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# Detection & Classification of Paddy Leaf Diseases Using Deep Learning (CNN)

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**Abstract.** India has a huge population and the major source of food supply is from agriculture. Agricultural lands are getting destroyed mostly due to crop diseases, pests and plant diseases. Nowadays it increased fiercely. Plant pathogens are fungi, bacteria, virus or nematodes that damage plant parts such as leaf, panicle, node, stem and roots. So In agriculture, one of the latest researches is detection and classification of crop diseases using images of leaves from plants. The detection of plant diseases by using the image processing methods can help the farmers to protect the agricultural field from getting destroyed or affected. Paddy is a staple crop for much of the world's population. In this research we discuss classification and detection of paddy Leaf diseases using convolutional neural network. We captured paddy leaf images from the field for normal, sheath rot, rice blast, bacterial leaf blight, rice blast, brown spot, rymv and rice tungro for processing the image. In pre-processing, background exclusion is done based on the hue value to extract the non-diseased and diseased part. Feature Extraction is executed by applying Convolutional Neural Network. The proposed system achieved a high accuracy.

**Keywords:** Crop diseases, Leaves, Pre-processing, Feature extraction, Deep learning model, Convolutional Neural Network.

## 1 Introduction

India is mainly an agriculture country. India is the world's second (2nd) largest producer of sugarcane, rice, cotton and wheat. Agriculture is an important sector of the Indian economy and many people livelihood depend on agriculture. It's the source of our food supply. Industries like small-scale and cottage industries directly depend on raw material from agriculture. It is also associated with foreign trade. Many crops are cultivated in India due to pests and pathogens, most of them are destroyed. Farmers are the backbone of India. Due to yield loss they suffer a lot in terms of production and money. The main thing is the producer wants to identify the disease at an earlier stage for preventing

the widespread of disease to the whole plant. Only early diagnosis of disease will prevent severe loss. Paddy is the primary source of energy for over half of the world's people. Due to this crop, India is one of the leading producers. It is a staple crop. It contains fibre, vitamins, manganese and protein. By-products of paddy are used in many ways. Paddy is affected by various causes. Major causes are fungi, pests, viruses and bacteria. Every year farmers lose nearly 40% of production due to crop disease. Farmers are unable to diagnosis and give preventive measures to control the disease. Like pesticides and insecticides there are various measures available to maintain the crop healthier. But prior recognition of disease and control of the spread of disease is essential. If the plant is affected with disease it shows some specific symptoms which are unique for that disease. These symptoms are known as features of that disease. Using these features, we can identify the disease. Identification of disease through the human eye will not produce more accuracy. It requires expert knowledge and it is expensive and time consuming. So, we approach one of the deep learning methods CNN to detect paddy crop disease from plant images. We take six major paddy crop disease for research they are *Pyricularia grisea* (P.oryzae) and *Xanthomonas oryzae* caused blast disease and bacterial leaf blight to paddy crop respectively, *Helminthosporium Oryzae* and *Sarocladium Oryzae* caused brown spot and sheath rot respectively, Sobemovirus and Rice tungro bacilliform virus (RTBV) and Rice tungro spherical virus (RTSV) caused rice yellow mottle virus and rice tungro respectively.

Nowadays deep learning has a major role play in recognition of image and speech. In deep learning, the algorithms are inspired from the neurons of the human which is in brain and act as neural networks. Convolutional Neural Network (CNN) is a class of deep neural networks. It is mainly used for processing and recognition of image. One of the advantages of CNN is it predicts the features of an input image automatically without involvement of humans. We develop the model using one of the deep learning methods CNN to detect the crop disease. For that the steps are prepare a dataset, pre-processing, convolution, Relu, pooling and classification.

