field. Bhavani J. Samajpati [16], performed fruits disease detection and classification using K-means clustering algorithm with given dataset. But their research is not very feasible for them who are non-technical or farmer's and want to detect or classify their fruits disease. They have used binary value pattern, textures feature etc. Md. Helal sheikh [17], they have been performed only the value of fault detection of tree leaves. They have done image processing with some fixed data set based on the Adam algorithm for decreasing the learning rate. So, they didn't perform any classification technique further. Kawaljit Kaur [18], they did research to gather information only about the disease and techniques theoretically. There is no practical work found in their works and they just provided year to year varies information. Fabio Augusto Faria [19], they have performed bootstrap aggregation machine learning algorithm on a sample collection for extraction disease info. They have created some program algorithm and based on their condition they used support vector machine to gain value and graph representation. Nikhita M [20], they have used V3 inception model to separate image layer and gain value by image processing to classify disease. They have worked on different dataset to collect dark or disease spot of fruits and calculate arithmetic mean to show desired output. There is no accuracy measurement appear in this research. Santi Kumari Behera [21], in their research they have performed fruits surface-based image processing for identifying disease. They have performed preprocessing, feature extraction and classification based on their output from the image set. But there is no vision-based algorithm or performance accuracy are shown here. They have used fuzzy logic for the system interaction from starting to end. Zechen zheng [22], they research for fruits tree disease recognition based on data science and computational intelligence. They used convolutional neural networks to gather information from the leaves and fruits by processing them. They have experimented their data by applying algorithm. Though they have acquired the fault detection value by applying the algorithm for the data set. Priyanka soni [23], they did research based on the image of leaves, fruits or any kind of vegetables by measuring their frequency of good and bad area to get a better view. After capturing the details, they generalized the data into a data set for acquiring the disease classification. But the accuracy measurement and techniques are not advance enough comparatively the fruits disease. So, based on the above scenario and for our research purpose we prepare a strong Keras model with logistic regression and vector input. At first the featured image will be extracted by the Keras model and then we will perform machine learning based logistic regression to get the desired output.

III. System Architecture

The architecture of "Deep Learning Based papaya disease Recognition and prediction system" for classification the papaya disease is shown in Fig-02. This system predicts the result based on the Convolutional Neural network. User/farmer should capture the papaya image then easily can check the papaya's disease [24]. If it is affected by disease then know it to the farmer by sending messages or pop-up systems. Generally, it will be a web-based applications where farmers easily can check in a short time. Farmer should have smartphone and need to have internet access for performing. After submitting an image, keras API is using for extracting the

image features in back-end and also able to predict the result using logistics regression and in font-end, user can show about the result by the messages or pop-up systems. This system is too user friendly and also time consuming if the internet is too fast. The system architecture is shown in fig-1.

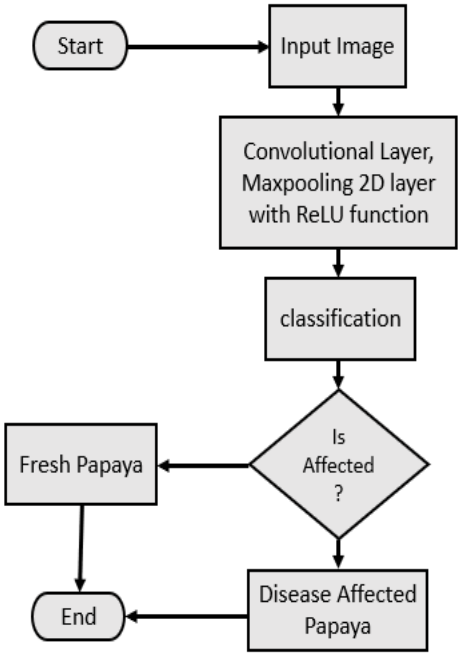

Fig.1: Flowchart of Papaya Disease classification model

Fig-1 defines the flowchart of papaya disease classification what we implemented. Here first of all in start section we need to take an image data or dataset as (200x200x3) size. Then it works in hidden layer where Convolution layer, MaxPooling and ReLU function is also used to feature select of the data and then in the classification section, Flatten, Dense and sigmoid function is also used for classification of the model [8]. After classification it show either "Fresh Papaya" or "Disease Affected Papaya" as the prediction of proposed model what we mostly want.

