Volume: 15 Issue: 04 Pages: 6009 - 6014 (2023) ISSN: 0975-0290

Detection and Classification of Rice Leaf Diseases using Local Features based on Convolutional Neural Network Model

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ABSTRACT

To withstand demand of rice for a massive population worldwide, the detection and classification of rice leaf diseases is significantly important now a days. Usually, rice leaf suffers from numerous bacteriological, virus-related, or fungous diseases and due to these diseases rice production is gradually decreases. The advancement of convolutional neural network shows the way for detection of rice diseases using local features with the expectation of high returns. In this article, the author propose a CNN-based model to detect and classifying the three different rice leaf diseases using fixed point local features. The achieved results exhibit the efficiency and advantage of our approach in contrast to the state-of-the-art rice leaf disease detection and classification methods.

Keywords -**Diseases, Feature Extraction, Local Features, Normalization, Neural Network, Pooling**

Date of Submission: November 01, 2023 Date of Acceptance: December 16, 2023

I. INTRODUCTION

India is known as the "land of agriculture" because of the importance of the sector to our nation's population, who are heavily invested/dependent in it. One of the key elements influencing the state of the domestic market in our nation is crop output. Agricultural companies started looking for innovative, high-yield, low-cost technologies as a result of population growth, unpredictable weather patterns, and an unpredictable political climate. A healthy plant or for food security and agricultural sustainability, crop is crucial. However, a number of variables might rapidly lead to the plants contracting diseases that can cause serious social and economic issues. Crop diseases one of the most common causes of productivity loss can affect a crops growth and development as well as crop production and quality therefore its critical to diagnose the condition and use specific pesticides from the beginning to avoid soil contamination.

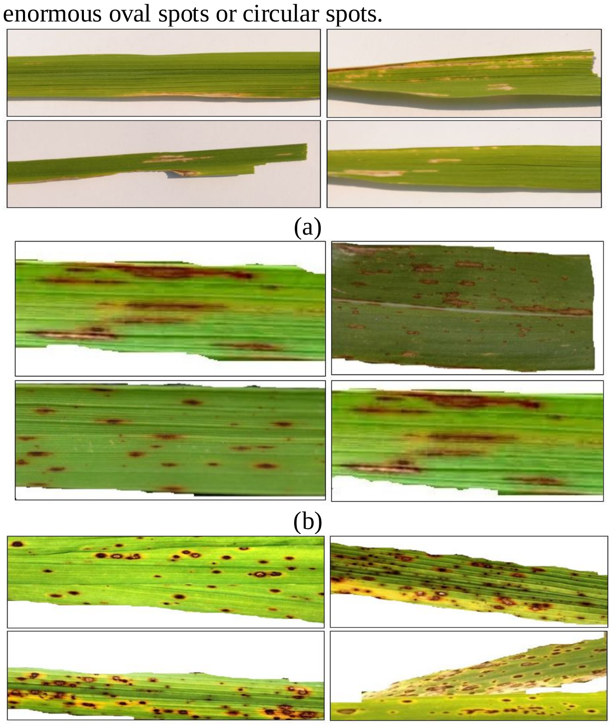
Rice is one of the most produced crops in the world, with a production volume of 104.80 million metric tons coming from various Indian states. Important food crops in our nation, as well as one of the crops with the greatest diversity of uses and nutritional value. The second-largest producer of rice in the world is our country, therefore the territory where rice is grown is continually growing. It has a substantial amount of dietary fiber, minerals, and both carbohydrates and protein in high concentrations. Most often, pathogens, including bacteria, fungi, viruses, and other organisms, are to blame for plant ailments. The variable it is simple for viruses to infect leaves in a field environment. Which renders rice leaves susceptible to diseases brought on by fungus and viruses. These infections will thrive in an environment made optimal by climate change. Infections brought on by fungus hinder crop growth in its early stages. A disease that develops while the crop is still growing could lower the crop's yield. It can be difficult to manually detect infections in sizable agricultural regions. Since farmers cannot recognize leaf illness with the naked eye and must call an expert to find that specific disease, which takes more time and demands considerable expense, diseases, particularly in rice plants, have become an issue.