## **2 Problem Statement**

In agriculture, loss in yield is due to many problems one of the main reasons is crop disease. This crop disease is caused by bacteria, fungi, viruses and pests. Farmers required lot of money for maintenance of yield. If we do not properly diagnosis the disease and causing agent, it leads to further loss in crop, money and time. Proper diagnosis is very important. Paddy is an important staple food crop for nearly 62% of India's population. Undiagnosed paddy crop diseases will lead to severe damage to the cultivation and production of crops. To overcome this issue, in this research we used deep learning (CNN) method. Deep learning is a network capable of adapting itself to new data. Deep learning is developed from composed algorithms of machine learning that enable software to train models to perform specific tasks. They recognise image and speech using neural networks. To overcome the disadvantages of conventional methods we approach a deep learning method. Using deep learning we can easily detect plant diseases. Identifying symptoms for crop disease and knowing the way to control plant

diseases is very important. So from this paper, we will give the idea of disease identification using images of leaf. We use image processing and deep learning to overcome this problem. We designed and trained the model using features extracted from CNN. In this system feature extraction is executed by CNN. This paper mainly points out six most common paddy diseases such as blast, sheath rot, bacterial blight, rice tungro, brown spot and rymv. For extracting a feature first we prepare a dataset. Then split that into two, one for testing and another one for training. The images are pre-processed to remove background and reduce the dimension. Feature extraction is carried out by the three layers of conventional neural network namely input, output and hidden layer. These images are fed into the CNN as input. CNN performs convolution and pooling operations and generates a feature map. Finally the output layer classifies the image and shows which disease affected the plant. The proposed system is a model of recognizing the leaf images by deep learning method.

## 2.1 PADDY LEAF DISEASES

### BLAST

. Caused by: *Pyricularia grisea* (*P. oryzae*)

Symptoms: At first stage, spots, dots or grey-brown lesions appear on the leaf. Next stage, these lesions become spindle or oval shaped. It has a grey with brown or grey centre. After the lesions become enlarged and affect the leaf.

Effects: This fungus affects all aboveground parts (node, neck, and leaf collar) of paddy. It can kill the plants at seedling stage. If it is severely infected it leads to yield losses.



Fig. 1. BLAST DISEASE

### BACTERIAL LEAF BLIGHT

Caused by: *Xanthomonas oryzae*.

Symptoms: Initially it appears as water-soaked or yellowish stripes in leaf edges. At severe stages in the leaves greyish white lesions appears and after sometimes it changes to yellowing. If it is severely affected, leaves tend to dry quickly.

Effects: This disease causes yellowing of plants. It leads to yield loss from 20 to more than 70 percent.



**Fig. 2. BACTERIAL BLIGHT DISEASE**

### **BROWN SPOT**

Caused by: *Helminthosporium Oryzae*

Symptoms: It occurs at all stages and affects different parts of the plant. Initially, it begins as small brown spots on leaves at the tillering stage. At a later stage it forms circular or oval brown spots and it kills the entire leaf. When the seed was affected, it leads to discoloration on the grains.

Effects: It affects the spikelet, panicle branches, leaf sheath, glumes, leaves, and coleoptile. Also it affects the rice grains.



**Fig. 3. BROWN SPOT**

### **SHEATH ROT**

Caused by: *Sarocladium Oryzae*.

Symptoms: It starts with rotting on the upper sheath of the spikelet that encloses the panicles. It looks like irregular spots with grey midpoint and reddish brown border. These spots become enlarged and often coalesce and it covers most of the leaf sheath. At drastic stage it affects the parts of the grains to persist in the cloak.

Effects: The outer surface of the infected leaflets had a whitish powdery layer. The affected grains became sterile, shrivelled and discoloured.



**Fig. 4. SHEATH ROT**

### **RICE YELLOW MOTTLE VIRUS (RYMV)**

Caused by: Sobemovirus.

Symptoms: Its characteristics are a general stunting of the plant, an overall yellowing in appearance. After infection, leaves formed are mottled and twisted. At a severe stage, the whole plant will appear yellowish green.

Effects: The infected plants have stunted growth, sterile spikelet and eventually die.



**Fig. 5. RYMV**

### **RICE TUNGRO**

Caused by: Rice tungro spherical virus (RTSV) and Rice tungro bacilliform virus (RTBV).

Symptoms: This disease is spreaded from grasshoppers. It changes the leaf colour into orange yellow colour. It affects plants in all stages of growth.

Effects: It causes leaf discoloration, stunted growth and reduction in tiller numbers. It causes half of the yield losses.



