Deep Learning Based Algorithm to Predict Plant Diseases: A Case Study with Rice Plant Disease Prediction

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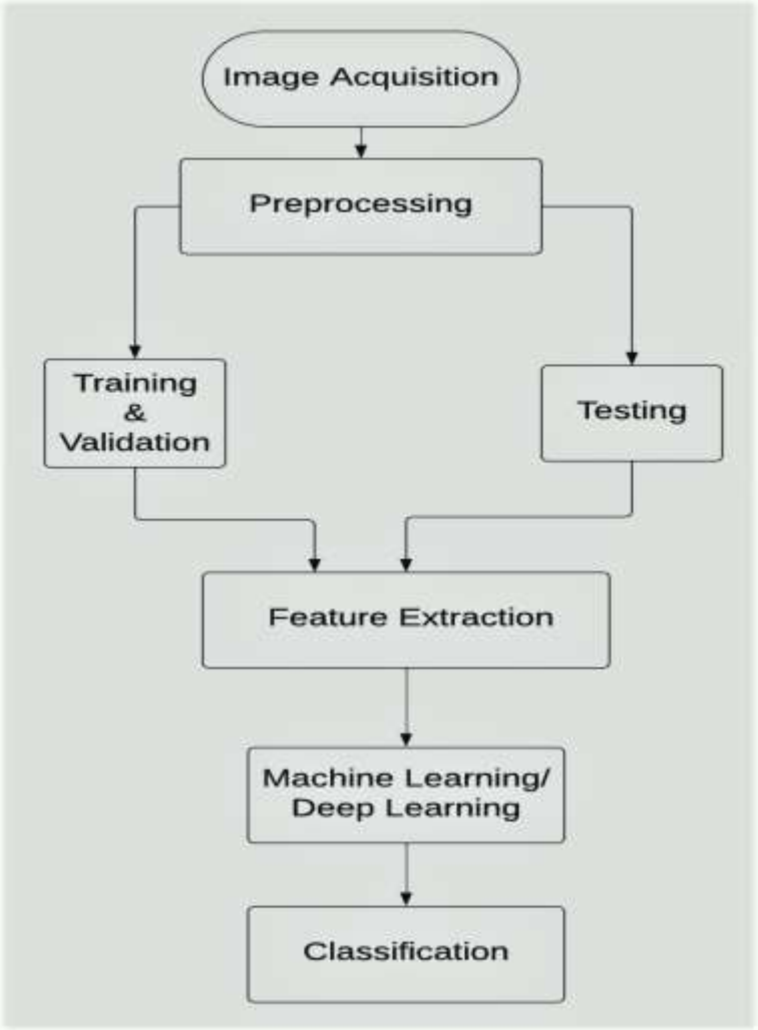
Thesis Statement:

- ❑ Building an automated accurate identification system of Rice plant diseases
- ❑ Giving a easier identification for detecting Rice plant diseases of Bangladesh
- ❑ Building an effortless system for the identification of Rice plant diseases
- ❑ Work with Bangladeshi Dataset that contains images of different rice plant diseases
- ❑ Data Augmentation technique to get better results
- ❑ Pretrained model for feature extraction
- ❑ CNN and other deep learning model to correctly classify Rice plant diseases
- ❑ Machine learning models for comparison analysis

Motivation :

- ❑ Early detection of rice plant disease is crucial for crop protection system.
- ❑ Traditional visual observation methods are mostly inaccurate.
- ❑ Laboratory testing requires time and can be expensive.
- ❑ Insufficient research done on Bangladeshi rice plant diseases.
- ❑ Availability of smartphones makes it easier for farmers to use advanced image processing methods to detect rice plant diseases.
- ❑ Prevent farmers from using excessive pesticides on rice plants.

Workflow Diagram



Literature Review :

Paper 01 : Rice Disease Identification and Classification by Integrating support vector machine with Deep Convolutional Neural Network.

- Date : 2019
- Author :Md.jahid Hasan,Shamim Mahbub,Md.Shahin Alam,Md.Abu Nasim.

- ❑ A hybrid network integrating Deep CNN with SVM for classification.
- ❑ Transfer learning Techniques has been used in order to improve proposed model.
- ❑ Features are extracted using D-CNN and SVM classifier is trained with the features.

Literature Review :

Strength :

- The proposed model achieved 97.5 % accuracy
- Complex AI system integrating SVM and D-CNN are used

Weakness :

- Small datasets for training and testing
- Combination of D-CNN and SVM only works on small dataset

Literature Review

Paper 02 : Rice plant Disease Detection and Classification Techniques: A Survey

- Date : 2021
- Author :Tejas Tawde,Kunal Deshmukh,Lobhas Verekar ,Ajay Reddy.

- ❑ Focuses to distinguish different methods based on classifier used.
- ❑ Gives insight of the different techniques used for the identification of Rice plant Diseases
- ❑ A hardware prototype and model using CNN is proposed

Literature Review

Strength :

- ❑ The proposed model achieved 96% accuracy
- ❑ Deep Learning models are used (CNN)

Weakness:

- ❑ Small datasets
- ❑ Latest Architectures of CNN model are not used

Literature Review :

Paper 03: Rice Leaf Disease Detection Using Machine Learning Techniques.

- Date : 2019
- Author : Kawcher Ahmed,Tasmia Rahman,Md irfanul Alam,Sifat Momen(NSU)

- ❑ Applied four supervised classification algorithms to detect three diseases
- ❑ Disease detection model was developed using CNN
- ❑ Affected parts were separated using K-means clustering and SVM
- ❑ For extracting the features of an image, HOG was used

Literature Review :

Strength :

- ❑ Achieved 96.77% accuracy
- ❑ Dataset trained using KNN, logistic regression, j48, naive bayes

Weakness :

- ❑ Only 400+ pictures are used here for training
- ❑ Only three rice plant diseases are detected here
- ❑ Deep learning models are not used here
- ❑ Only traditional machine learning models are used

Literature Review :

Paper 04: Rice Blast Disease Detection and Classification Using Machine Learning Algorithm.