II. TYPES OF RICE LEAF DISEASES

The diseases are mainly caused because of bacteria, fungi and viruses with their infection spread rapidly. The various diseases which affect rice crop. Fig. 1 shows different rice leaf disease. Some of the significant diseases as follows:

2.1 Bacterial Leaf Blight: The cause of bacterial blight is the pathogen Xanthomonas oryzae pv. oryzae. As a result, seedlings wilt, and their leaves dry out and turn yellow. Areas containing weeds and plant waste from contaminated plants are where the disease is most prone to spread. Both tropical and temperate environments can have it, especially in lowland regions that get irrigation and rainfall. Generally speaking, the illness prefers conditions with relative humidity of at least 70% and temperatures between 25 and 34 °C. Rice varieties that are sensitive to high nitrogen fertilization may experience severe bacterial blight. The gram-negative bacterium Xanthomonas oryzae pv is responsible for the illness. **2.2. Rice Leaf Blast (RLB):** RLB disease is one of the biotic factors that reduces rice production globally. It has become a prevalent hazardous illness in Malaysia as a result of its vast dissemination and ability to survive in a variety of environmental conditions .The fungus Pyricularia oryzae cavara, which attacks rice plants and degrades rice quality, is the main cause of RLB. Professionals can identify the signs of this sickness by looking at a leaf with lesions, which frequently start close to the leaf tip border or both.

2.3 Brown Spot: The young rice leaf plant blight caused by the fungus Cochliobolus miyabeanus attacking rice plants during emergence results in sparse or inadequate stands and weak plants. The brown spot is caused by poor growing conditions such as a lack of nitrogen or a plants inability to use nitrogen due to damage from rice water weevils root rot or another unfavorable soil condition. However they appear smaller on young leaves than on older ones depending on their size and shape the spots can be tiny black spots enormous oval spots or circular spots.



(a)

(b)

(c)

Fig. 1: Different diseases of rice leaf. (a) Bacterial Leaf Blight (b) Rice Leaf Blast (c) Brown spot

The green layer of the leaves is damaged by rice leaf disease, which may have an effect on quality and yield. Based on literature analysis, many authors have been proposed method for automated rice disease diagnosis based on image processing and machine learning techniques such as using pattern recognition, support vector machine, digital image processing and computer vision. Although, the machine learning techniques have made the great accomplishment on image identification, still it has some limitations: restricted data handing capability, the requirement of segmentation & feature extraction. Therefore, the traditional machine learning techniques face difficulties for classification of agricultural diseased images with adequate results. With the advancement of machine learning techniques, the deep learning methods are capable enough to solve and model the big data problems. The deep learning methods can be applied in agricultural diseased image classification without the need for pre-required processes such as segmentation and feature extraction.

The significant inspiration for designing a convolutional neural network model for rice leaf disease is to offer the agriculturalists an easy to find early-stage infections by digital camera. Second, extracting active features for detecting rice leaf diseases is an inspiring problem, and CNNs are extremely expected to be automated feature learning from the original inputs images in a very organized way. Through the CNN architecture, the supervised features are considered as the higher level abstract representation of low level rice leaf disease images. To increase diagnostic results, the CNNs is regarded as one of the best classifications in pattern recognition problem. Hence, in this article the authors developed CNN model for rice leaf diseases detection and classification.

The identification of rice leaf diseases contributes to higher crop production and better rice quality around the world. The major contribution of this article is as follows:

- CNN-based model that can categories three prevalent rice leaf diseases that are widespread.
- The disease predicted is accurate, which helps the farmers to spray the correct fertilizers.
- It reduces the physical observation of the rice crop leafs diseases for farmers.
- Various types of loses occurring to the field can be reduced.

III. LITERATURE SURVEY

Study on plant leaf disease recognition and classification using image processing techniques [1-4] has gain concentration in recent years. The authors in [1] defines a software model for rice leaf disease detection and classification based on Self organizing map (SOM) neural network. The infected images of various rice plants which are taken by digital camera and processed by image growing, entropy based bi-level thresholding segmentation techniques to detect infected regions. Then the infected region has been used for the classification using neural network. In [5] the gradient-descent features based deep convolutional neural networks (CNNs) designed for rice leaf diseases identification. Detection and classification of rice blast disease based on Artificial Neural Network (ANN) [6] uses statistical features such as Mean Value, Standard Deviation and GLCM are calculated to detect the disease automatically. The authors in [7] proposed a method for disease detection in plant leaf based on Random Forest classifier. In order to train random forest classifier they are extracted Histogram of an Oriented Gradient (HOG) features. The HOG feature descriptor provides appearance of the object and outline of the image described by its intensity gradients.