IV. SYSTEM METHODOLOGY

We made a complete guide line of solutions to classify disease affected papaya and fresh papaya and used Convolution Neural Network (CNN) to classification papaya dataset and mostly used Keras API.

The novelty of proposed approach is utilize a low cost, high accuracy system which defines a deep learning method. The CNN (Convolutional Neural Network) is faster than other machine learning algorithm. It can smoothly identify the diseases using keras API.

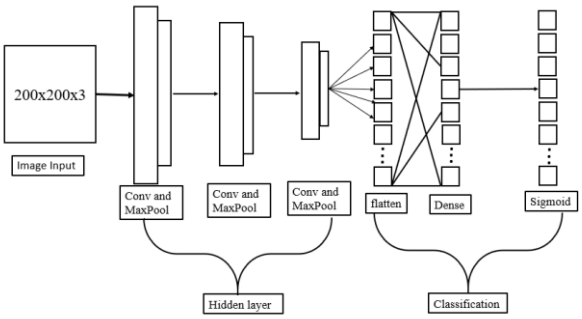

Fig.2: Papaya Disease classification of CNN model

We mainly classify disease to take RGB image where we fixed the input shape as 200x200. Now in hidden layer, the learnable convolutional layer first provides output shape as (198,198,16) and not learnable layer MaxPool just decrease the output shape by divide 2 and new output shape is (99,99,16). In the same rule, it is used to learnable layer and also MaxPooling layer reduce by half. This calculation is completed by using a rule is given below,

$$n_H = n_W = \frac{n + 2p - f}{s} + 1$$

Where,
Size of Height (nH) = 200 (initially from input image)
Size of width (nW) = 200 (initially from input image)
Padding (p) = 0
Kernel shape (f) = 3
Stride (s) = 1

Fig.3: Output shape changes rules

This is the equation of the output changes in CNN model. Where n_H is "size of height" and n_W is "size of weight" for input image data and it is fixed for our model. Padding is the relevant term to CNN (Convolutional Neural Network) which refers the amount of pixel on input image in CNN model and in proposed model, padding is zero means the added pixel value is zero. Kernel shape (f) is known as the batch size which is 3. Now Stride defines number of pixels which shift over the input matrix and we have use 1 as stride that's mean it can filters to 1 pixel at a single time.

After the Hidden Layer, it is main part to classify the image both fresh papaya nor disease affected papaya and it is known as "Classification" part. For learnable layer, it changes the parameters and below the calculations and also rule is given, Rules: {(Previous channel * Filter shape) + 1}*Current channel.

Table.1. Learnable layers calculation

Learnable Layer	Calculate Parameters	No. of parameters
Conv2d_9	{(3*3*3) +1} *16	448
Conv2d_9	{(16*3*3) +1} *32	4640
Conv2d_9	{(32*3*3) +1} *64	18496
Dense_6	(33856+1) *512	17334784
Dense_7	(512+1) *1	513

Now from the fig-1, the last output shape of Convolution Layer and MaxPooling layer are flatten and the works the Dense layer and finally it is successfully classified and it is also known as output. For testing our model, we also used the OpenCV so that our model can perfectly predict as disease affect or fresh papaya. We total used 234image for predict our model and 184 images are for training, 28 images for validations and 22 images for testing the model. We complete 30 epochs and the maximum accuracy is 98% and most of them are more than 80% accuracy.