- Date : 2018
- Author : S Ramesh and D.Vydeki (VIT Chennai)

❑ Appropriate features are extracted

❑ Images are classified using ANN

❑ K-Means Clustering is used for Image Segmentation

Literature Review :

Strength :

- ❑ An accuracy of 99% for the blast infected images
- ❑ An accuracy of 100% for the normal images

Weakness :

- ❑ Only one leaf disease is detected here
- ❑ Testing phase accuracy is found to be 90% for the infected and 86% for the healthy images
- ❑ Total 300 leaf samples are taken as dataset

Literature Review :

Paper 05 : Rice Leaf Disease Recognition using Local Threshold Based Segmentation and Deep CNN

- Date : 2021
- Author: Anam Islam,Redoun Islam,S. M. Rafizul Haque,S. M. Mohidul Islam(KU)

- ❑ Local Threshold method is used for image segmentation
- ❑ Three CNN architecture models VGG16, ResNet50, DenseNet121 are used for classification
- ❑ CNN is trained with the segmented images

Literature Review :

Strength :

- ❑ A dataset of their own is created and used
- ❑ Segmented dataset is used

Weakness:

- ❑ A small dataset of 786 images is used
- ❑ 78.84 % test accuracy

Literature Review :

Paper 06 : Application of machine learning in detection of blast disease in South Indian rice crops.

- Date : 2019
- Author: S Ramesh and D.Vydeki (VIT Chennai)

- ❑ Detected Rice Blast disease using KNN and ANN classification techniques.
- ❑ K-means Clustering is used for image segmentation
- ❑ The extracted features are applied to a classifier to determine whether it is an image of infected crop or not

Literature Review :

Strength :

- The ANN classifier provides 99% accuracy for normal images and 100% for blast infected images

Weakness:

- Detected only one type of disease(Rice Blast)
- A small dataset of 451 images is used
- K-means Clustering segmentation method is used whereas there are other methods which gives more accurate result

Literature Review :

Paper 07 : Identification of Various Rice Plant Diseases Using Optimized Convolutional Neural Network

- Date : 2021
- Author : Md. Sazzadul Islam Prottasha , A. B. M. Kabir Hossain , Md. Zihadur Rahman , S M Salim Reza , Dilshad Ara Hossain

- ❑ An optimized CNN architecture based on depthwise separable convolutions
- ❑ 1677 images were used which were further augmented to 16770
- ❑ Along with proposed CNN model different lightweight state-of-the-art CNN architectures have been used and results were analyzed

Literature Review :

Strength :

- ❑ Relatively small parameter size of 2.4 Million
- ❑ Depthwise convolution reduce computational cost and parameter size
- ❑ 12 classes of diseases are being used in the dataset
- ❑ Accuracy of 96.3%

Weaknesses :

- ❑ Bias and misclassification among some diseases, namely brown spot, leaf smut and leaf scald due to similar characteristics

Literature Review :

Paper 08: Rice Plant Disease Classification Using Transfer Learning Of Deep Convolutional Neural Network

- Date : 2019
- Author : Vimal K. Shrivastava , Monoj K. Pradhan, Sonajharia Minz , Mahesh P. Thakur

- ❑ Deep convolutional Neural Network (CNN) as feature extractor & Support Vector Machine (SVM) as a classifier
- ❑ AlexNet deep CNN pre-trained on large ImageNet dataset was used for feature extraction

Literature Review :

Strength :

- ❑ Accuracy of 91.37%
- ❑ AlexNet model pre-trained on large ImageNet dataset of 1.2 Million Images & 1000 classes

Weakness:

- ❑ Relatively small dataset of 619 images
- ❑ Research based on only 3 types of rice diseases
- ❑ Unavailability of standard labelled rice disease images

Uniqueness in our work:

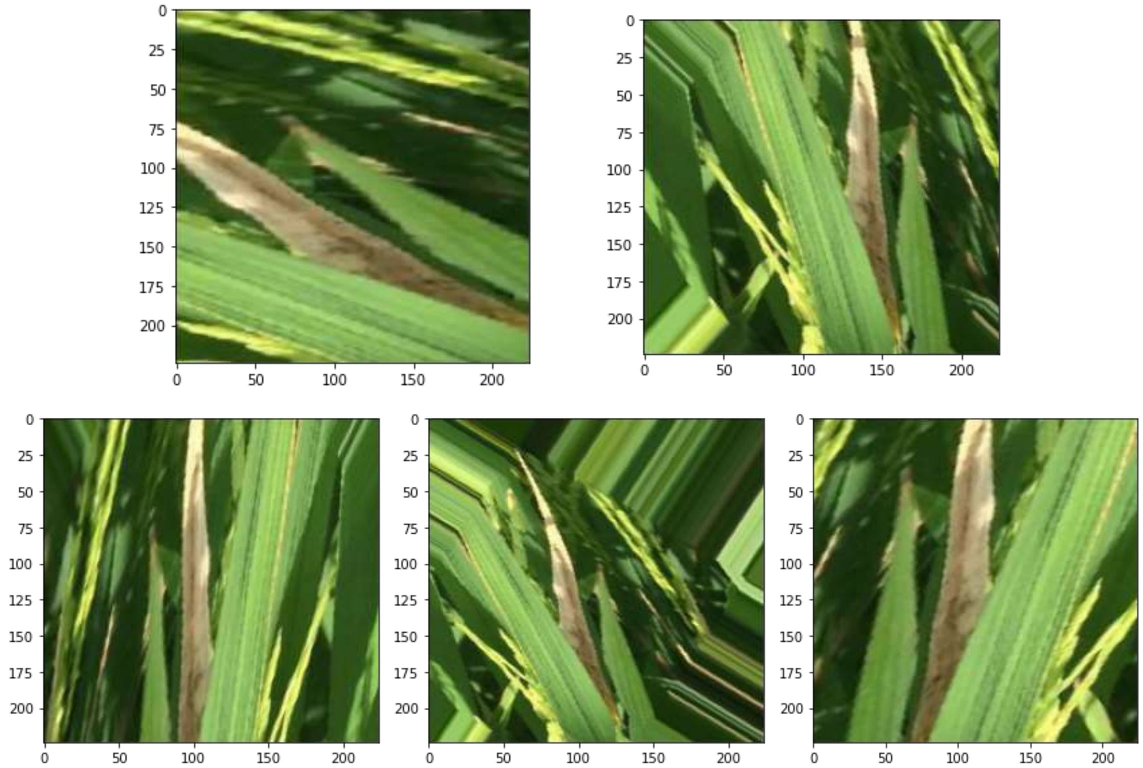
- ❑ Work on a dataset that is not previously used before
- ❑ Use Transfer learning approach
- ❑ Use both deep learning and machine learning approach for comparison analysis
- ❑ Fine tuning of the pretrained models
- ❑ Different Augmentation techniques to increase the dataset and get better training accuracy
- ❑ Custom Cnn model is used which provides superior accuracy
- ❑ Gabor and Sobel Filter for feature extraction
- ❑ Changing some layers of the pretrained models