The authors in [8] presented technique to detect and classify the diseases based on percentage of RGB value of the affected portion using image processing technique. Once the percentage of RGB features extracted from region of interest, they are fed to a Naive Bayes which classifies the disease into rice brown spot, rice bacterial blight, and rice blast. Random Forest, Decision Tree, K-Nearest Neighbor (KNN), Support Vector Machine (SVM) classifiers are used [9] for recognizing infected part of the leaf based on GLCM feature. In[10] deep learning CNN architecture proposed with training on 1509 images of rice leaves and testing on different 647 images and they quote correctly classifies 92.46% of the test images. Transfer learning using fine-tuning the predefined VGGNet of the model which number of epochs is 25. CNN, Harr-wavelets are played major role in recognition of rice blast diseases [11]. Authors extracted Local Binary Pattern Histograms (LBPH) feature from infected region, then the radial basis function (RBF) kernel function of SVM is chosen to build SVMs. And also authors evaluated the automatically optimized features learned by CNN on pedestrian detection, and showed that the CNN + SVM combination can achieve a very high accuracy to improve the performance of rice blast disease classification. Rice leaf disease detection model [12][16][20][23][27][28][29] using machine learning algorithms[30], Convolutional neural network [13][21], Support Vector Machine With Deep Convolutional Neural Network[14-15], deep learning model with support vector machine[17][26], Deep Neural network[18-19], AlexNet convolutional neural network [22], artificial neural network[24], R-CNN[25].

IV. CONVOLUTIONAL NEURAL NETWORK (CNN) MODEL

CNN [11] is a multi-layer neural network with a supervised learning architecture that is often made up of two parts: a feature extractor and a trainable classifier. The feature extractor contains feature map layers and retrieves discriminating features from the raw images via two operations: convolutional filtering and down sampling. Convolutional filtering as the key operation of CNN has two vital properties: local receptive field and shared weights. Convolutional filtering can be seen as a local feature extractor used to identify the relationships between pixels of a raw image so that the effective and appropriate high-level features can be extracted to enhance the generalization ability of a CNN model. Specifically, the general structure of CNN is composed of the following layers as shown in Fig.2 and Proposed CNN model for leaf disease classification based on local features shown in Fig.3.

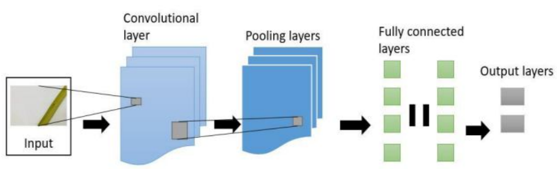


Fig. 2: General structures of CNN Layers

The above-mentioned image displays how CNN is operated the input shown as in picture is transferred to CNN. Having extracted the preprocessed data, the relevant features where it undergoes five stages of processing to accurately represent it the final result is then shown.

• Input layer: The dataset is used as the input layer in a CNN model, a 3x3 matrix will be used to represent the input data.

• Convolution layer: draws inspiration from filters more manageable subsets of the information needed to add characteristics to a picture.

• Pooling layer: By reducing the number of image dimensions this layer can reduce the processing power needed by upcoming layers there are two distinct pooling strategies similar to optimal pooling the input is divided into its parts.

• Max Pooling: The result is sent to the pixel with the highest value in comparison to average pooling it is the strategy that is applied the most commonly.

• The final layer of CNN is Fully Connected Layer (Dense): Can find features that are closely related to the output class. The outcomes of the pooling layer are flattened to yield a one-dimensional vector.

• Dropout Layer: By removing a random collection of neurons from the model, this layer addresses the problem of overfitting. It is linked to the FC layer. The network's final layer.

• The SoftMax Layer: Aids in classification the input photographs based on the attributes the network has detected, from the dataset into various categories.

• The output layer final categorization result is kept in the output layer.

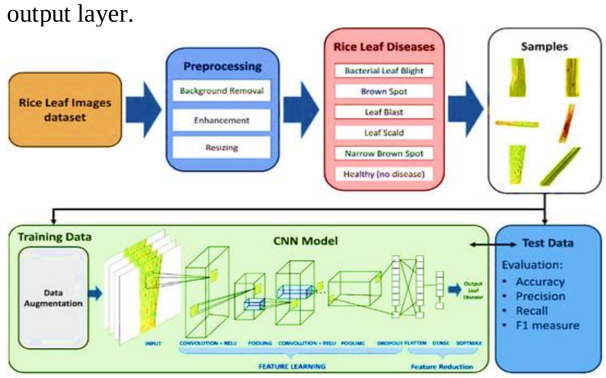


Fig. 3 Proposed CNN model for leaf disease classification based on local features

V. PROPOSED METHOD

The proposed methodology for detection and classifying rice leaf diseases is shown in the Fig.3. The proposed method is broken down into several stages. Initially, the creation of a training dataset, followed by the creation of a CNN model, local feature extraction in the region of interest for CNN model training, and finally, classify the diseases which is affected to rice leaves. To get better results in terms of accuracy and precision, a high-resolution camera is used to capture the leaves. Then, image processing techniques is applied to rice leaf in order to extract dominant local features. The pipe line of the proposed method shown in Fig.4.

