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Rice leaves disease classification using deep convolutional neural network

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***Abstract*---**The rice disease due to fungus, bacteria, spot and sheath blight, leaf scald effects the crops yield. The farmers have limitation predicting the quality on the crop for large scale evaluation. Therefore, there is a need for an automatic leaves disease prediction tool to assists to apply corrective procedures. Deep learning models have outperformed in several sectors of computer vision. In this paper a deep leaning model based on pre-trained CNN is customized through altering the architecture of the models and apply transfer learning methods and the resulting model named PaddyLeaf15 CNN is evaluated on the benchmark dataset from Kaggle. The results indicate that the proposed model outperforms as compared to VGG-16 and Inception V3 based models with highest model accuracy of 95%.

***Keywords*---**CNN, VGG 16, inception V3, rice blast.

Introduction

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The rice is the major crop in India contributing to the economy in India. The fungus, bacteria, spot and sheath blight, leaf scald etc. disease affects the quality of rice crop. But due to various diseases of rice, farmers can't yield rice according to their expectation. The quality, quantity and production of rice are being interrupted. It is difficult for the farmers to diagnose diseases. The quality of the rice based on the diseases can be predicted using image processing techniques by analyzing the image features. These features classification for disease identification is carried out using discriminant analysis, decision tree, neural network, and support vector machine classifiers etc. deep learning methods have outperformed in several applications on par with traditional image processing methods. Therefore, in this work suitability of deep learning models for prediction of rice disease and classification into different types is explored.

Deep learning techniques have attracted the attention of researchers due to its great performance in image classification. Among different deep learning techniques, the deep convolutional neural network (CNN) has been used mostly for image classification. Different deep learning architectures can be used for image classification. The proposed model is evaluation for its performance using the dataset from the Kaggle that includes four different rice plant diseases, they are Brown spot, Leaf Smut and Bacterial Leaf Blight, the crop damage due to these diseases. Different deep learning architectures can be used for image classification.

There are various diseases that affects the rice plant. Such issues affect the crop yield. Brown spot is a fungal disease and most observable damage is the numerous big spots on the leaves which can kill the whole leaf, Leaf Smut is the presence of small black spots on the leaves. Bacterial leaf blight can cause heavy losses, Lesions begin as water-soaked stripes on the leaf blades and later stripes would increase in length and infected leaves will later dry up. Convolutional neural networks is one the deep learning architectures and CNNs is for feature learning extraction which extract features and makes hierarchies of nonlinear features. The proposed system is a solution for recognition and classification of rice leaf diseases. Early detection and diagnosis of Rice Leaf Disease to prevent loss and help farmers with a high yield.

The presentation of research work is organized into various sections, section II gives Relative work, section III gives insight into proposed model, section presents results and discussion, and section V gives conclusion.

Related Work

In [1], Logistic Regression, K-Nearest Neighbor, Decision Tree and Naive Bayes Classifier were applied for detection of diseases of rice leaf - Leaf smut, Bacterial blight, and Brown spot. The performance of the algorithms is evaluated on a database with 480 rice leaf samples and the metrics F1-score, AUC (Area Under ROC) indicates the results are satisfactory. However, the model accuracy is dependable when evaluated on larger set of datasets.

In [2] provides a method for automatically classifying diseases in rice plants by analyzing photographs of rice leaves. The method involves identification of lesions in leaves, extract features based on the number of lesions, size, color, and pattern of distribution in a particular area. These features are classified using Random Forest, Logistic Model Trees, and Sequential Minimal Optimization for Support Vector Machines. It is observed that Random Forest algorithm outperforms performs other algorithms.

In paper [3], SVM classifier is combined with a deep CNN and the model is optimized using transfer learning techniques. The model is evaluated on a dataset comprising 1080 images falling into the category of nine different rice diseases. The model has given 97.5% prediction accuracy in training phase, however, there is a need to improve model accuracy further.

In [4], the researchers have created own database K5RD, this the dataset consists of 12223 images and five classes. The five rice diseases are blast, bacterial blight, brown spot, narrow brown spot, and bacterial leaf streak. The research work proposed deep learning models including ResNet50, ResNet101, DenseNet161, and DenseNet169.to classify such rice diseases DenseNet161 model achieves the best result at 95.74%.