Proposed Approach And its Solution

- Training and testing on a unique dataset consists of 5932 images
- Classification of four different Rice plant diseases
- Vgg19,Vgg-16,Resnet50,custom CNN,InceptionV3 for feature Extraction
- Data - Augmentation for increasing the datasets size and better train the model
- Transfer Learning for getting better accuracy
- Using machine learning models KNN, SVM, Decision tree,Adaboost,Random Forest as per necessity
- Comparison within different models
- Gabor Filter and Sobel filter for feature Extraction

Augmented Images

Original Image



Data Acquisition :

- A dataset of four major diseases of rice leaf called Brown Spot, Bacterial Blight, Rice Blast, Rice Tungro.
- The dataset contains 5932 images of rice plant diseases of Bangladesh as well as other countries.
- This dataset of “Rice Leaf Disease Image Samples” is used for rice leaf diseases classification, diseases detection using Computer Vision and Pattern Recognition for different rice leaf disease.
- Website Link:” https://data.mendeley.com/datasets/fwcj7stb8r/1”

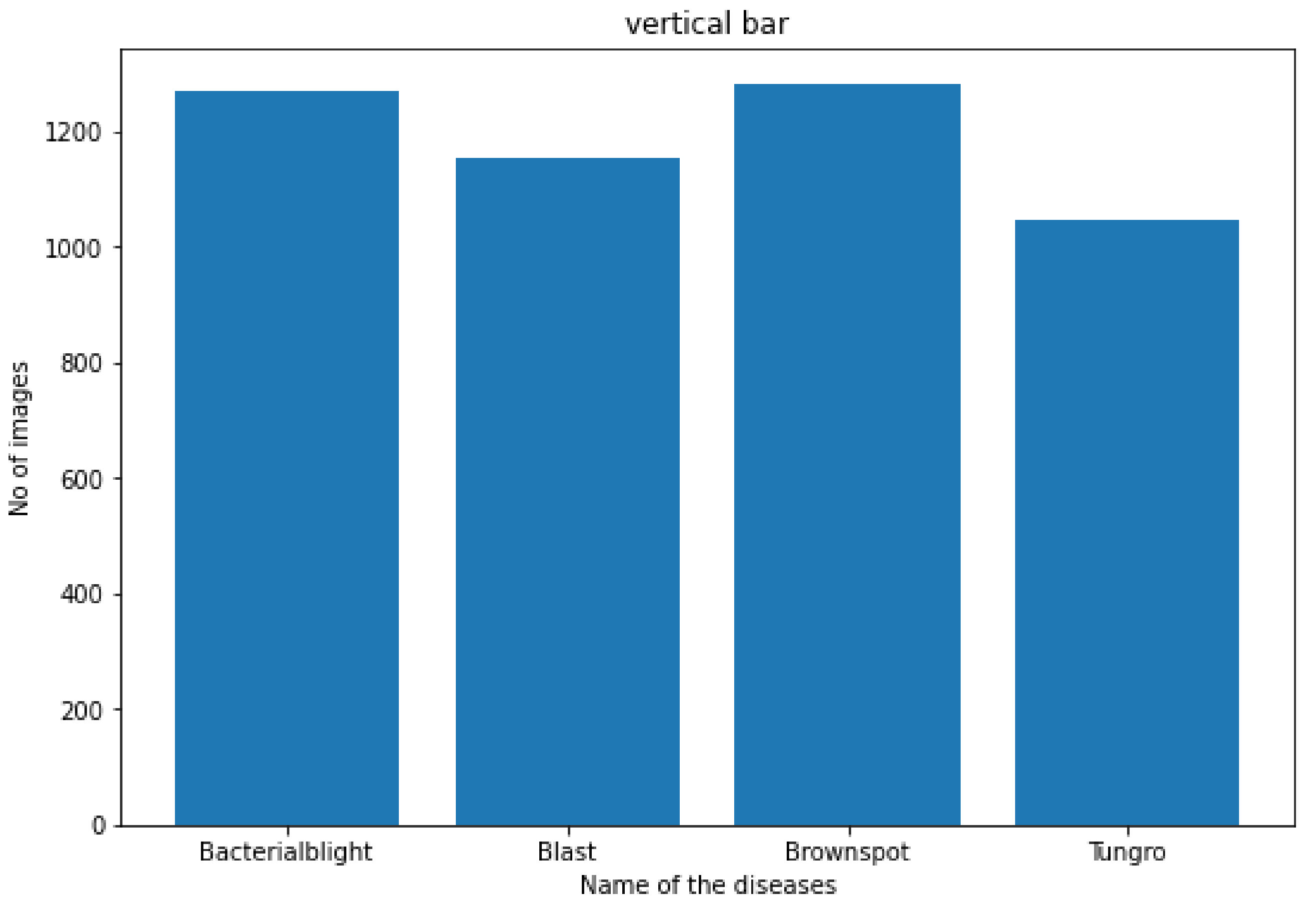


Figure: Training Data Distribution

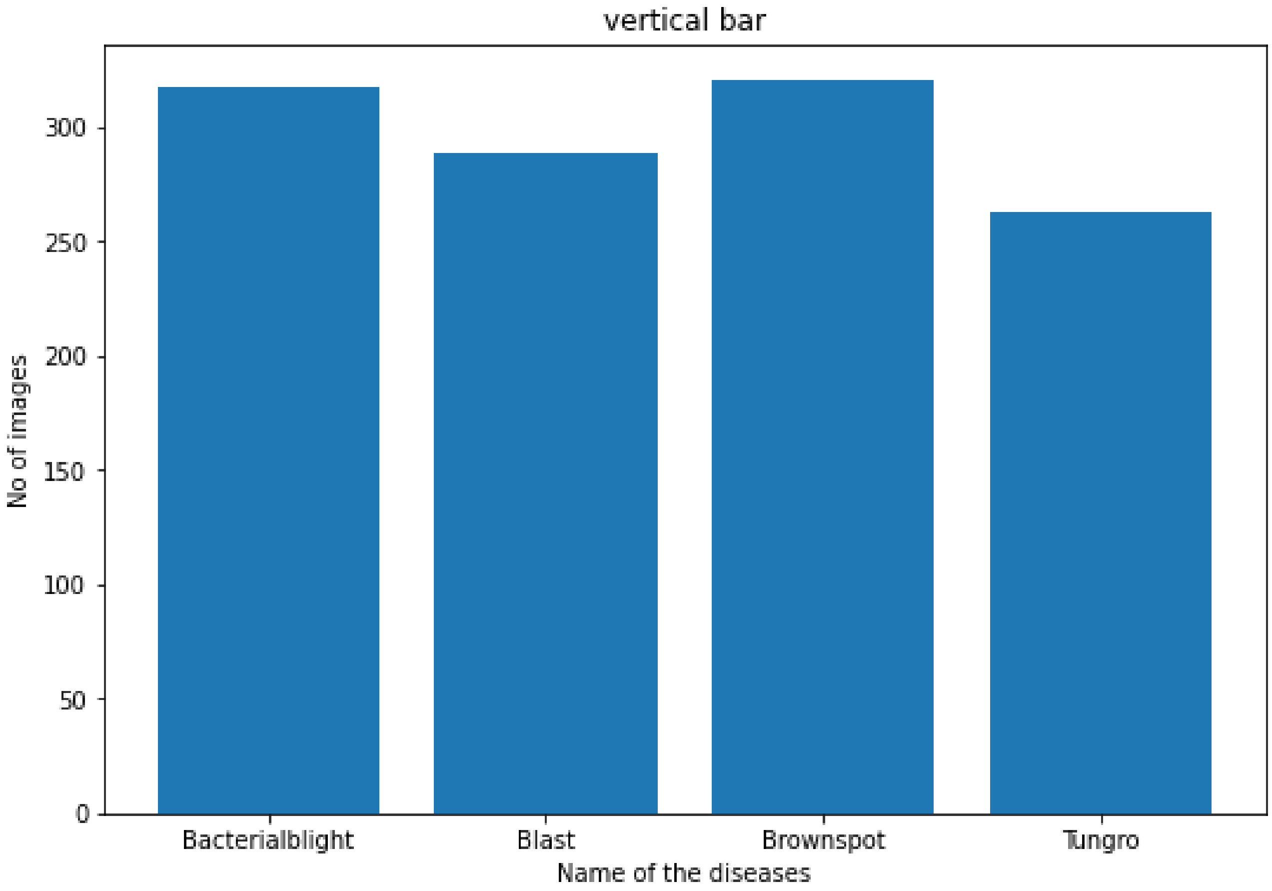


Figure: Test Data Distribution

Methodologies and Algorithms

- Deep learning and Machine learning models are used for comparison
- Transfer Learning techniques are used to get higher prediction accuracy