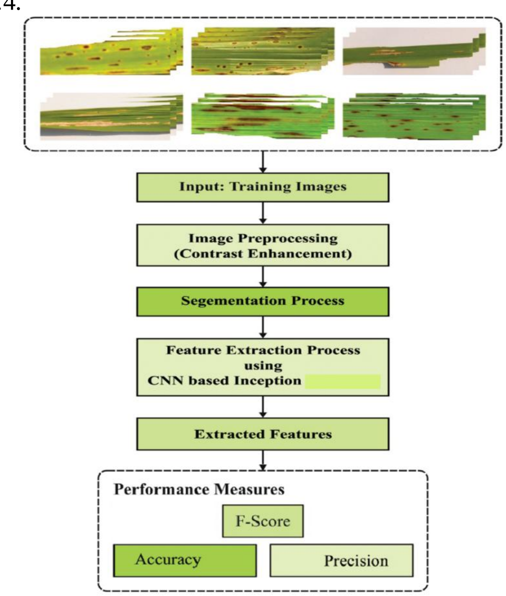


Fig.4. Pipe line of the proposed model

Volume: 15 Issue: 04 Pages: 6009 - 6014 (2023) ISSN: 0975-0290

CNN-based algorithm for identifying rice leaf diseases extracts the deep characteristics of these diseases. In our CNN-based model, activations in each layer transform the granular information into a more abstract representation and emphasize its salient properties as the input image of rice leaf disease advances through the deeper levels. The visual representations of our model's convolution and pooling layers for an example image of a rice leaf are displayed in Fig. 5. The deeper and more accurate summarized information is then used as a feature and categorized using the softmax layer of our model. In order to develop and tune the network parameters in the convolution, pooling, and dense layers to condense the features into a 1 x64 vector, we input the images to our model in batches. A 1x5 vector is created by passing these characteristics through a second dense layer.

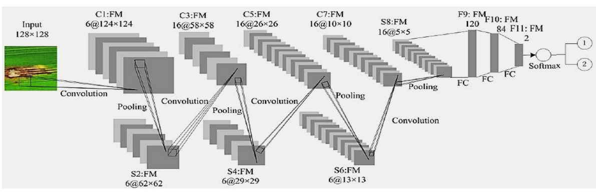


Fig 5. Architectural diagram of CNN model

In order to assign an image of rice leaf disease to the appropriate class, this vector is finally transferred into the softmax layer. We run the training photos through a series of iterations, or epochs, and use the collection of validation images to verify the model and its associated parameters. Summary steps of CNN model and local feature approach

- Step1: Choose the datasets
- Step2: Prepare dataset for training
- Step 3: Create training data
- Step 4: Assigning Labels and features
- Step 5: Normalizing x and converting labels to categorical data.
- Step 6: Split X and Y for use in CNN
- Step 7: Define, compile and train the CNN model
- Step 8: Accuracy and F1 Score of a model

To implement a fault prediction model with the proposed metrics inputs and predicted-faults as an output parameter, machine learning-based techniques have been used. Fig. 6 shows the basic working procedure of machine learning for prediction. The machine learning methods are either supervised methods or unsupervised methods.

