Rice Leaf Disease Detection Using Covolutional Neural Network Architecture with Transfer Learning Approach

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***Abstract*—Rice (Oryza Sativa) is one of the most grown crops all over the world. The seed of the grass species Oryza Sativa is commonly identified as rice. Rice is consumed all over the world as a main source of carbohydrate, specially in Asian countries. As a South Asian country, our homeland Bangladesh has identified rice as its staple food. Throughout the world, rice leaf diseases cause a huge loss in rice production each year. Traditionally, rice leaf diseases are detected in laboratory tests, which is time consuming. If machine learning and computer vision based approaches- which are faster and more accurate comparing to manual detection of rice leaf diseases- can be implemented to detect rice diseases, a substantial amount of production loss pertaining to these diseases can be mitigated. Deep learning frameworks, such as, Convolutional Neural Networks have been proven to be highly efficient in image classification and object detection from images. They can be utilized to classify different rice diseases and thus, can play a vital role in early detection of rice diseases and consequently, improving the production. In this work, we proposed a Convolutional Neural Networks (CNN) architecture based on InceptionV3 to detect three prominent diseases of rice (Oryza Sativa) leaf seen in our country. Our proposed model showcased an accuracy of 84%.**

***Index Terms*—Convolutional Neural Network, Rice Leaf Disease, Rice Leaf Disease Detection, CNN, Image Classification, Transfer Learning, InceptionV3**

I. Introduction

Bangladesh is an agricultural country. Around 80% of its workforce is involved directly or indirectly with agriculture sector, among which, 60% is involved in rice production. Among all the crops, rice is one of the vital crops of our country. Bangladesh is the 3rd largest rice producing country in the world. Combined endeavors of farmers, rice researchers, expansion workforce, of Bangladesh was able to produced 37.4 million tonnes of rice in 2020 [5].

Unfortunately, the efforts of agriculturists and farmers to improve the production of rice have been dismayed by various rice plant diseases every year. Various rice plant diseases has cost the farmers to bear a heavy burden of loss each year. Among the frequent thirty diseases of rice plants, seven to eight diseases are found common in Bangladesh [8]. Rice diseases of financial significance that require cautious consideration for expanded efficiency are Blast, Narrow brown spot, Tungro, Brown spot, Blight, Stem Rot, False Smut, Foot Rot, Bakanae, Bacterial Leaf Streak, , Grassy Stunt, Yellow Dwarf, Root-knot, White Tip, Ufra [2].

Traditionally, rice diseases are detected through laboratory inspection of rice leaves. Although carrying high accuracy, these traditional approach is time lengthy which has an adverse effect in rice disease detection. Farmers have a very short time window between disease infestation and curing of plants. If the detection process can be made faster with high accuracy, rice production can be improved drastically.

The development of Artificial Intelligence (AI) has revolutionized many sectors including diseases detection of plants and animals. Deep learning methods can now be deployed to detect diseases from image classification by neural network frameworks. A wide range of diseases in animals and plants can now be precisely and faster through the utilization of theses classification architectures. Likewise, agriculture sector is no alien to deep learning frameworks. Various AI technologies are now being utilized in agriculture everyday. Multiclass image detection architectures can be used in agriculture sector to classify various diseases of plants from diseased images. Furthermore, Deep Learning approaches are applied in crop detection [6], weed discrimination [3], and identification of fish species [16].

Convolutional neural networks(CNN) have showcased highers efficiency in image classification task with lesser time duration without human intervention. Therefore, machine learning methods such as the various CNN models, Probabilistic Neural Network, AlexNet Neural Network, Deep CNN, Support Vector Machine- Sequential Forward Floating Selection (SVM-SFFS), Deep Feature Based SVM has employed to make it easier to identify the diseases at early stages to detect diseases [20] [12]. Hence, the disease detection time span can be lessened resulting in early curing procedures of crops.

In this paper, we have used a Convolutional Neural Network Framework, InceptionV3, to detect three prominent rice leaf disease of Bangladesh, namely, Brown Spot, Hispa,. To train and test the model we have used diseased rice leaf dataset that we collected from Kaggle. The model showed 84% efficiency in detecting these three diseases from images.

II. Related Works

Chowdhury Rafeed Rahman et. al used a simple CNN to identify six rice diseases. They worked with a rice image dataset of 1,426 collected from the Bangladesh rice research institute (BRRI).Their main focus was three rice diseases which are bacterial leaf blight, brown spot, and leaf smut. They have utlized five convolutinal neural network models: InceptionResnetV2, InseptionV3, Xception, ResNet50, and VGG16, achieving 93.3% accuracy on the training dataset and 73.3% on the test dataset [15].