- Pre-trained models (vgg-16, Inception-V3, vgg-19, ResNet-50) is used for feature extraction
- Convolutional Neural Network (CNN) is used for disease classification
- From traditional Machines learning models KNN, SVM, AdaBoost, Decision Tree and Random Forest are used
- For feature extraction in machine learning approach, the Gabor filter followed by the Sobel filter is used for better texture analysis and edge detection

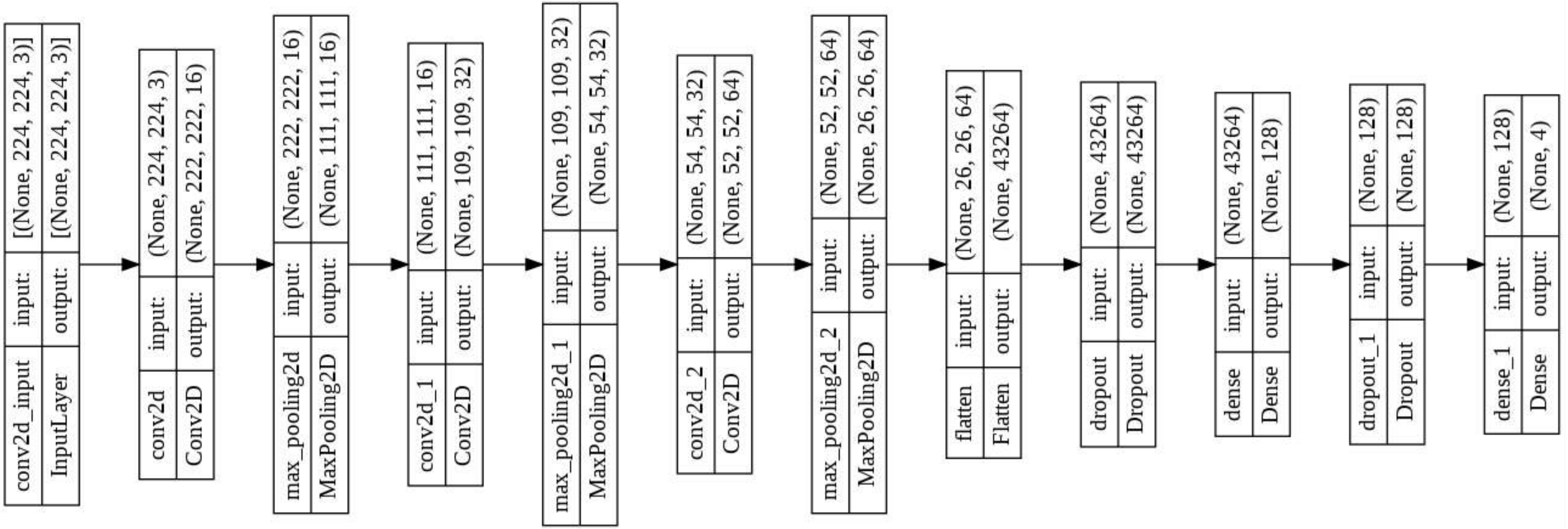


Figure: Custom CNN Model

Deep Learning Model Architectures

- Custom CNN model of total twelve layers
- Convolution layer followed by max-pooling layer are used
- Relu activation function after each convolution layer
- Flatten layer to convert the 2-D arrays to a single linear vector
- Two dense layer of output 128 and four(number of classes)
- Two dropout layers of dropout ratio of 0.2
- Softmax activation in the output layer
- In pretrained models, input and output layers are changed
- All other layers are kept frozen
- A flatten layer and two consecutive dense layers are added at last

Gabor Filter

$$g_{\lambda,\theta,\varphi,\sigma,\gamma}(x,y) = exp\left(-\frac{(x^2+\gamma^2 y^2)}{2\sigma^2}\right) cos(2\pi\frac{x}{\lambda}+\varphi)$$

λ – Wavelength of Gabor function cosine factor.

θ – Orientation of Gabor function normal to the parallel stripes.

φ – Phase offset of the of Gabor function cosine factor.