In [5], 40 types of diseases in rice are considered with rice blast is the most damaging disease. The work presents a classifier using SVM and Principal Component Analysis (PCA) is applied to reduce model learning time. the results obtained are accuracy of more than 95%, Effectiveness is 90%, the sensitivity 95.6% and the specificity is 71.4%. there is a scope for optimizing the model to improve specificity.

In [6] CNN model is proposed to classify rice leaf diseases classification using CNN with transfer learning. The proposed CNN architecture is based on VGG-16 and is trained and tested on the dataset collected from rice fields and the internet. The model is evaluated on a dataset which consists of 1649 images of diseased three most common diseases namely Rice Leaf Blast, Rice Leaf Blight, and Brown Spot. There are 507 images of Healthy leaves. The accuracy of training set is 97% and the test accuracy of 92.4%. In this work it is demonstrated that transfer learning technique increases the accuracy of classification.

The work in [8] paper proposes a machine learning algorithm to find the symptoms of the disease in the rice plant. The total data set consists of 300 images and divided for training and testing purposes, K-Means Clustering is used for image Segmentation and statistical features such as Mean Value, Standard Deviation and GLCM are computed, and artificial neuron network (ANN) is used for classification. The blast disease accuracy obtained in training is 99% and testing is 90%. The healthy life accuracy obtained in training is 100% and testing is 86%.

In [9], the dataset used consists of 600 images of six rice diseases and augmentation and scaling were done. The three pre-trained models of CNN such as Inception -v3, MobileNet-v1 and Resnet50, are explored for the classification problem under consideration. The prediction model based on Inception-v3 gives highest performance with 98% precision.

In this paper [10], paddy leaf disease detection using optimized fuzzy interference system (OFIS) has been proposed. Totally, 85 images of leaves are tested. In the pre-processing stage, the image is split into R G and B components and texture and color features are extracted. The proposed algorithm gives an accuracy of 95% for detection of leaf diseases.

In paper [11] diseased and non-diseased rice leaves classification is proposed Support Vector Machine (SVM) and Artificial neural network (ANN) classifiers. The segmentation of affected leaf region is done by using the k-means clustering algorithm SVM provides higher disease detection accuracy (92.5%) than ANN (87.5%).

Researcher in [12] introduced a hierarchical strategy for the diagnosis of rice leaf diseases, based on the color moments the leaves are classifies as diseased and non-diseased. In the next step diseased one are categorized models Bayes' classifier, Support Vector Machine (SVM) and decision tree, KNN, and MLP are used for classification.

In paper [13], the rice plant leaves images were captured with digital camera and image data has been created with 330 images out of these 60% of images are used for training and 40% of images are used for testing. The segmentation of leaf regions is carried out using a combined Otsu and Global threshold method. The classification is carried out using KNN classifier which gave 76.59% of accuracy.

Table 1. Comparative analysis of literature review

Sl No.	Year	Dataset	Methodology Used	Recommendation
[1]	2019	Rice Leaf Disease Dataset consists of 480 images	■ Logistic Regression ■ K-Nearest Neighbour ■ Decision Tree ■ Naive Bayes Classifier	Decision tree algorithm
[2]	2020	Rice Leaf Disease Dataset	■ Random Forest ■ Logistic Model Trees ■ SVM	Random Forest
[3]	2019	Rice Leaf Disease Dataset with nine different diseases	■ SVM classifier is combine with an AI model named deep CNN. ■ Transfer Learning	Deep CNN
[4]	2020	Rice Leaf Disease Dataset with five different diseases	■ ResNet50 ■ ResNet101 ■ DenseNet161 ■ DenseNet169	DenseNet161 model
[5]	2018	Rice Leaf Disease Dataset	■ SVM	SVM
[6]	2020	Rice leaf disease dataset consists of 1649 images	■ VGG-16 ■ Transfer Learning	VGG-16
[7]	2018	There are 30 pictures of each type of rice blast	■ SVM ■ Otsu segmentation algorithm	SVM
[8]	2018	Rice leaf disease data set	■ K-Means Clustering	ANN