**Fig. 6.** RICE TUNGRO

### 3 Literature Review

In [1], they used histogram to detect paddy leaf. They used image processing methods like enhancement, pre-process, augmentation and then transformed into histogram. Using histogram they extract the difference between the intensity among the original paddy leaf and disease affected leaf. In [2], they used threshold values for identify the symptoms due to rice blast disease. They use the image processing techniques for their research. By using Multi level thresholding, blast disease is split into three stages for identification. In [3], rice diseases are detected from two classifier's Bayes and SVM. The implemented steps are collected images from the plants, it is pre-processed, that result is segmented and feature extracted. Finally, classification is based on classifiers. In [4], detection of crop disease using image processing. In acquisition images are collected and the dataset is prepared and using pre-processing the background is removed. Using segmentation method the Feature extraction is done and finally classification of leaf disease.

In [5], using colour and shape features diseases are detected. After pre-processing, histogram is plotted then segmentation of image, extraction of feature and finally classification. In [6], for recognition of paddy leaf disease they used optimised deep neural networks. They followed image processing methods such as acquisition of image, pre-processing of image, segmentation, extracting features and identification. In feature extraction they used JOA and then classification.

Even though many methods have achieved better results for recognition and classification of plant disease, they have some problems [7-13]. In segmentation, if the image has another leaf or plant it will not consider it. Like histogram, threshold values many methods rely on hand-crafted features they require expensive work and depend on expert knowledge. So we proposed CNN in this research. The better way for leaf disease detection is convolutional neural network [14-18]. This method doesn't require segmentation and hand-crafted features. Compared to many methods CNN provides better accuracy [19-21].



## 4 Proposed Methodology

Plants are destroyed by various causes. They are crop disease, temperature, climate, insufficient food, sunlight, pests and disease caused by bacteria and fungi. So we proposed the CNN algorithm to diagnosis the disease in plants. From this system, we can achieve high accuracy. The presented system is advanced with three stages they are acquisition of image, pre-processing and extracting features based on CNN. The dataset is prepared by images captured from paddy fields. Then the dataset is divided into two groups for testing and training. In pre-processing background is removed from the images in the dataset and dimensions are reduced. Then feature extraction is carried out by CNN which has a convolutional layer for convolution, Rectified linear unit for non-linearity, pooling layer for decrease the dimensions and fully connected layer for classification. Using this we trained the model. Then it classifies the images of paddy leaves.

