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Identification of Unhealthy Leaves in Paddy by using Computer Vision based Deep Learning Model

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ABSTRACT- India is one of the leading productions of Paddy. Compared to previous year Gross Domestic Product (GDP) Export rate of Paddy in the year 2021 has increased to around 33%. Paddy is the Major food production crop in India. Every crop is prone to many diseases throughout their lifespan. The disease can affect the crop at any stage of their growing phase. Early detection of disease is the only solution to reduce the damage. Early detection may reduce the damage caused and increase the quality as well as quantity of Production. Major disease which causes more damage in paddy production is Rice Blast, Brown Spot, Sheath Blight, Sheath Rot and False Smut. Early detection of these diseases can reduce the damage and increase the production value. Recent technology of computer vision and by using Deep learning model can accurately predict and diagnose the early symptom of diseases. We used Convolutional Neural Network classifier of deep learning model to predict the early symptom of disease in paddy. We compared four main classifier VGG16, VGG19, Inception-V3 and ResNet50, among these four Inception-V3 achieved a highest accuracy of 95.3%.

Keywords: Paddy crop, Disease attacks, Computer Vision, Deep Learning Model.

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1. INTRODUCTION

60% of agriculture land is utilized for Paddy cultivation. The quantity of the total production is reduced due to the damage caused by both Abiotic and Biotic agentsp10]. The disease first affects the leaf and spreads to all parts from season to season. Environmental changes are one of the major causes of infection. Pathogens like fungi, bacteria and virus are the major spreading agents of infectious diseases.

Finding the correct disease at early stage of plant growth is an important factor. Either External Expert or cultivator investigate the disease affected parts through his naked eyes and gives the solution. Identifying disease and which is the best pesticide can be used is still the big question for the cultivator. we need a model which clearly identifies the disease which is majorly affected. There are five main disease which affects paddy leaf from seedling stage to harvesting stage of crop growth. Rice Blast, Brown Spot, Sheath Blight, Sheath Rot and False Smut are majorly affecting and causing more damage to paddy. The symptoms of these five diseases were shown below,

1.1 Rice Blast

Rice Blast is the fungal disease which causes damage in all parts of paddy crop at all stages of growth. Rice blast disease causes brownish black color spot in leaf and in nodes the severity of damage is more because it breaks the affected part. This disease can cause 70-80% of grain loss.

1.2 Sheath Blight

Sheath Blight is the fungal disease which affects the paddy at any stage of plant growth. The symptoms are color change in the sheath portion which is near to soaked in water level. White brown or brownish black spot in leaf is the symptom. The damaged can affect the partial filling of grains in paddy.

1.3 Sheath Rot

Sheath Rot is the fungal disease which causes more damage on rice production because this disease affects in vegetative stage. Symptoms of this disease are discoloration in the leaf sheath, spots or lesions of dark brown color, white powdery inside the affected sheath and causes less filled grain in paddy.

1.4 Brown Spot

Brown Sot is fungal disease which affects leaf in all stages of plant growth. It causes dark brown spot in leaf and later it spreads to the entire parts of plant like oval or round shape which cause the leaf to dry 50% of reduction in crop growth is noticed if the severity is more.

1.5 False Smut

False smut is fungal disease which affects the paddy in vegetative and harvesting stage. Symptoms of False smut are, individual rice grain will look like yellow color velvet portion surrounded around the grain later may change to dark brown.