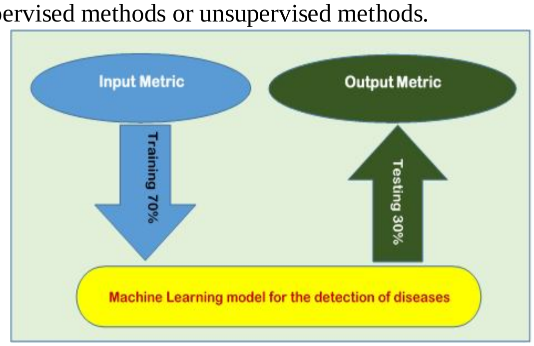


Fig.6. Basic working procedure of machine learning for prediction

VI. EXPERIMENTAL RESULTS

The experimental studies were implemented using the MATLAB 2019a deep learning toolbox. All applications were run on a laptop, i.e. Intel(R) Core (TM) i5-3210 CPU @2.50GHz(8 GB/1 TB HDD/128 GB SSD/Windows 10 Home/4 GB Graphics) and equipped with NVIDIA. The dataset contains total 3092 images which includes three types of diseased leaf images and healthy leaf images (Rice disease images are collected from database available in http://bcch.ahnw.gov.cn/Right.aspx). All the images were treated as samples and resized to 128*128 pixels as shown in Fig.1. In order to effective disease detection and classification purpose images were divided into training set and testing set. Among them, 2136 leaf images are trained including 577 Bacterial leaf blight images, 841 Rice leaf blast images, 633 brown spot images, and 245 healthy images. 1020 leaf images are trained including 323 Bacterial leaf blight images, 247 Rice leaf blast images, 231 brown spot images, and 219 healthy images.

The proposed model is executed for 2136 training data followed by 1020test data. In order to evaluate the performance of our approach, we conducted the experiments and results are evaluated based on popular metrics such as Sensitivity (Recall), Specificity (Precision), False Positive Rate (FPR), F1 Score and training time. Specificity gives the percentage of true positives as compared to the total number of leaf images retrieved by the approach. Sensitivity gives the percentage of true positives as compared to the total number of true positives in the dataset and F1 score is the weighted harmonic mean of precision and recall, which can be used to calculate the accuracy of the approach. For a given query word image, we evaluate, True Positives (TP), True Negative (TN), False Positives (FP), and False Negative (FN). Based on these values, we computed calculated Sensitivity, Specificity.

$$\text{Sensitivity (Recall)} = \frac{TP}{TP+FN}$$

$$\text{Specificity (Precision)} = \frac{TP}{TP+FP}$$

$$\text{FPR} = \frac{FP}{FP+TN}$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN}$$

$$\text{F1 Score} = 2 \times \frac{Sensitivity \times Specificity}{Sensitivity + Specificity}$$

Where,

- TP (True Positive) is the number of relevant leaf disease images correctly retrieved
- FP (False Positive) is the number of leaf disease images retrieved as other than query image
- FN (False negative) is the number of relevant leaf disease images does not retrieve from the dataset
- TN (True Negative) is the number of irrelevant leaf disease images does not retrieve from the dataset

The accuracy of training set is 97.8% and the testing set accuracy of 97.40%. Table 1 shows the classification performance of our proposed model.

Leaf Type	*Sensitivity (Recall)*	*Specificity (Precision)*	*FPR*	*Accuracy*	*F1 score*
Bacterial leaf blight	93.80	98.37	0.71	97.54	96.03
Rice leaf blast	88.66	96.90	0.90	96.56	92.60
Brown spot	92.64	98.61	0.38	98.03	95.53
Healthy leaf	89.95	98.01	0.49	97.45	93.80
Average	**91.26**	**97.97**	**0.62**	**97.40**	**94.49**

Table 1. Classification performance of diseased and healthy leaf images

Table 2 shows confusion matrix attained for our proposed model. From this confusion matrix we determined TP, FP, FN, and TN values and presented in Table 3.

	Bacterial leaf blight	Rice leaf blast	Brown spot	Healthy leaf
Bacterial leaf blight	**303**	**4**	**1**	**2**
Rice leaf blast	**2**	**219**	**2**	**0**
Brown spot	**3**	**2**	**214**	**2**
Healthy leaf	**0**	**1**	**0**	**197**

Table 2. Confusion matrix for proposed CNN model

	TP	**FP**	**FN**	**TN**
Bacterial leaf blight	303	5	20	692
Rice leaf blast	219	7	28	766
Brown spot	214	3	17	786
Healthy leaf	197	4	22	797

Table 3. TP, FP, FN, and TN values of proposed CNN model for testing dataset size 1020.

VII. CONCLUSION

The advanced computer vision technology encourages researchers around the world to carry out extensive experiments on plant disease recognition using leaf image analysis techniques. In this article, detection and classification of three different rice leaf diseases using local feature based on CNN model has been proposed. The proposed method yields a consistent performance due to discriminant use local features. The experimental results indicate that the proposed approach could be a good approach, which might considerably support and correct detection of rice leaf diseases with little effort. From experimental result it is observed that local features based CNN model is most effective, with a 97.40% accuracy rate. Therefore, further study should be carried out to implement a dynamic and automatic system to recognize large-scale rice leaf diseases. This system could be made up of a mobile terminal processor and agricultural Internet of Things that may be favorable to modernize the agricultural industry.

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