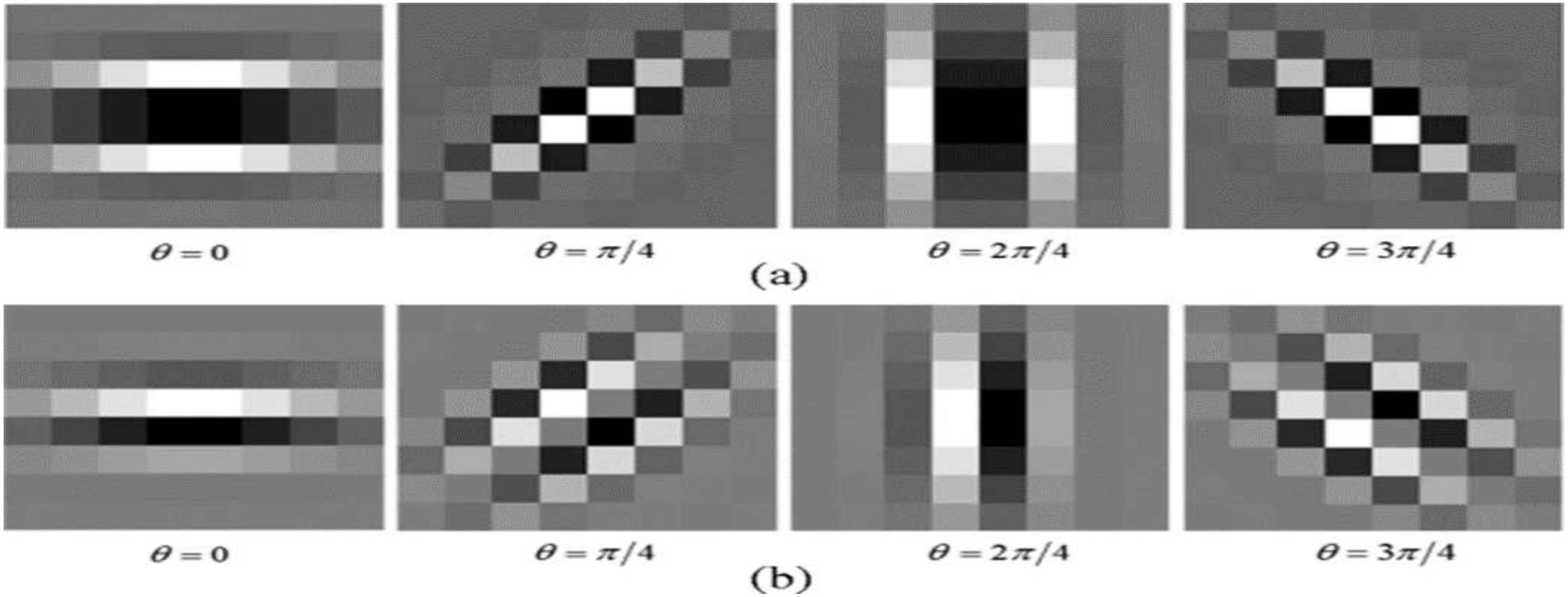
σ – Standard deviation sigma of Gaussian factor.

γ – Ellipticity of the Gaussian factor.

Gabor Filter

- This filter is convoluted over the image to extract feature
- Used to extract feature, texture analysis and edge detection
- Similar as gaussian filter
- if gamma=1 which means it is a circular kernel
- theta determines the orientation of the kernel
- phi is the phase difference which is usually set to 1
- Can create a gabor feature bank and convolute over the images

Gabor Filter



Gabor Filter Parameters settings

- Created 256 Gabor features byt changing the parameter of gabor kernels
- theta values range is 0 to .78(radian) which sets the orientation of the Kernel
- lambda values 0 to .78(radian) determines the wide of the strips
- gamma values .05 to .5 determines the height of gabor kernels
- phi is set to zero so phase offset is set to zero for all generated kernels
- kernel size is set to 5*5
- kernels are convoluted over the images and features are extracted

Feature Extracted Images
(Gabor Features)

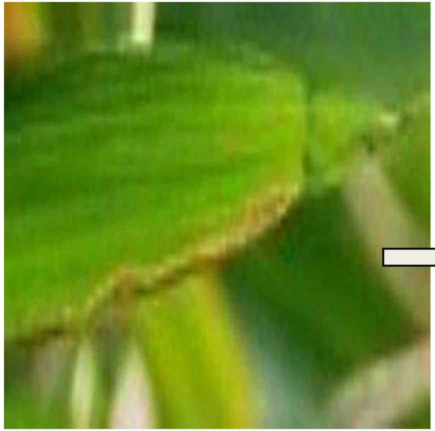


fig: **Normal Image**

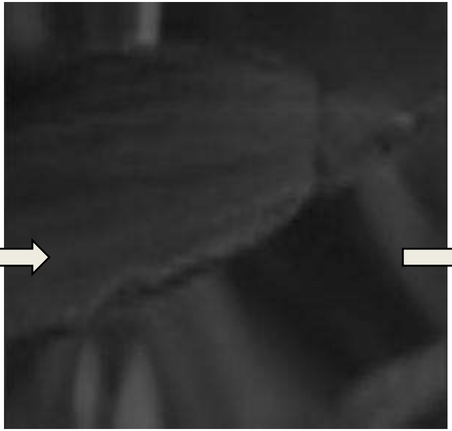


Fig: **7th Stage**

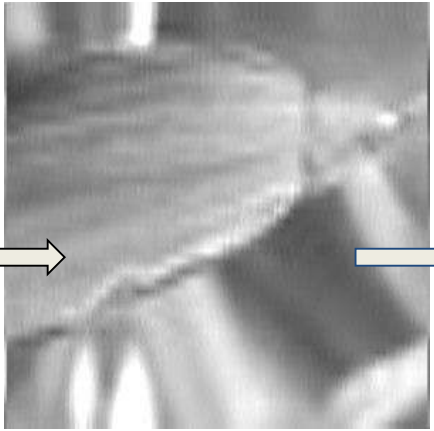


Fig: **63rd stage**

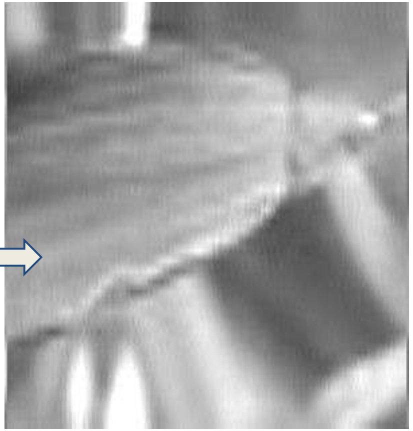
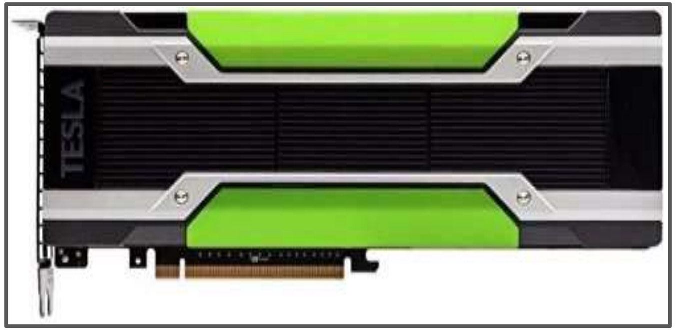