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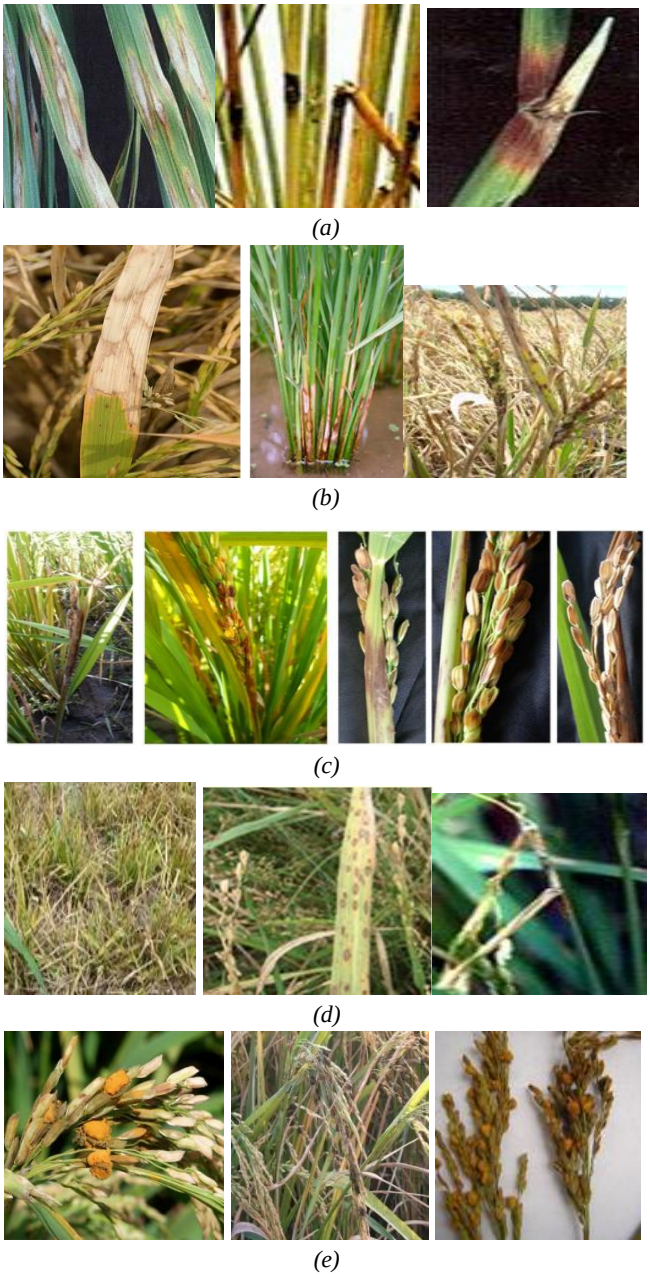

Figure 1: Disease affected in different parts of paddy namely (a) Rice Blast affected on leaf, Nodal, neck and collar, (b) Sheath Blight affected on leaf and near to water level, (c) Sheath Rot affected on grain, (d) Brown Sot affected on leaf and advanced stage of infection, (e) False smut affected on grain

2. RELATED WORKS

Md. Ashiqul Islam et al. [3], has proposed a model based on Convolutional Neural network with transfer learning approach. They achieved accuracy of 92.68% by using Inception-ResNet-V2 model. They classified four major diseases affecting rice with the dataset collected from internet and few from real field. Prajwal Gowda B.S et al. [5], proposed a machine learning model using Convolutional Neural Network algorithm which detects two majorly affected disease in rice crop Rice Blast, Bacterial Blight and also used healthy leaf images. They have added a feature of suggesting pesticide or insecticide for the damaged caused by disease. Their model was trained and tested by using 4000 images of two class disease which causes damage and 2000 healthy leaf images.

Krishnamoorthy N et al. [1], proposed the model based on Deep Neural Network with Transfer learning approach. InceptionResNetV2 is one of the Convolutional Neural Network models which uses transfer learning approach was used for automatic identification of disease in Rice leaf. Their model achieved highest accuracy of 95.67%. The dataset was collected from kaggle and few images from internet. They used around 5200 images in their model which classified three diseases such as leaf blast, bacterial blight and brown spot.

Elakya. R et al. [4], had made a review of different algorithms and model used for identifying early stage of disease and pest attacks in paddy leaves. Deep neural network-based transfer learning classifier can give the better accuracy for diagnosing early symptom of disease and pest attacks.

N. Nandhini et al. [6], Proposed the model with machine learning algorithms KNN, support vector machine and decision tree for diagnosing disease in rice plant leaves. Among these three ML algorithm Support vector machine achieved a highest accuracy. They made a comparative study to test the accuracy of ML algorithms.