Mahadi Hasan Kamrul et. al worked with six rice leaf diseases which are common rice diseases in Bangladesh. They used datasets provided by the Bangladesh rice research institute (BRRI). Resnet50, Inception -v3, and MobileNet-v1 were used in this project. The accuracy of the training dataset was 98% for Inception-V3, 99% for MobileNet-V1, and 96% for the ResNet-50 model. The validation accuracy was 98% [10].

Solemane Coulibalya et. al have used VGG16 architecture to dectect disease in millet crop using a dataset containng 124 imafes of millet leaves [1]. They divided the dataset into two categories: mildew diseases and healthy. Their approach was able achieve 95% accuracy level.

S.Santhana Hari et. al suggested a convolutional neural network framework for identifying diseases in apple, tomato, maize and grape was suggested [4]. The dataset the have used contained a total of 15,210 images belonging to 10 classes, which were used for training and testing the model. Their proposed method achieved 86% accuracy.

Ding Jiang et. al utilized ResNet50 Convolutional Neural Network model to classify diseases in tomato leaves. A dataset containing 3,000 images of diseased tomato leaves of three diseases or in this case, classes was used to train and test their model, which achieved an accuracy of 98.0% [9].

Rice plant diseases can easily be detected from infected leaves. Detecting discoloration of leaves is a convenient method to detect infected leaves. Generally, color properties of an image can be efficiently described by a color histogram. Swain and Ballard prposed an automated system to detect rice leaf diseases color image analysis. The major conception is to detect color bin intersections of the computed histograms of RGB ingredient within two images [13] [11].

Shrivastava et. al used used a pre-trained deep convolutional neural network(CNN) as a feature extractor and Support Vector Machine (SVM) as a classifier to develop a rice leaf disease detecting framework. Their model was able to classify infected rice leaves of three diseases: Rice Blast, Bacterial Leaf Blight, and Sheat Blight trained and tested from a dataset of 619 rice plant diseased images collected from the real field [18].

Islam et. al used VGG16, ResNet50 and Denset121 architectures to detect Blast, Blight, and Sheath Blight from infected images of three different datasets. In their project, DenseNet121 showed the highest accuracy among three models [7].

Pujari et. al developed a framework using Statistical based Mahalanobis distance and Probabilistic neural network (PNN) as classifiers, Discrete wavelet transform (DWT), and principal wavelet analysis as feature extractor. Their classifier had an accuracy of 83.17% and 86.48% respectively [14].

Sladojevic et. al utilized deep convolutional network to detect 13 type of leaf diseases based on CaffeNet architecture. The dataset ciontained 30880 images among which 2589 images were used as validation set. Their approach had 95.8% accuracy, later boosted to 96.3% accuracy with fine-tuning [19].

III. Methodology

In this work, we used transfer learning method to develop a multiclass classifier based on InceptionV3 CNN architecture to identify three diseases of rice (Oryza Sativa) plant Brown Spot, Hispa, and Leaf Blast. We utilized a pretrained weight which was based on the ImageNet Large-Scale Visual Recognition (ILSVRC) dataset [17]. Our workflow is demonstrated in Fig. 1:

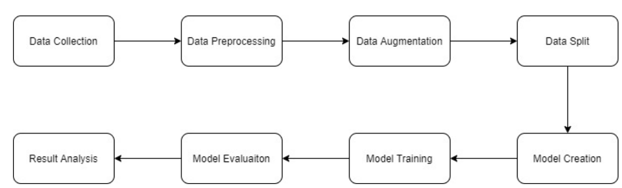


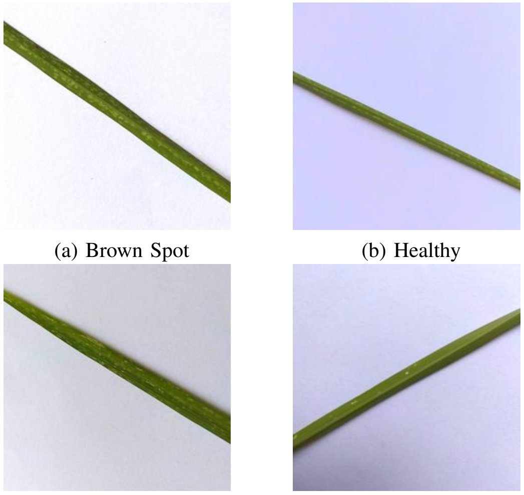
Fig. 1: Workflow Diagram

A. Dataset Description

We collected images of three leaf diseases of rice plant from Kaggle. Our Dataset contains 2,092 images of diseased leaves belonging to four classes or disease which are: Brown Spot, Healthy, Hispa, and Leaf Blast. All the images were of 256x256 pixel dimensions. Sample images from the dataset are displayed in Fig. 2