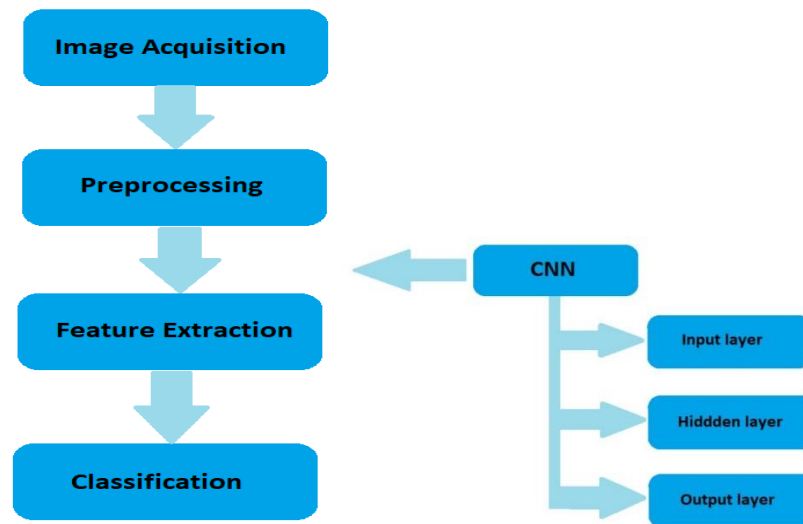
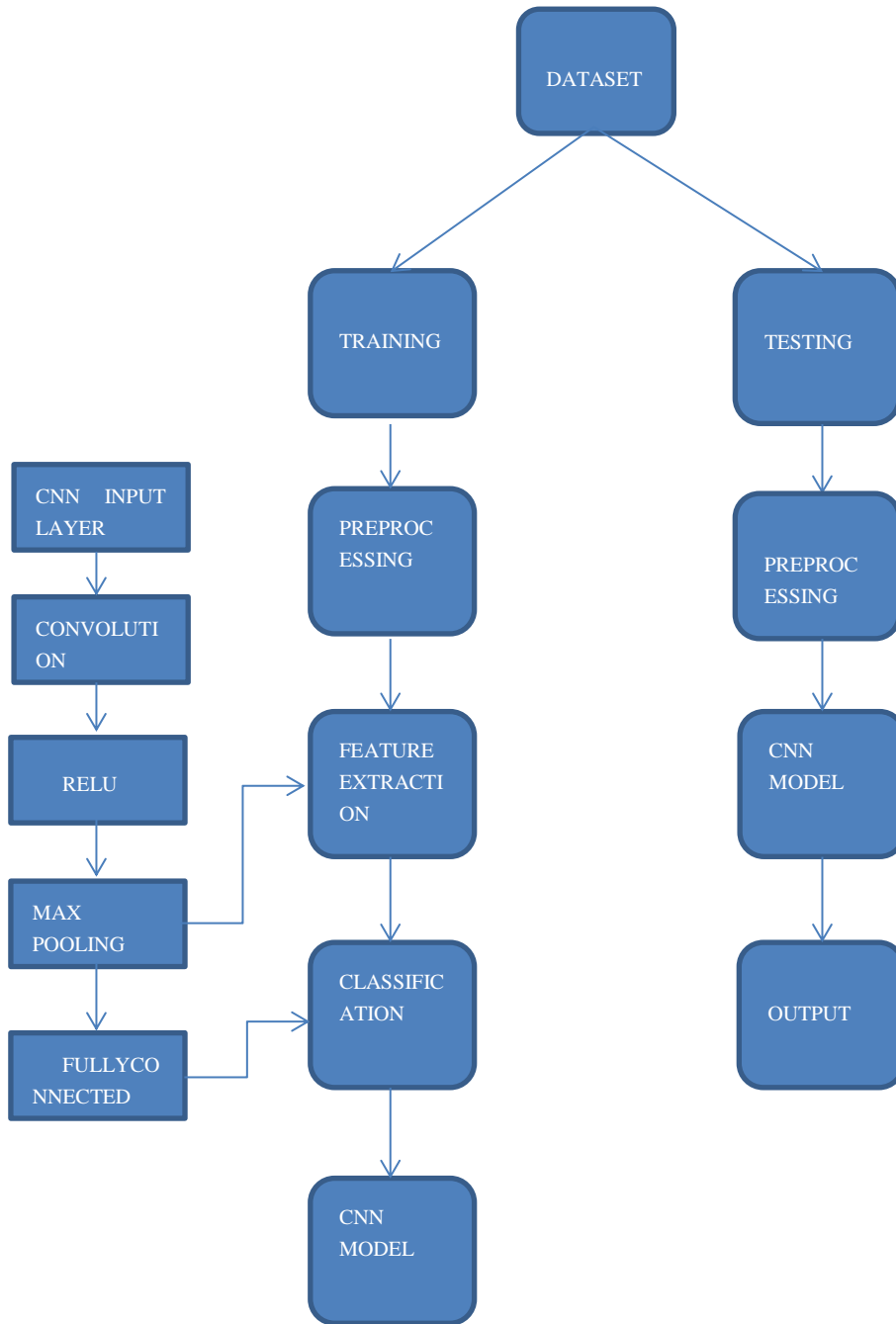


Fig. 7. Basic Workflow



**Fig. 8.** Workflow Block Diagram

#### 4.1 ACQUISITION OF IMAGES

It means retrieving an image from whatever source which is used for research purposes. We captured the image from the farm field of a paddy plant in real world circumstances. After images are captured, move it into the computer. Then it will carry out an implementation process for the recognition of diseases. The dataset is prepared by storing the images of the disease affected plant at various angles.