Md. Mafiul Hasan Matin et al. [7], proposed a Deep learning classification model AlexNet. They achieved an accuracy of 99% by modifying data augmentation. They classified three commonly affected rice disease named as, brown spot, bacterial blight and leaf smut. They collected images from kaggle and proposed their work with 40 images of each Rice disease class. Data augmentation technique was used to increase the dataset size. Finally, they used 900 images to train and test the model.

Chowdhury R. Rahman et al. [8], proposed the two stage Convolutional neural network architecture and compared the result with CNN classifier like NasNet Mobile, MobileNet and SqueezeNet. This model achieved a highest accuracy of 93.3%. They used 1426 images of healthy and disease affected rice plant leaf images collected from real field.

3. MATERIALS AND METHDOS

The work is proposed on accurately diagnosing disease in early stage. First step is collection of data. We collected images from kaggle and plantvillage dataset [9]. Our model is mainly designed on focusing five major disease affecting paddy crop in all stages of plant growth like Rice Blast, sheath Blight, Sheath Rot, Brown Spot and False Smut. The data which is collected is not sufficient to build our model efficiently so we have applied data augmentation technique to increase the data set size for better performance.

3.1 Data Pre-processing

This is the first step in processing the data. The data which is collected from different sources looks messy. Those data should be cleaned up for further process.

3.2 Data Augmentation

If the data is insufficient for building and developing our model, we can go for data Augmentation. It is the technique to generate

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some more data for training the model. The label of all the generated images will be the same as original image from which model have generated more. Different techniques used in Augmentation is as follows,

3.2.1 Image Rotation

This is most commonly used technique. Even if we rotate in any degrees, the image will look same. The information which is present on the image will never change. Following *figure* is an example of rotated images in different degrees. The example taken is Brown Spot disease affected in Rice plant.

Figure 2: Different rotations performed in Brown spot disease of paddy

3.2.2 Image Shifting

Shifting is the process of changing the position of objects which is present in the image. The position can be shifted to either horizontal or vertical direction by keeping the dimensions of the images by same.

3.2.3 Image Flipping

It is an extended version of image rotation. This method flip the image either in Up -Down direction as well as Left-Right directions.

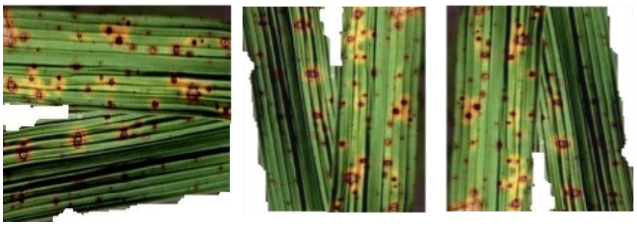

Figure 3: Image Flipping of vertical and horizontal is performed in Sheath Blight disease

3.2.4 Image Noising

This is the technique of applying noise to the images so that our model will learn how to separate signal from noise in image.

3.2.5 Image Blurring

As the image collected for training our model is developed from different sources. Some might be in healthy environment other can be in very bad quality. If we blur our images, the robust of our model will get improved so that we can train from any type of images.

4. PROPOSED DEEP LEARNING MODEL

After completion of Data Augmentation our dataset size is increased. Now we got more images to train and test the data. We are going to diagnose five main disease of paddy which affects in all growing stage. The five main diseases are Rice Blast, sheath Blight, Sheath Rot, Brown Spot and False Smut. We divided the dataset to 70:30 to train and test the model. Deep learning model VGG16, VGG19, Inception-V3 and ResNet50 were used and compared. To provide the best result Fine tuning from pre-trained ImageNet weight is done.

Training and testing process of deep learning model is done by Keras Framework with Tensor Flow backend.