		consists of 300 images.	algorithm ▪ Artificial neuron network (ANN)	
[9]	2019	Rice plant dataset consists of 600 images of six rice diseases.	▪ Inception -v3 ▪ MobileNet-v1 ▪ Resnet50	MobileNet-v1
[10]	2019	Rice plant dataset	Optimized Fuzzy Interference System (OFIS)	OFIS
[11]	2019	Image database consists of 40 images of each class	▪ Support Vector Machine (SVM) ▪ Artificial neural network (ANN) ▪ k-means clustering algorithm	SVM
[12]	2017	The sample image database of brown spot and leaf blast has been acquired	▪ Bayes' classifier ▪ Support Vector Machine (SVM) ▪ Decision tree ▪ KNN	Bayes' classifier
[13]	2017	Images have been captured in paddy fields, Shivamogga district, Karnataka state	▪ otsu segmentation method ▪ kNN classifier	kNN classifier

The work presented in this paper proposes a method for rice leaves disease classification using deep learning CNN model as deep learning models have outperformed in several applications. The various tools required for implementation of deep learning model include Tensor Flow, Keras, and Google Colab etc.

Proposed Method

Early and accurate detection of rice (plant) diseases allows corrective action that reduces the negative impact. However, such disease detection by human experts is time-consuming and does not scale because a human can examine only a very limited number of plants carefully. The proposed system for classification is shown in Figure 1.

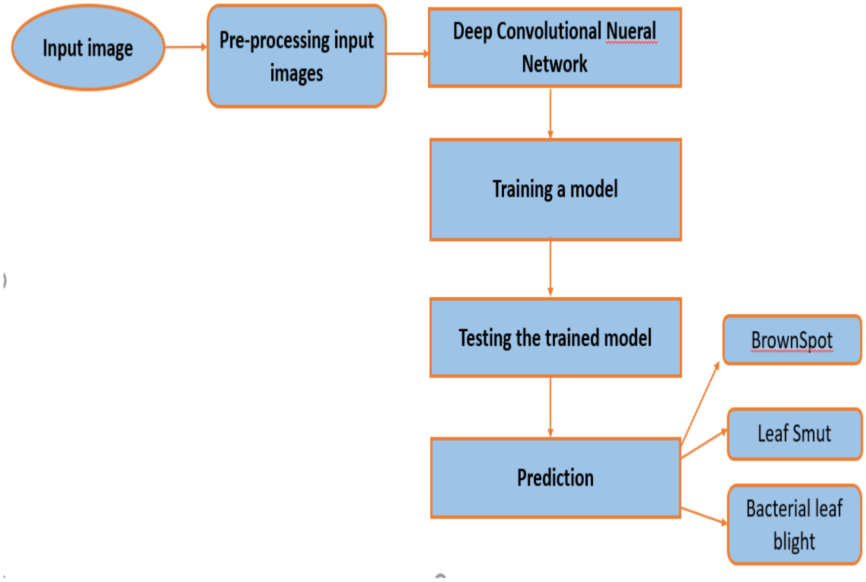


Fig. 1 Proposed system

The steps involved in Proposed System are resize images to 224 x 224, augmentation through horizontal flip and zoom operations. The deep learning models explored for the classification are VGG16, VGG19, Inception V3 and PaddyLeaf15 CNN Architecture. The experimentation is carried on Intel Core2 Duo.