V. DATASET DESCRIPTION

We have used 234 images for predict the approach model and 184 images are for training, 28 images for validations and 22 images for testing the model. The data sets are collected from real life images and also from kaggle. The name of dataset is Papaya and the location of dataset is (https://github.com/imdadulhaque1/papaya). For the disease data sets we are taking some disease types like anthracnose, black spot, blossom spot, and angular leaf spot. The literature dataset and the approach dataset are not same, we are increasing the number of real image data to increase the accuracy of CNN model. In CNN model, the input image data are used as 3 dimension and that's are height, width and RGB colors. In our model we fixed and first of all the all images are converted as 200x200x3 pixel. So CNN model mainly works RGB color of a papaya image and then classification completed.

VI. DISEASE FEATURES DESCRIPTION

A. DISEASE DESCRIPTION

This is very important part of our research approach for this section we can analysis disease properly and understand this disease flaw and we gain more knowledge about suitable feature. For this research we use five papaya disease to recognize our model [2]. Those five diseases are very common in our country Bangladesh. Most of the farmer are facing this disease in their plants and this disease are: Anthracnose, Black spot, Phytophthora, Powdery mildew, Ring spot.

B. DATASET PREPROCESSING

There are different types of image data are used in our papaya classification based on deep learning and some mentioned size of the image data are 800x533, 220x230, 336x366(from test dataset, some image size in pixel), 1254x836, 1024x768, 1500x750, 100x100(some training image data size in pixel) and 336x448, 61x159, 800x533(some validation image data size in pixel). So it is too difficult to prepare the image dataset for classification without a fixed size of image data [8]. So we have used input_shape function in our Convolutional neural network with a fixed size as 200x200 and it must be a RGB image dataset and for using this input_shape our model train is so fast and classify the disease accurately.

C. FEATURE EXTRACTION PROCESS

In this approach there are some distinct layers which are valuable to transmit the input, output data. First of all the Convolutional Neural Network needs to take input image as 200x200x3 and set input layer to last max pooling layer (23x23x64) is regarded as feature extraction of the approach model, while the rest of the network is regarded as classification model.

Hidden layer and classification part are completed in our CNN model and hidden layer basically used for filtering image data and also feature extraction is also done. Then flatten and dense layer is use for classification for our model so that is it disease affected of fresh papaya. And after running our CNN model we need to fit out model with respect to CNN model and our own dataset as train dataset. Then we predict our model using test dataset with respect to training model.

VII. RESULT ANALYSIS

In this research we have performed constitutional neural network algorithm (CNN) model using Keras API module. Firstly, we have collected data set regarding papaya diseases and per-process them by minimizing shape and transforming. This research has performed both papaya disease image recognition and prediction for fruits and leaves [4], [17]. We trained the image dataset and validate dataset using two different training and validation image dataset. The trained and test ratio for this model is 80:20. Later we create CNN model using Keras module. For this model Keras conv2d is constitutional 2D layer and this layer creates a convolution kernel that is wind with layers input which helps to produce a tensor of outputs.

Fig.4: Fresh and affected papaya disease classification

On the above figure we detect a disease affected papaya. Where our CNN model using Keras API able to classify the image layer and find the pattern of affected area using neural network. Later we test remain dataset and obtained an average of 91% accuracy. Where our model works more accurately than other model about papaya disease recognition.

Fig.5: Disease affected papaya leaf vs. Fresh leaf

For papaya leaf classification and detection, we reshape (200, 200, 3) the image in the time of pre-processing. Later we perform CNN neural network to find confusion matrix of the trained dataset using Keras layers. Finally, we fit the trained dataset to the model to check accuracy.

Here is the confusion matrix of image data shown in fig.6.

TP **10**	FN **1**
FP **1**	TN **10**

Fig.6: Confusion Matrix from test image data

Here is the accuracy, precision, recall and f1 score result of CNN model.

Table.2. Result of Accuracy, Recall, Precision and F1 Score

Accuracy	Recall	Precision	F1 Score
0.909	0.909	0.909	2

For the betterment of farmer many of our scientist have performed different algorithm to detect the papaya disease like K-means clustering, random forests. But using CNN neural network and Keras API module we are able to get a better result than others and have an average 91% accuracy. This research algorithm helps to identify the papa disease more accurately.