B. Dataset Preprocessing

We developed our model on InceptionV3 convolutional neural network model. InceptionV3 has takes image inputs of dimension 380x380 but our dataset contained images of dimension 256x256. So we first resized all the images of our dataset to 224x224 dimension using keras image preprocessing



(a) Brown Spot (b) Healthy (c) Hispa (d) Leaf Blast

Fig. 2: Diseased Leaf Images

tool. We divided our whole dataset with 70-20-10 formation-70% training dataset, 20% validation dataset, 10% test dataset.

As our original dataset was relatively small, we adopted data augmentation process to further increase our dataset volume. Sample augmented images of a single blast diseased leaf are shown in Fig. 3. We used this augmented dataset to train and validate our model.

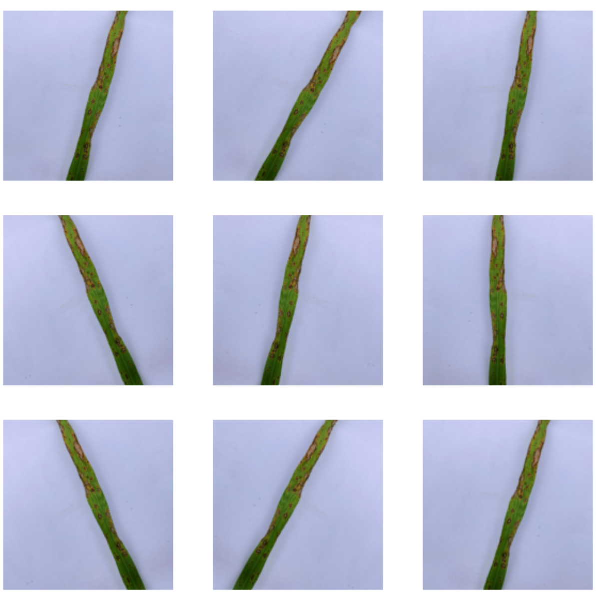


Fig. 3: Augmented Leaf Blast Diseased Leaf

C. Model Architecture

In this work, we utilized InceptionV3 to detect rice leaf diseases. We modified the InceptionV3 accordingly to classify the diseased leaves into four classes. Our model had input layer of 224x224x3 shape. We used average pooling and imagenet weights from ImageNet Large-Scale Visual Recognition (ILSVRC) dataset [17].

The input layer of our model was created according to our input image shape. As our preprocessed dataset had image shapes of 224x224, our model had input layer of 224x224x3 shape. We removed the top layer and added an output layer containing four neurons to the model to correctly classify our dataset into four classes: Brown Spot, Healthy, Leaf Blast, and Hispa. The output layer had softmax activation function as our project is a multiclass classification task. Softmax activation is used for multinomial probability distribution.

$$Softmax(x) = \frac{e^{z_i}}{\sum_{j=1}^{N} e^{z_j}}$$

The softmax activation function takes a vector of positive, negative , or zero values as input and turns it to a vector of real values between 0 and 1.

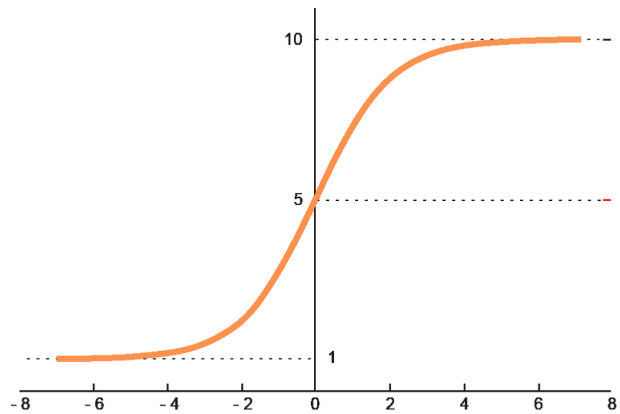


Fig. 4: Softmax Activation Function

A function or algorithm that modifies or tunes the weights of a neural network is called an optimizer. In our model we used Adaptive Moment Estimation (Adam) optimizer with a learning rate of 0.001. Adam optimizer changes the learning rate separately for all the weight updating.