The proposed methodology is based on Transfer learning with deep learning, to recuse deep neural network models that are trained on ImageNet Data. To optimize the performance of the proposed mode for rice leaves classification fine tuning is achieved by adding more layers to the output of pretrained models. In the process, fine tuning one global spatial average pooling layer, batch normalization layer and two dropout layers, with two dense layers and flatten layers are added. Relu activation function and an output layer with a softmax classifier is added to classify the images into three classes. Dataset used is Kaggle Rice Leaf disease images database

Result and Analysis

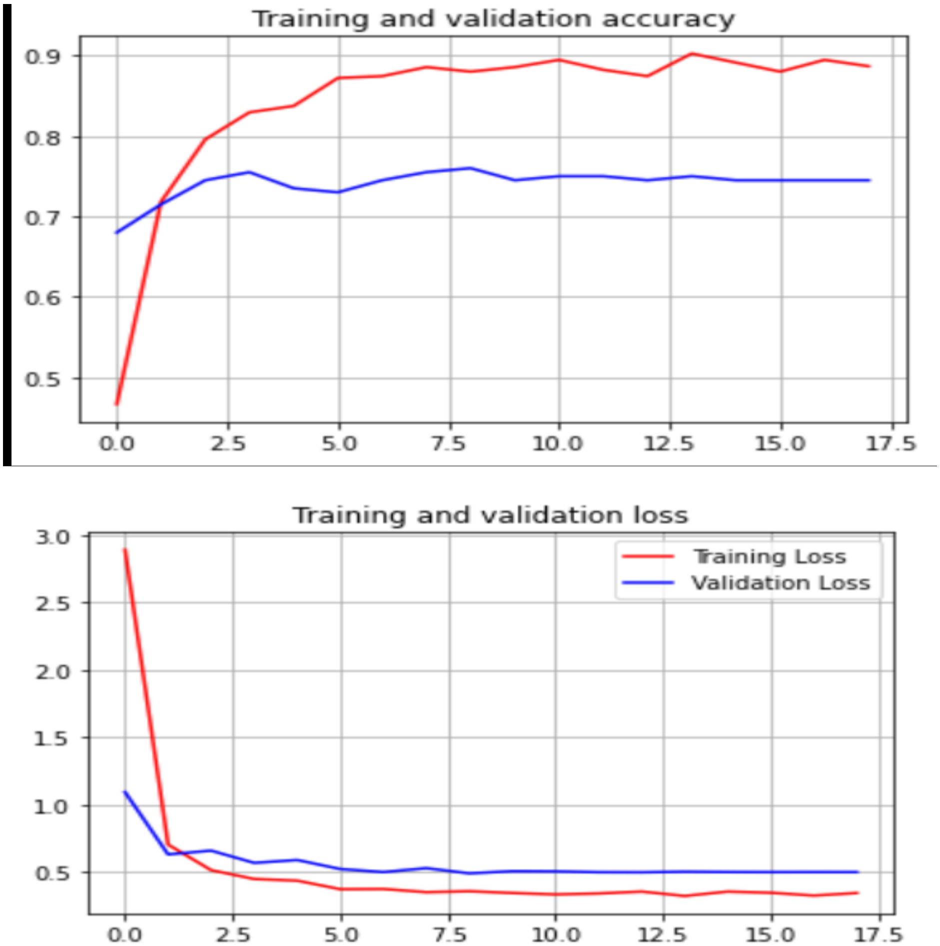
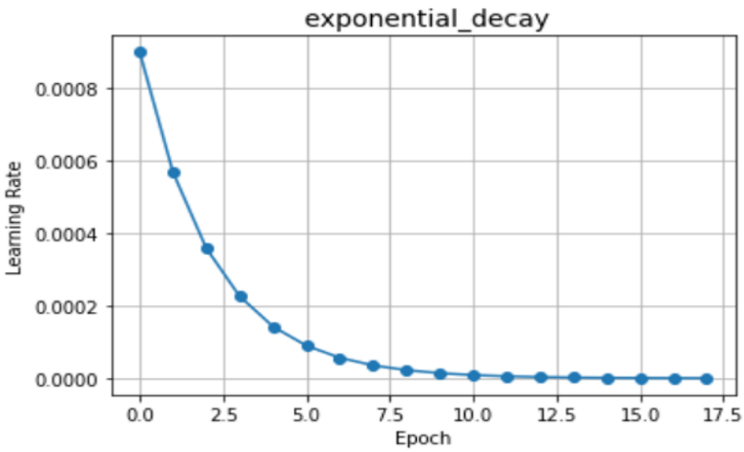