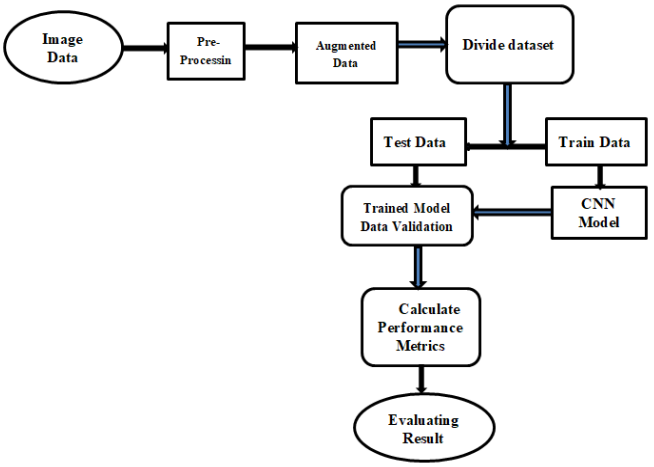

Figure 4: Architecture diagram of the proposed model

5. RESULTS AND DISCUSSION

Deep learning model VGG16, VGG19, Inception-V3 and ResNet50 were used for obtaining Training and Testing accuracy. Classification Metrics of Accuracy, Precision, Recall, F1 score were calculated and compared for all the four deep learning model. Dropout layer is added after convolutional layer to fine-tune because overfitting problem can be avoided and reduced. To save some computations we have used Max-pooling before ReLu. 30 Epoch was used for all the training procedure. Batch size is set to 32 for 30 Epoch. RMSProp optimizer is used for training the model. Multi-class classification problem Softmax function is used. Following *table* shows the definition of performance metrics which we have considered in this model for evaluating performance.

Table 1: Evaluation metrics

Metrics	Definition	Formula
Accuracy	No of correctly classified data over total data	(TN+TP)/(TN+FP+TP+FN)
Precision	Positive prediction value	TP/(TP+FN)
Recall	True Positive rate	TP/(TP+FN)
F1-Score	Takes both precision and recall value to obtain test performance	$2*\frac{Precision*Recall}{Precision+Recall}$

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TP-True Positive, TN-True Negative, FP-False Positive, FN-False Negative.

Let us see the classification done by our deep learning model for calculating the performance.

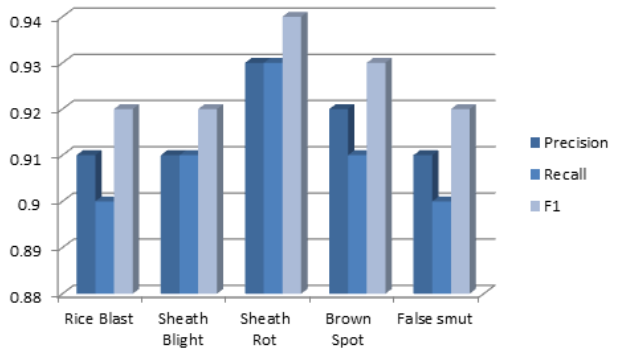
TRUE POSITIVE: A leaf which is actually affected from disease and classified as disease affected (TP).
TRUE NEGATIVE: A leaf which is healthy and classified as not affected from any type of diseases (TN).
FALSE POSITIVE: A leaf which is healthy but it is classified as affected from any of the disease (FP).
FALSE NEGATIVE: A leaf which is actually affected from disease but it is classified as healthy, not affected (FN).

If there is a confusion in classifying whether the leaf is affected from any type of disease or not, we make classification of data inside the matrix called as confusion matrix. This is required for computing the accuracy for our deep learning model in classifying data into its label.

ImageNet dataset consist of nearly 5000 images of five majorly affecting diseases in Paddy namely Rice Blast, Sheath Rot, Sheath Blight, Brown Spot and False Smut. We have used four Convolutional Neural Network classifier VGG16, VGG19, Inception-V3 and ResNet50.VGG16 achieved an accuracy of 93.2 %, VGG19 achieved an accuracy of 94.4%, Inception-V3 has achieved a highest accuracy of 95.3% and ResNet50 achieved an accuracy of 94.9%. Following *table* shows the comparison of performance metrics of four widely used Deep learning model.