Further, we used "categorical_crossentropy" as our loss function as we are working on a multiclass classification problem. The log function of this loss function is:

$$-\sum_{c=1}^{N} y_{o,c} \log(p_{o,c})$$

Our model had a total parameters of 22,007,588 of which trainable parameters were 204,804 and non-trainable parameters were 21,802,784.

IV. Results

The parameters we used to evaluate our model are:

Accuracy: Accuracy of a model is the percentage of correct predictions from all the predictions made by the model.

$$Accuracy = \frac{TN + TP}{TP + FP + TN + FN} \quad (1)$$

Here, TN = TrueNegative. TP = TruePositive, FN = FalseNegative, FP = FalsePositive.

Precision: Precision of a model is the ratio of correct predictions of a model over total predictions that were perceived as correct by the model.

$$Precision = \frac{TruePositive}{TruePositive + FalsePositive} \quad (2)$$

Recall: Recall of a model is the ratio of all correct predictions over the total number of actual positive cases.

$$Recall = \frac{TruePositive}{TruePositive + FalseNegative} \quad (3)$$

F1 Score: F1 score is a combined metric of precision and recall.

$$F1Score = \frac{2 * Precision * Recall}{Precision + Recall} \quad (4)$$

Our model exhibited training accuracy of 84%, 88% precision, 83% recall, and 85% F1 Score. The confusion matrix and accuracy of our model is shown in Fig. 5 and Fig. 6 respectively.

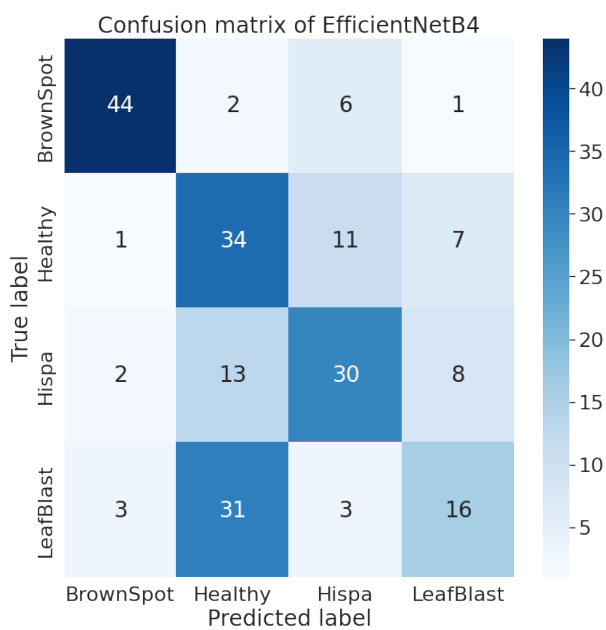


Fig. 5: Confusion Matrix

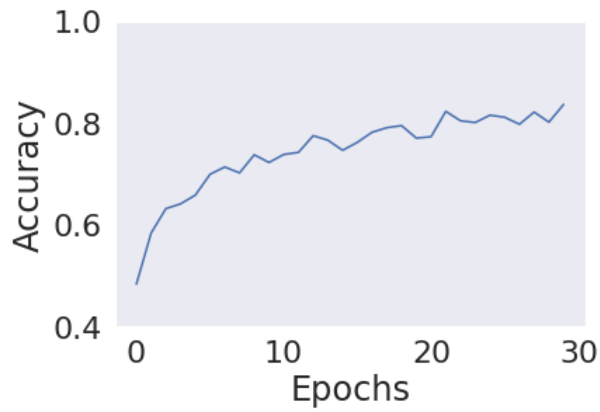


Fig. 6: Model Accuracy

V. Conclusion

In this work, we utilized transfer learning with InceptionV3 to detect three prominent diseases of rice (Oryza Sativa) leaves, e.g. Brown Spot, Leaf Blast, and Hispa. We also added another class which contained healthy leaf images so that our model can also detect healthy leaves. Our Model showcased 84% accuracy. We used data augmentation process to overcome the limitation of images in our dataset. Our model could have achieved better accuracy if we had larger dataset. We also faced infrastructural limitation to train our model. In future, we plan to include more diseases in our classification task. Our model can be utilized to detect rice leaf diseases early and contribute to mitigate substantial losses from the diseases.

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