Fig. 2. Training and validation accuracy plot for VGG19

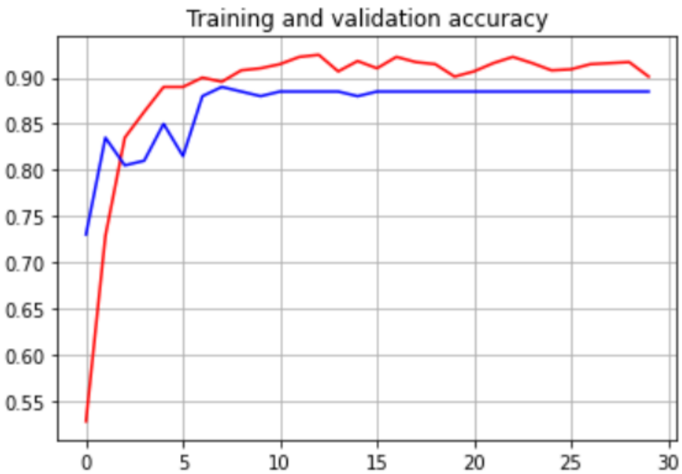
Fig. 2. shows the training and validation accuracy obtained with respect to epochs and shows the train and validation loss with respect to epochs for VGG19 with Adam architecture. Total number of epochs used is 30.



	precision	recall	f1-score	support
0	0.98	0.93	0.95	55
1	0.70	0.89	0.78	54
2	0.79	0.62	0.69	55
accuracy			0.81	164
macro avg	0.82	0.81	0.81	164
weighted avg	0.82	0.81	0.81	164

Fig. 3 Classification report for VGG19 with Adam Architecture

The above Fig.3 shows the classification report for VGG19 with Adam architecture which shows "Precision, recall, f1-score and support" for each of its class.



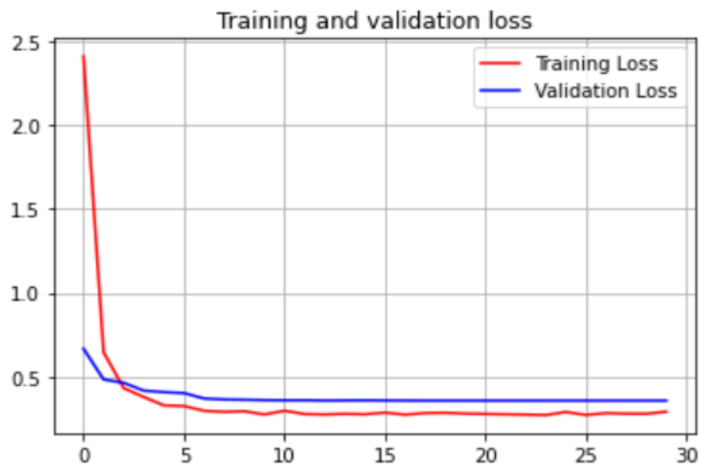
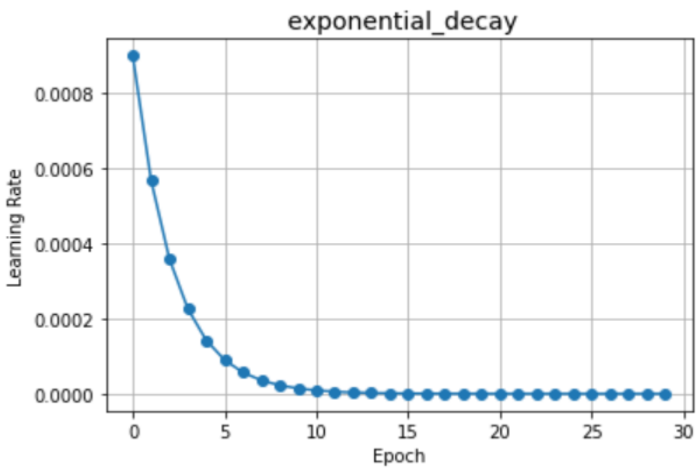


Fig. 4 Training and validation accuracy plot and train loss and validation loss for VGG16 with Adam Architecture

Fig. 4 shows the training and validation accuracy obtained with respect to epochs and shows the train and validation loss with respect to epochs for VGG16 with Adam architecture. Total number of epochs used is 30.



	precision	recall	f1-score	support
0	0.92	0.89	0.91	55
1	0.87	0.85	0.86	54
2	0.81	0.85	0.83	55
accuracy			0.87	164
macro avg	0.87	0.87	0.87	164
weighted avg	0.87	0.87	0.87	164

Fig. 5 Classification report for VGG16

The Fig.5 shows the classification report for VGG16 with Adam architecture which shows “Precision, recall, f1-score and support” for each of its class.