fig: **256th stage**

Tools, Devices/Platforms



Result Analysis for Machine Learning Models

Classifiers	Accuracy	Precision	Recall	F1-Score
Random Forest	**0.96**	0.97	0.97	0.97
KNN	**0.75**	0.80	0.75	0.75
AdaBoost	**0.902**	0.90	0.90	0.90
SVM	**0.81**	0.82	0.81	0.79
Decision Tree	**0.89**	0.91	0.89	0.89

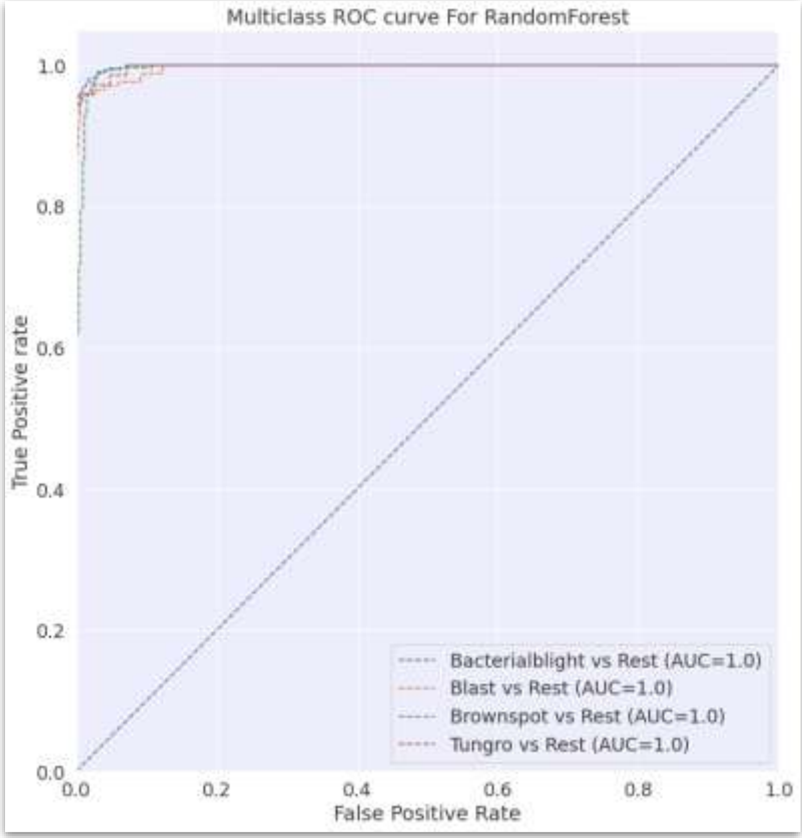


fig: ROC curve for Random Forest

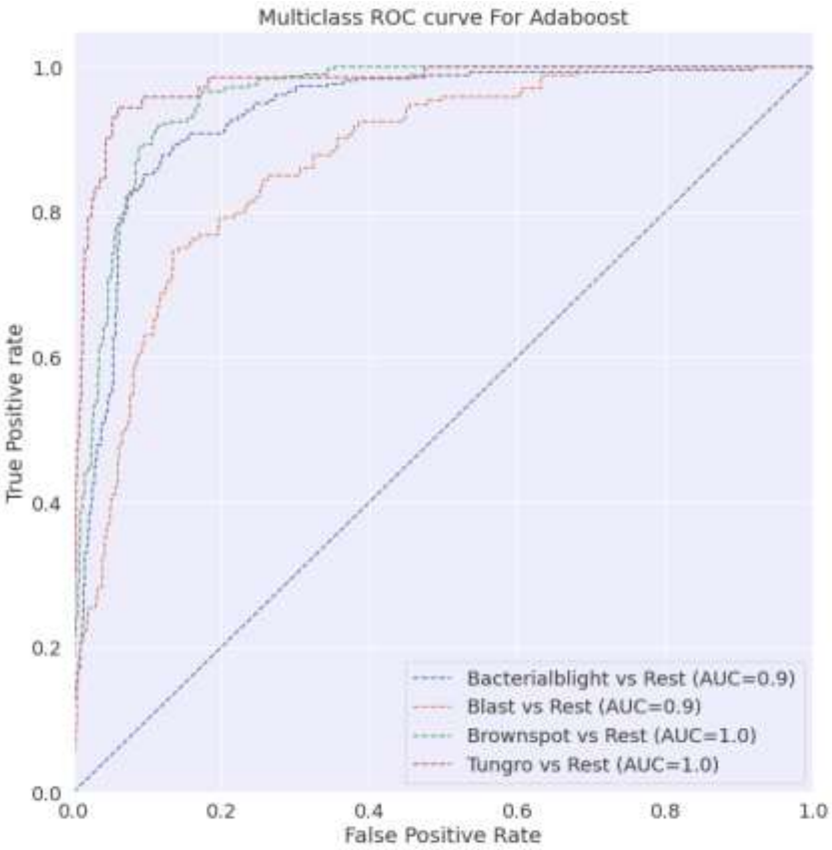


fig: ROC curve for AdaBoost

Parameters and Hyperparameters

- Besides the inceptionV3 model, all other models have the same input size of 224x224x3.The inceptionV3 model needs to have an image input size of 229x229x3.
- After many trials and errors, a batch size of 8 for these images has been selected for the best possible accuracy.
- The Adam optimizer has a faster computation time, and requires fewer parameters for tuning. This makes it the best option for all the deep learning models.
- The Loss Function used for all the models is the Sparse Categorical Crossentropy (SCC).
- Since the truth labels are integer encoded, the loss function for the deep learning models has been fixed to Sparse Categorical Crossentropy (SCC)
- The Learning rate has been fixed to 0.001
- We have set the number of epochs to 40 for all the models.