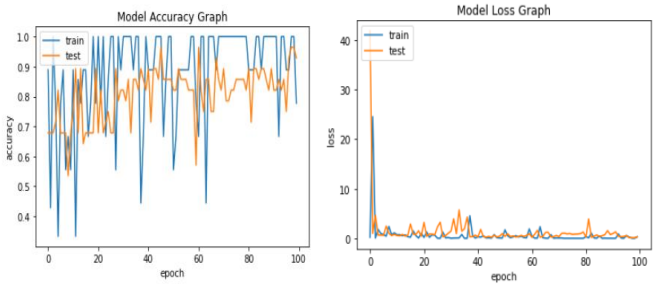

Fig.7: Model accuracy and Loss graph

On the above figure we have shown our model accuracy and loss graph according to the trained and test dataset. We achieve an average of 91% accuracy from our prediction model.

VIII. COMPARATIVE ANALYSIS

For the purpose of mitigating farmer's loss of cultivation for papaya we do our research that people can aware and get benefited. If the disease of fruits or papaya leaves are predicted early then the farmers can reduce the disease by doing proper treatment [4], [5], [12]. That's why we tried to perform papaya disease recognition and prediction based on image dataset. We have used CNN and Keras module API and had already been pretrained by ImageNet dataset. This model reliable with fully connected featured extraction. All the process is machine learning based. It has a function called loading () to take input initially and perform logistic regression to perform the desired output to detect the disease. Many of our scientist have performed different algorithm research for the papaya and other fruits disease prediction using algorithm like K-means clustering, K-nearest neighbor, Random forest with a small train and test data set. But they didn't pay attention for the prediction accuracy where our research model has achieved 88% accuracy with the machine learning based papaya disease classification and recognition. We also working on a large data sets with different disease category and a descent amount of training and testing set. Some of the comparative research analysis are shown in the following table.

Table.3. Comparative analysis

Research work/ Method	Problem domain	Segmentation Algorithm	Accuracy
Proposed Approach	Detection and classification	Keras API with CNN	91%
Incidence of post-harvest fungal diseases of ripe papaya [14]	Recognition	K-means clustering	65%
Application of Image Processing in Fruit and Vegetable Analysis	Recognition	K-means clustering	75%
Hybrid Approach for Apple Fruit Diseases Detection and Classification Using Random Forest Classifier [16]	Detection and classification	K-means clustering	60% – 90%
Fruit Recognition and Grade of Disease Detection using Inception V3 Model	Recognition and detection	Inception V3	Not mentioned
A Segmentation Improved Robust PNN Model for Disease Identification in Different Leaf Images	Identification	Robust PNN	65%

IX. FUTURE WORK

Our Convolutional Neural Network model is predicting the fresh papaya or disease affected papaya using image dataset as test data [14], [18]. Behind the history of our model there is a hidden target to help of farmer all over the world. Not only for educative farmer but also the uneducated and remote area farmers can use this model to predict papaya disease as soon as possible so that they can take this right decision to protect papaya from disease using mobile camera as real. It will be able to take the papaya image as input from video, image as real time object detector using tensor flow. It will be works as generates the small segments in the input image then feature extract [15] and finally converted into a single bounding rectangle and use it as input of our CNN model and then predict disease affected or fresh papaya.

X. CONCLUSION

Papaya disease classification and prediction techniques using the Convolutional Neural Network. Our model has performed relatively better compared to other's provided model and the accuracy is 91% which is too better. The main purpose of presenting this model is for the village farmers and these farmers who are deprived of suggestions from the agriculture office [2]. So that they can diagnose papaya disease at the right time and get the expected yield with proper care [14]. In addition, using this model will save the farmer from wasting his time as well as it is able to accurately diagnose papaya is affected or not. The main part of our research is to help those farmer's so that they can easily get their papayas condition details through our model and take necessary steps.

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