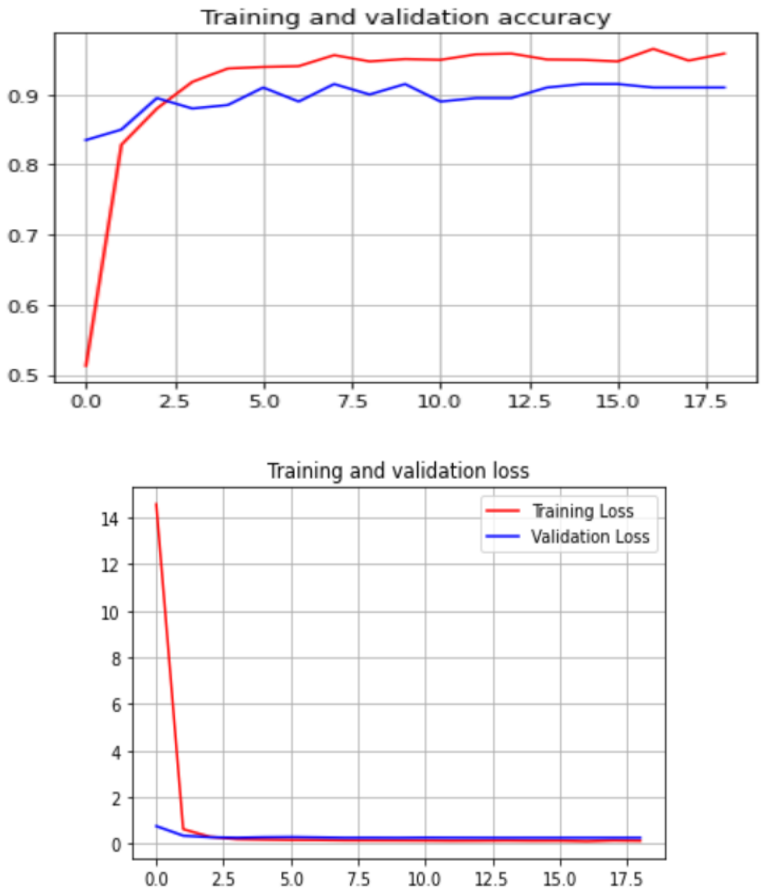
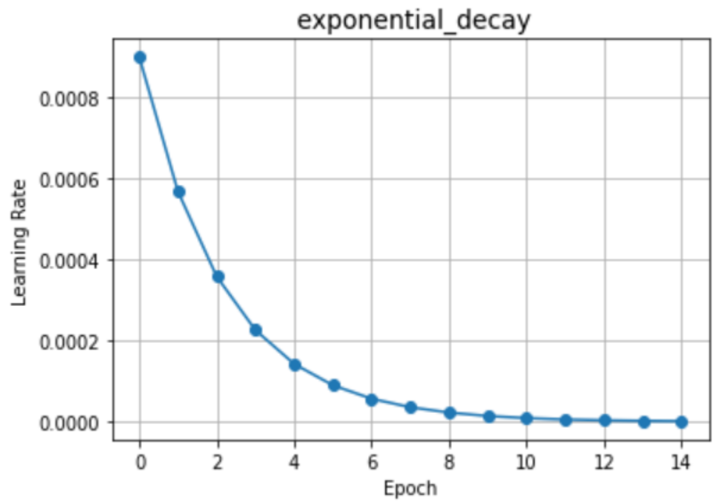


Fig. 6 Training and validation accuracy plot and train loss and validation loss for Inception V3 with Adam Architecture

Fig.6 shows the training and validation accuracy obtained with respect to epochs and shows the train and validation loss with respect to epochs for Inception V3 with Adam architecture.