Hyperparameter Tuning (for 40 epochs)

Classifiers	Batch Size	Accuracy(%)
	32	85
Custom CNN	16	88
	8	97
	32	89
Inception V3	16	90
	8	98
	32	91
VGG-16	16	94
	8	97

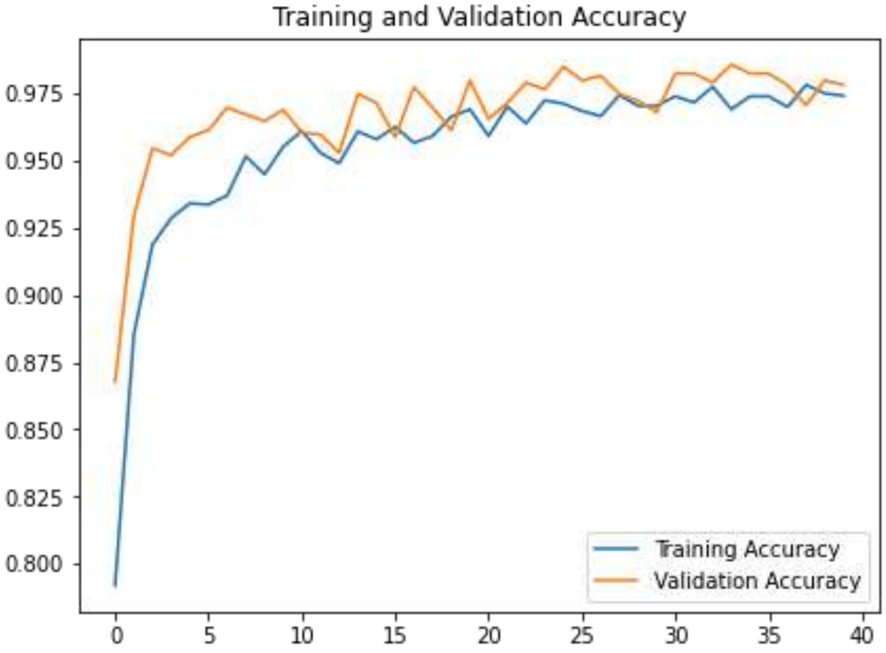
Hyperparameter Tuning (for 40 epochs)

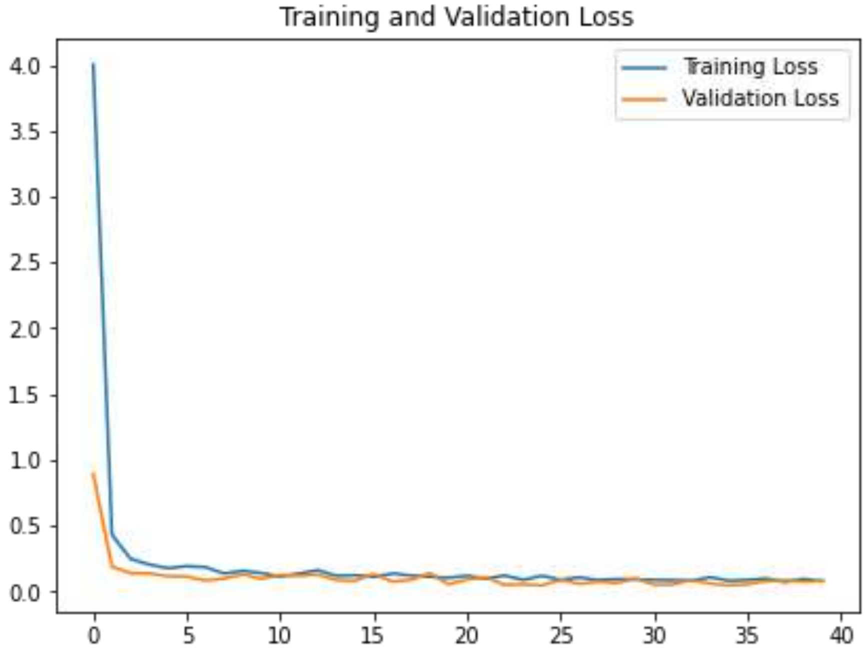
Classifiers	Batch Size	Accuracy(%)
	32	89
VGG-19	16	95
	8	98
	32	69
Resnet-50	16	65
	8	71

Result Analysis for Deep Learning Models

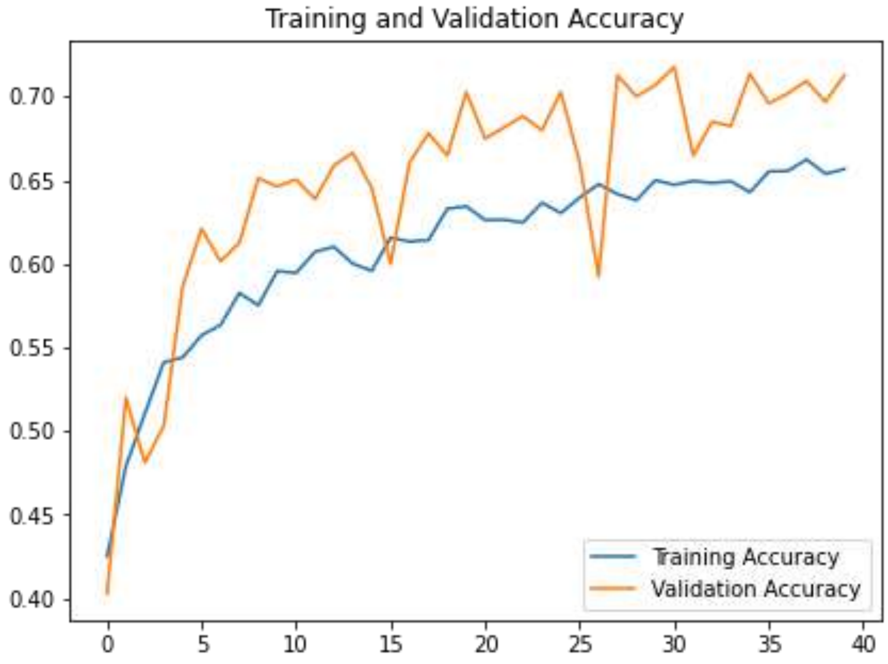
Classifiers	Accuracy	Precision	Recall	F1-Score
Custom CNN	**0.97**	0.97	0.97	0.97
VGG-16	**0.97**	0.97	0.97	0.97
VGG-19	**0.98**	0.98	0.98	0.98
InceptionV3	**0.98**	0.98	0.98	0.98
ResNet-50	**0.71**	0.72	0.71	0.69