Table 2: Evaluation metrics

Metrics	VGG16	VGG19	Inception-V3	*ResNet50*
Accuracy	0.932	0.944	0.953	*0.949*
Precision	0.91	0.91	0.93	*0.92*
Recall	0.90	0.91	0.93	*0.91*
F1	0.92	0.92	0.94	*0.93*



Detailed results of calculating Precision, Recall and F1-Score for five commonly affected disease in paddy for the deep learning model Inspection-V3 is shown in above, for a good classifier, Precision and Recall value should be high *i.e.* 1. our model obtained the good precision and recall value which means false Positive and False Negative Value is zero.

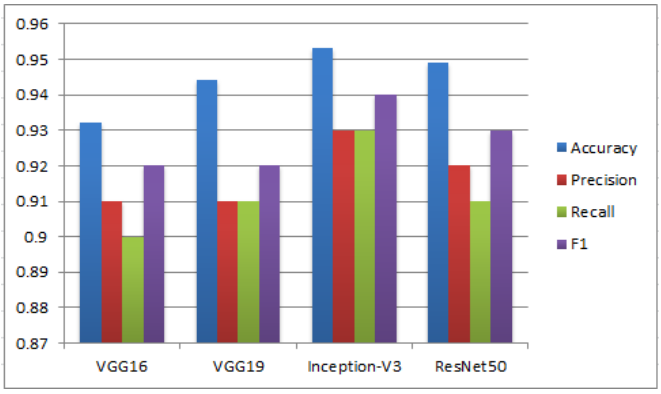


Figure 5: Performance metrics of Deep learning model

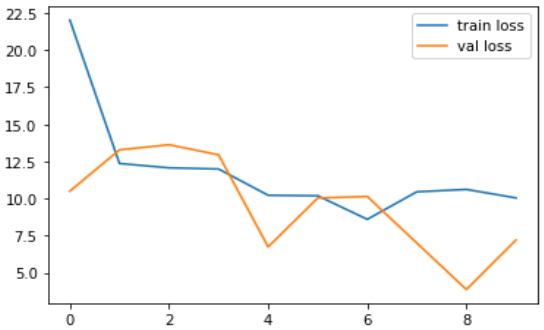


Figure 6: Train and val loss of Inception V3

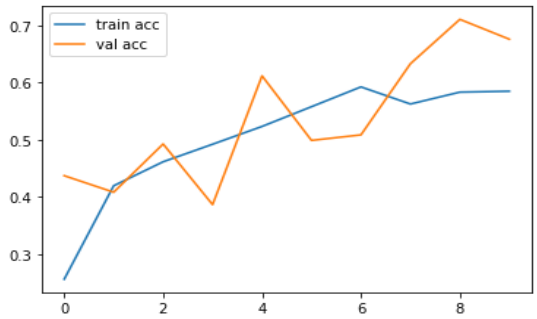


Figure 7: Train and val laccuracy of Inception V3

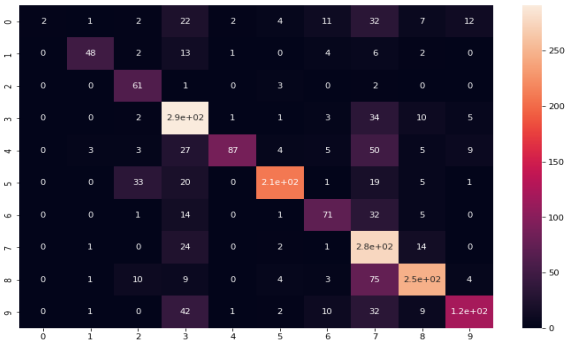


Figure 8: Confusion Matrix for Deep learning model

6. CONCLUSION

Detecting disease at early stage can reduce the loss caused. Farmers are still facing lot of issue inaccurate predicting of disease in paddy. We proposed the deep learning model with

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computer vision technique for predicting five commonly affecting disease in paddy. We have compared the results of four main CNN classifier VGG16, VGG19, Inception-V3 and ResNet50. Our experimental result proved that Inception-V3 has achieved a highest accuracy of 95.3% which is the best result among other classifier used. In future how the climatic change causes infection in paddy can be researched for better diagnosing of disease. object detection algorithm can also use for predicting disease. Segmentation process can be applied for separating disease affected parts and healthy or normal parts of the leaf.

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