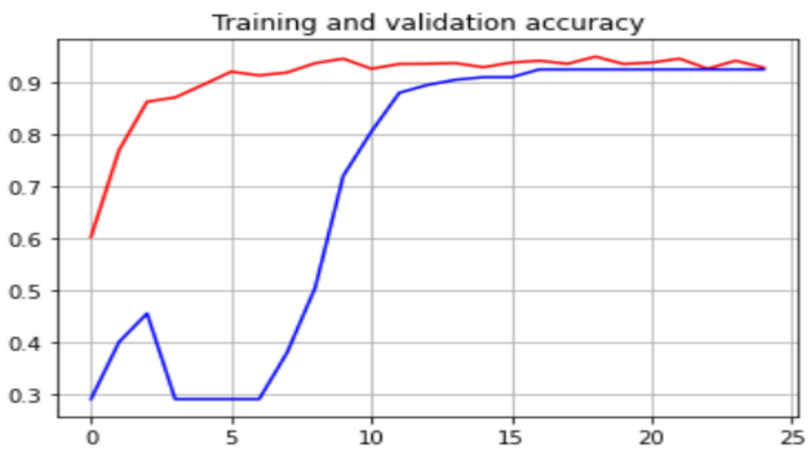


	precision	recall	f1-score	support
0	1.00	1.00	1.00	55
1	0.88	0.81	0.85	54
2	0.83	0.89	0.86	55
accuracy			0.90	164
macro avg	0.90	0.90	0.90	164
weighted avg	0.90	0.90	0.90	164

Fig. 7 Classification report for Inception V3

The Fig. 7 shows the classification report for Inception V3 with Adam architecture which shows "Precision, recall, f1-score and support" for each of its class.

PaddyLeaf15 CNN Architecture
Plot of accuracy and loss for PaddyLeaf15 CNN



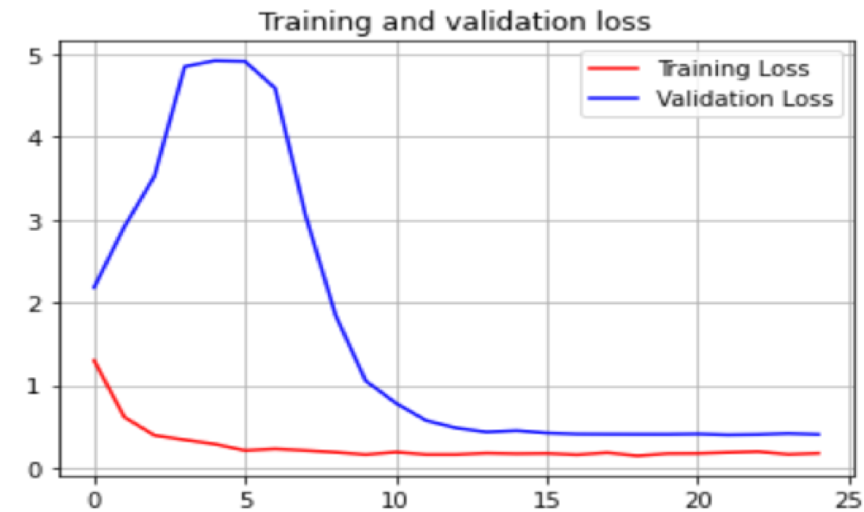
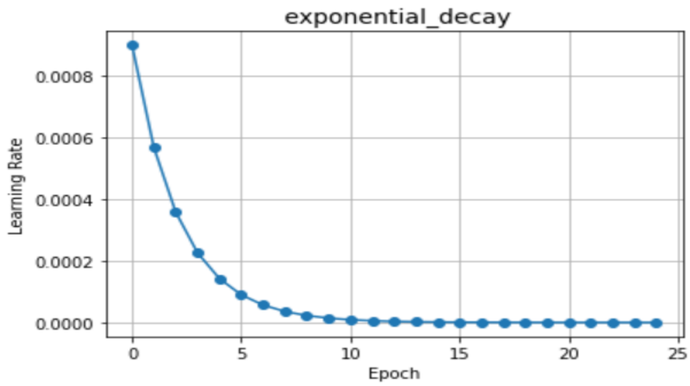