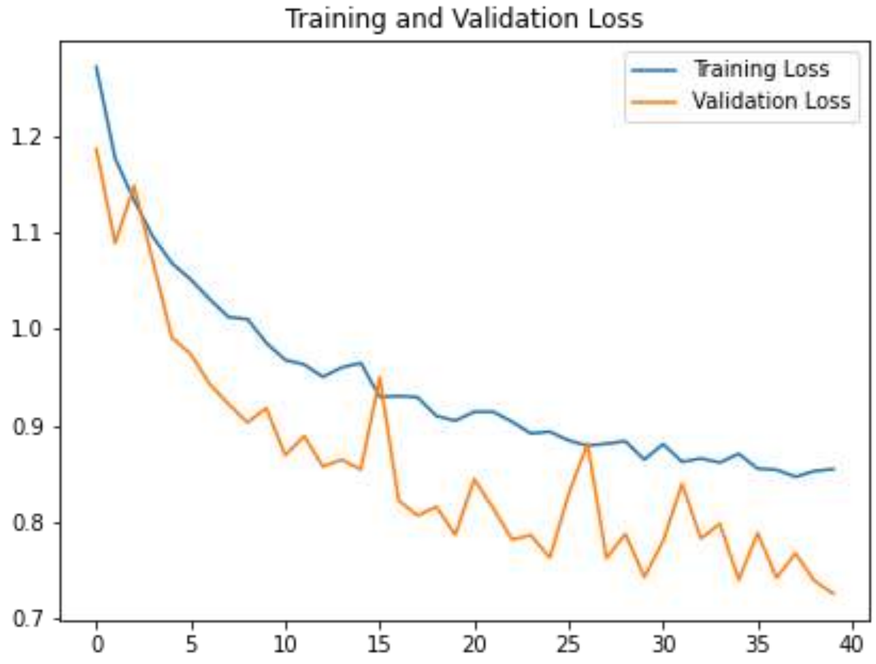
Training Vs Validation Graph
(Inception V3)



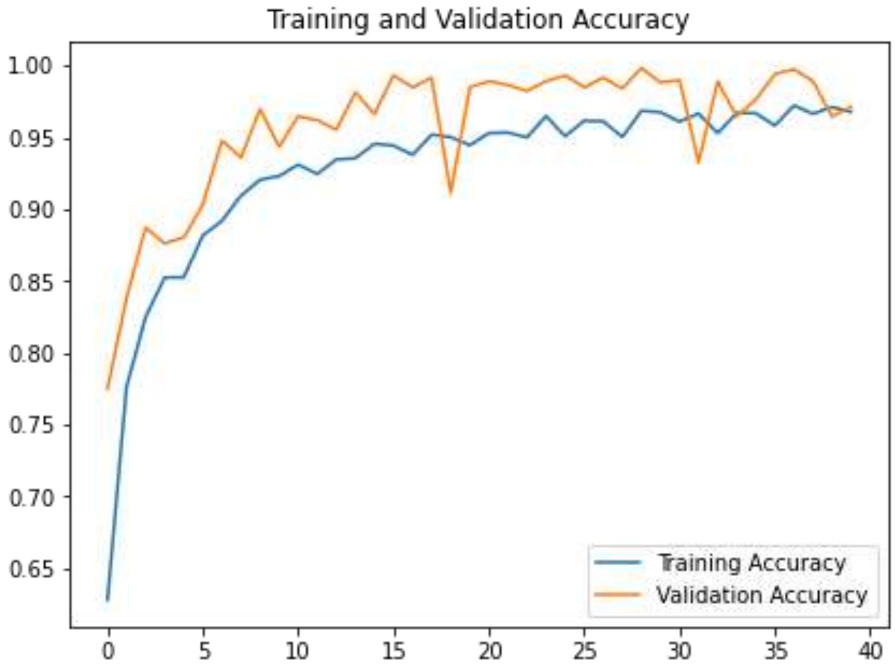


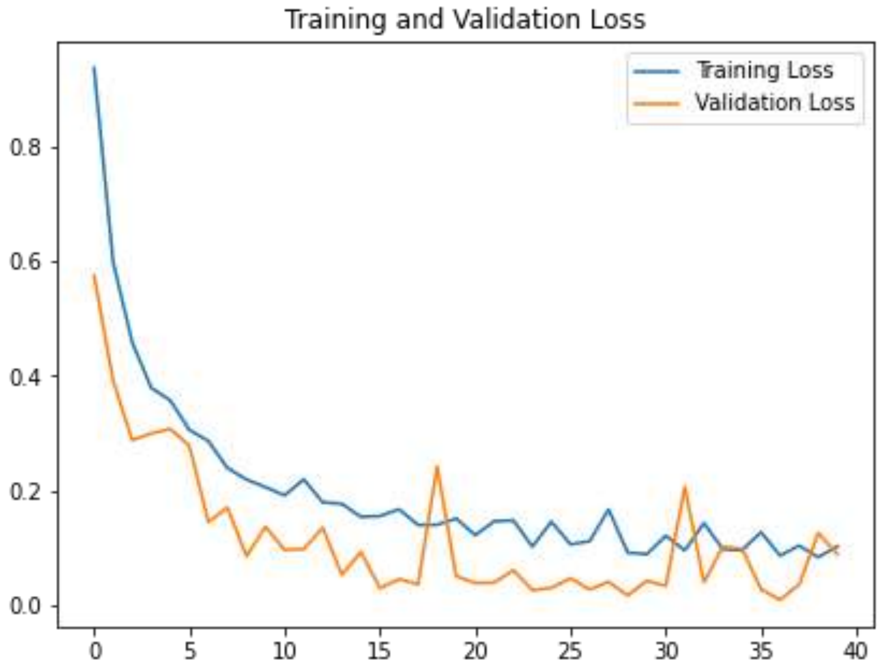
Training Vs Validation Graph (ResNet-50)





Training Vs Validation Graph (Custom Model)





Limitations

- Minimize the number of parameters to optimize the custom CNN model to make it lightweight
- The dataset only has four types of Rice plant diseased images
- Use other plant diseases for classification
- Deep Learning is very hardware dependent and takes a lot of time to prepare in a larger dataset as it is not possible to get a good result without tuning hyperparameter a reasonable amount of time. Therefore, a powerful Quadro GPU is needed to reduce this time-consuming problem, which is economically very expensive.
- We could have tried more feature extraction methods to increase the accuracy of the machine learning classifiers

Future Work

- First of all, dataset size can be increased. The bigger the number of images the better the model is trained
- More types of Rice plant diseases can be added to classify a variety of Rice plant diseases
- The system can be transformed into a web application or mobile Application. Using the mobile application the farmers can automatically detect Rice plant diseases

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Thank you