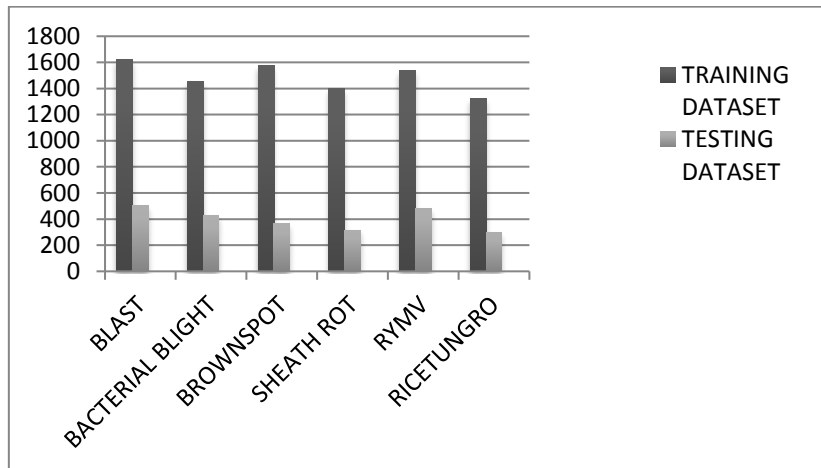


Fig. 9. Training and testing dataset

#### 4.2 PREPROCESSING

Pre-processing means steps taken to format images. It reduces the computation power. From pre-processing we get a high quality images which is helpful for implementing. Images collected in the dataset are resized and reduced the dimensionality. Pre-processing aims to eliminate the background of the images in the dataset by using hue values. After pre-processing, we get a background removed image only with the leaf portion and disease affected part. Then this will be given to the input layer in CNN.

#### 4.3 FEATURE EXTRACTION

Feature extraction means creating new features from the dataset using feature maps from the existing ones. In this research we applied CNN for extracting features. It is used to summarise most of the features. CNN is a neural network that extracts features from the images which are given as input. Then it classifies the images based on their extracted features.

## 4.4 CONVOLUTIONAL NEURAL NETWORK

ConvNet is a deep learning method shown in Fig. 10. Uses of CNN are recognition and processing of image and to process pixel data. CNN is a location invariant. It has the ability to develop an internal representation of a two dimensional image. Using CNN it is fast to implement. A CNN consists of three layers. First an input layer, where we give input data. Second hidden layer, which processes feature extraction and it has three layers. Third an output layer processes classification and produces output.

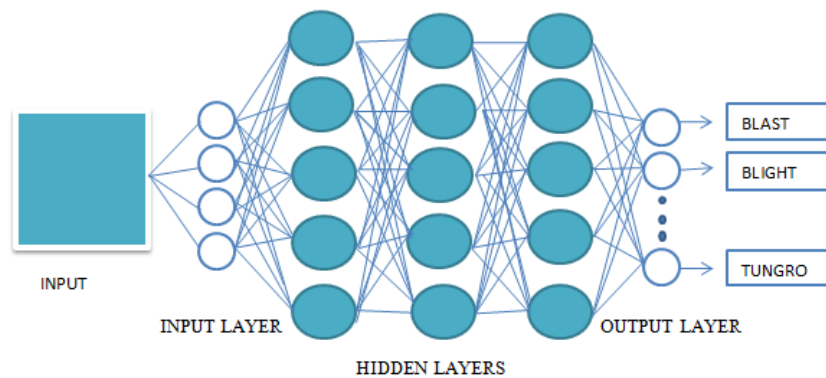


Fig. 10. Layers of Convolutional Neural Network

### Input Layer

The images of the disease affected leaves and normal paddy leaves which want to be trained are given as an input to input layer of ConvNet. It takes the grey scaled images for implementation. It accepts the pixel data of the image as input in order of arrays.

### Hidden Layers

#### *CONVOLUTIONAL LAYER*

Convolutional layer carry out convolution operation on input images. Filters are feature detectors by using these filters (like corner, edge, diagonal etc.,) we generate a feature map. The input images are convoluted with filters. It is known as kernels. This is mainly used for extracting features from images which was given.

#### *RECTIFIED LINEAR UNIT*

Rectified linear unit is called the activation function. In CNN we use Relu to increase the non-linearity of the images. Usually images are nonlinear so we use this Relu. It speeds up and is faster to compute. There are different types of activation functions

available; here we used the Relu activation function. In this layer if the input has positive value it takes the same as output. Or else it replaces the negative value with zero. From this we get a sort out feature map for further implementation.

#### *POOLING LAYER*

Pooling layer is used to decrease the image dimensions. Two methods of pooling, they are average and max. In max pooling, it considers the maximum value of the pixel data. It reduces the size as much as possible. Max pooling along with convolution helps with position invariant detection. In another method average pooling it considers the average of the pixel data. Most max pooling is used. After pooling it generates a new feature map. Benefits of pooling layers are reduced dimensions and computation power. So the model is tolerant towards variations and distortions.

#### *FULLY CONNECTED LAYER*

It has a dense network of neurons and there is a connection between every two neurons. They are interconnected. This is used to categorize the image to a particular group after we extracted features using convolutional layer and max pooling layer. It associates features to a particular label. The images obtained from convolution layer and pooling layer are flattened to form a one dimensional array, which is given as input for this layer. This is the layer where classification is processed.