Fig. 8: Training and validation accuracy plot with respect to epochs and train loss and validation loss with respect to epochs for PaddyLeaf15 CNN Architecture

Figure 8 shows the training and validation accuracy obtained with respect to epochs and shows the train and validation loss with respect to epochs for Retina CNN with SGD architecture. Total number of epochs used is 25.

Classification report for PaddyLeaf15 CNN

Figure 9 shows the classification report for PaddyLeaf15 CNN with Adam architecture which shows "Precision, recall, f1-score and support" for each of its class.



	precision	recall	f1-score	support
0	0.96	1.00	0.98	55
1	1.00	0.78	0.88	54
2	0.85	1.00	0.92	55
accuracy			0.93	164
macro avg	0.94	0.93	0.92	164
weighted avg	0.94	0.93	0.92	164

Figure 9. Classification report for PaddyLeaf15 CNN

Table 2. Comparison of performance of proposed model with pre-trained deep CNN models

CNN Architectures	Training Accuracy	Testing Accuracy
Proposed CNN	95%	93%
VGG16	92%	87%
VGG19	88%	81%
Inception v3	95%	92%

Table 2 and figure 10 shows the comparison for different architectures and proposed model named PaddyLeaf15 CNN with Adam optimizer gives a training accuracy of 95% and testing accuracy of 93%. VGG19 architecture with Adam optimizer gives a training accuracy of 88% and testing accuracy of 81%. VGG16 Architecture with Adam optimizer gives a training accuracy of 92% and testing accuracy of 87%. Inception V3 architecture with Adam optimizer gives a training accuracy of 95% with 92% testing accuracy.

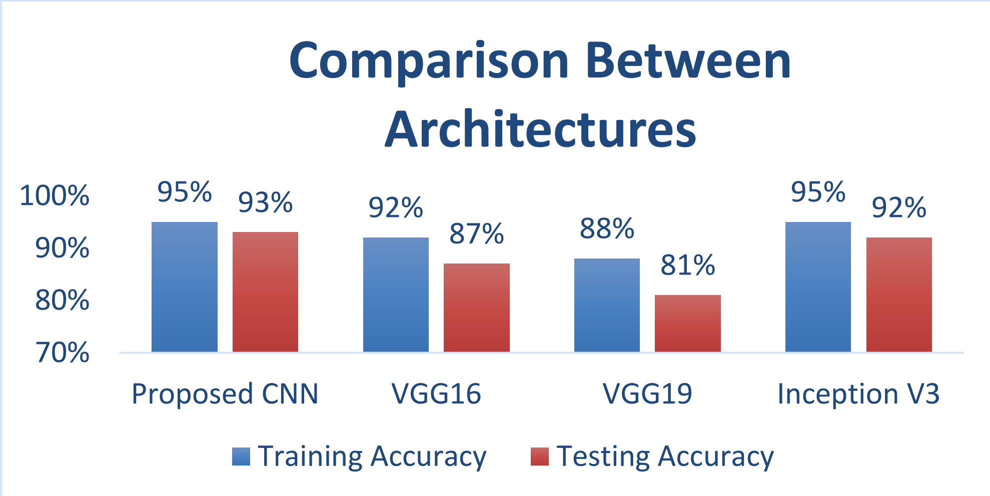


Figure 10. comparison of performances of deep CNN models

Conclusion

The classification of plant *diseases* biggest difficulties in the agricultural sector. Early detection and diagnosis of Rice Leaf Disease to prevent loss and help farmers with a high yield. An accurate and timely detection of diseases and pests in rice plants can help to reduce economic losses substantially. The results indicate that proposed PaddyLeaf15 CNN gives a accuracy of 93% as compared to deep learning architectures VGG 16 and Inception V3 models.

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