#### **Output Layer**

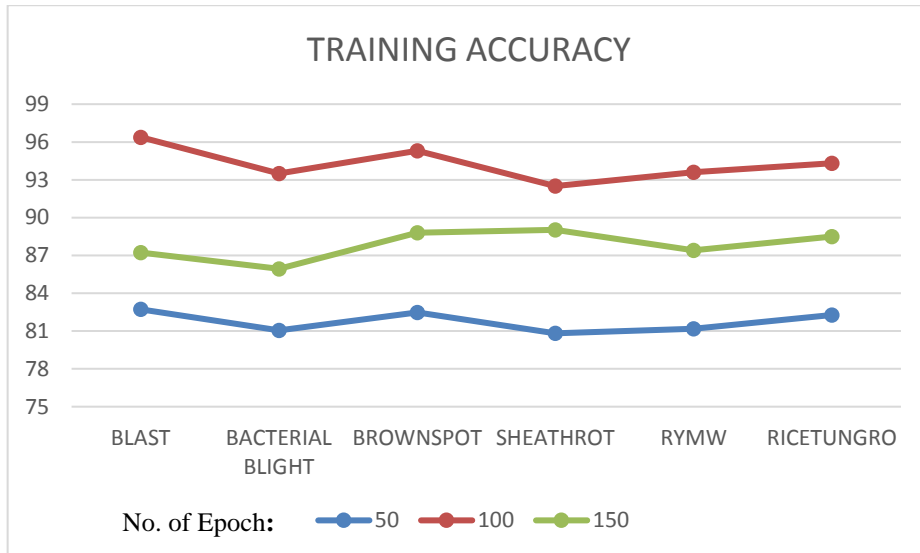
The last layer of the above layer is called an output layer. The number of neurons in the final layer is equal to types of categories trained. In this layer softmax activation function is used for classification. It classifies the paddy leaf diseases.

### **4.5 EXPERIMENTAL RESULT**

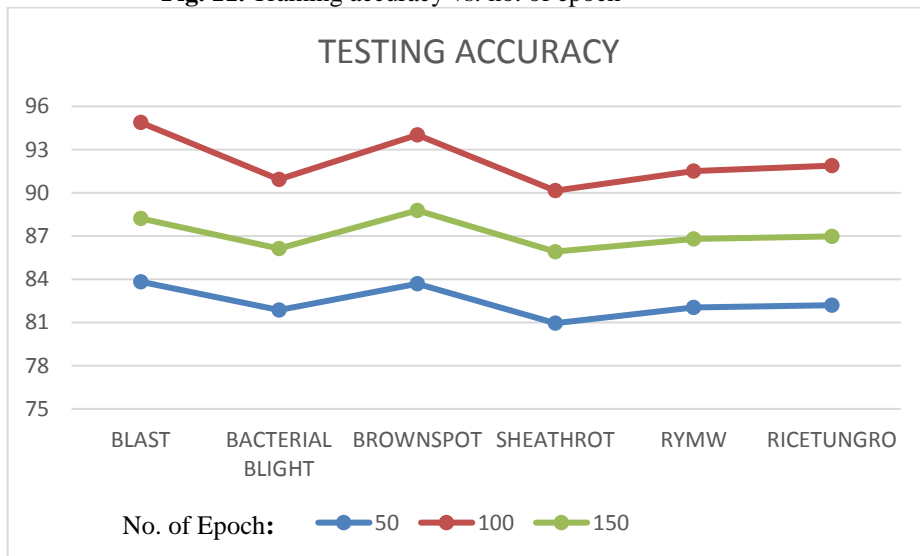
We have obtained results from the training model. For six paddy leaf disease we obtained recall and precision in percentage whereas, average precision is obtained by sum of recall and precision divided by two. Mean average precision is the mean of average precision of six diseases. In this research the mean average precision is 95.06%.

**Table 1.** Disease Detection Result

DISEASES	RECALL(%)	PRECISION(%)	AVERAGE PRECISION(%)
BLAST	98.2	96.43	97.31
BACTERIAL BLIGHT	99.5	95.6	97.55
BROWNSPOT	85.3	93.2	89.25
SHEATHROT	100	100	100
RYMV	93.55	99.12	96.3
RICETUNGRO	82.1	97.8	89.95



**Fig. 11.** Training accuracy vs. no. of epoch

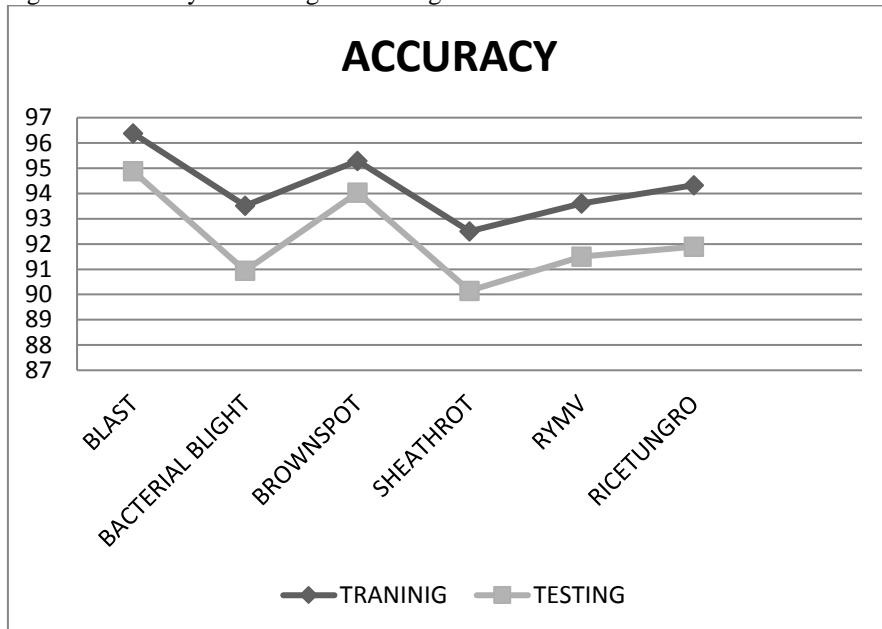


**Fig. 12.** Testing accuracy vs. no. of epoch

For developing the model more efficient we trained it with three different no.of epoch 50,100,150. Training and testing accuracy for no.of epoch is plotted above in Fig.11 and Fig.12. Both training and testing accuracy are high in 100 epoch. In 100 epoch we get a maximum accuracy for all six paddy leaf diseases.

## 5 Results and Discussions

After we trained the model using CNN, we tested it with samples we took. If we give an input image, at the output layer it shows which disease affected the leaf (bacterial blight, sheath rot, rice tungro, brown spot, blast and rymv). From that we can easily diagnose the disease so we prevent the plant from getting affected. We took 2385 images for testing and 8910 images for developing the model. In training we got accuracy of 96.38% for blast, 93.51% for bacterial blight, 95.29% for brown spot, 92.5% for sheath rot, 93.6% for RYMV and 94.32% for rice tungro. In testing we got accuracy of 94.88% for blast, 90.94% for bacterial blight, 94.03% for brown spot, 90.15% for sheath rot, 91.5% for RYMV and 91.89% for rice tungro. In training we got higher accuracy than testing. If we increase the samples for training and testing we will get more accuracy. Using this data we plot a graph for training and testing accuracy shown in Fig. 13. Accuracy of training and testing dataset is shown in Table 2.



**Fig.13.** Training and testing accuracy

**Table 2.** Accuracy of training and testing dataset

ACCURACY	TRANINIG	TESTING
BLAST	96.38	94.88
BACTERIAL BLIGHT	93.51	90.94
BROWNSPOT	95.29	94.03
SHEATHROT	92.5	90.15

RYMV	93.6	91.5
RICETUNGRO	94.32	91.89

## 6 Conclusion

In agriculture, loss of crops mostly occurs due to plant diseases. After the disease gets into a severe stage, we identify the disease. So it leads to severe loss. Plant disease reduces the production and quality of food. It also causes loss in money. We proposed the CNN method because more accuracy can be achieved. For this issue we developed a model using CNN which can recognize and classify the image. For training we took 8910 images and testing 2385 images. In the output, it shows out of six which disease affected the plant. The results can be made more accurate by taking more convolutional layers and hidden neurons. From this we can predict the disease at an early stage. We can prevent crop losses due to plant disease.

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